EnergyAction

Modelling & Sensitivity Analysis

NCC Section J Revision October 2018

18 December 2018

Energy Action (Australia) Pty Ltd
ABN 23 103 365 199

Prepared for:

Australian Building Codes Board

Prepared by: Energy Action

Reference: REP09391-A-001

Table 1: Quality Control

Quality Control	Final Revision 3
Authors	Daniel Johnston, Daniel Shen, Dev Vrat Bhardwaj
Reviewers	Hongsen Zhang, Grace Foo
Report Number	REP09391-A-001
Job Number	REP09391-A
Edition Date	18 December 2018
Print Date	18 December 2018

Table of Contents

Executive Summary

In late 2016, Energy Action was contracted by the Australian Building Codes Board (ABCB) to review the 2016 National Construction Code (NCC2016) and make recommendations on increasing the stringency of the Section J provisions[1]. Each Deemed-to-Satisfy (DTS) element was analysed with the aim of producing cost-effective and practical energy efficiency improvements having a Benefit-Cost Ratio (BCR) of between 1 and 1.5 where possible. As a result a new set of Section J DTS provisions has been recommended.

This is now the third round of whole of building modelling of the proposed DTS which comprises the following analyses:

- Impact of a fixed window-to-wall ratio (WWR) of 30% across the climate zones 1 to 7 for building Class 3A and 9aC. These WWRs were taken from the commercial buildings WWR study conducted by Energy Action in 2018 for the Department of the Environment and Energy.
- Impact of higher WWR (56% for all, except climate zone 7 which was 50%) across climate zones 1 to 7 for building Class 5A.
- Impact of lower and compliant external wall insulation costs for Class 5A, 3A, 6B, 9aC and 9bH across climate zones 1 to 7.
- A decomposition test for the respective impacts of building services and façade for Class 5A, 3A, 6B across climate zones 2, 5 and 6.

The primary aim of this report is to provide data that can be used for the basis of the Decision Regulation Impact Statement (RIS), and to test the approach taken to setting the DTS stringency level.

This analysis includes both updated core modelling and some additional sensitivity analysis to expand on the previous round of models. The previous round of models had differing WWRs across different façades. These results do not invalidate any of the earlier reported modelling results which showed 26% to 38% energy savings and 35% to 43% greenhouse gas emission savings for the proposed 2019 DTS relative to the 2016 DTS (see REP07830-B-026 issued in June 2017).

Readers should keep in mind that the results in this report are based on simulated building models with predetermined forms and geometries. In reality, the specific building archetype may perform differently depending on their designed form and geometry.

[1] Excluding Class 2 sole-occupancy units and Class 4 parts of buildings.

Key Assumptions

The following key assumptions are used in the preparation of this report:

- A least cost approach has been taken for building façade elements, particularly glazing. For glazing, the construction costs presented in this report used the cheapest compliant glazing. For external wall insulation, non-combustible glasswool insulation was used for cost modelling (except for Class 9aC).
- The incremental costs for LED lights and lifts were excluded from the RIS modelling. This is largely because the use of efficient lighting and lift technologies to the level proposed by DTS 2019 regulation is considered to be generally representative of industry trends.
- Total building façade U-values impacting external wall insulation thickness requirements account for the impacts of thermal bridging. The impact of thermal bridging on resultant wall construction R-values were calculated when Section J stringency level changes were determined throughout the Section J revision work in 2017. This result was then filtered through to determine the R-value required for external wall insulation. This calculation was conducted for 2016 and 2019 models.
- No learning rates were applied for pricing or technology performance.
- Energy costs used are in line with previous Energy Action reports.

The results presented in this report (summarised below) show that, in almost all cases modelled, the proposed DTS provisions lead to reductions in a building's energy use, greenhouse gas emissions and reductions in operational costs. This is consistent with earlier modelling results and confirms that the proposals are sound.

There is, however, a wide variation in results depending on building class, geometry and climate zone. In 3 out of 35 cases, the results show a building performing slightly worse in some aspect under the 2019 provisions when compared with what it would have achieved under the 2016 provisions. These anomalies are investigated and explained in this report.

Final DTS levels

It should be noted that as a result of the consultation processes undertaken by the ABCB in finalising the setting of each DTS element, a BCR of above the 1 to 1.5 range resulted as the final setting needed to take into account issues in addition to energy cost effectiveness, these included:

- the ability of the market to provide product at the proposed stringency;
- whether provisions could be simplified to increase compliance;
- the need to maintain amenity and be consistent with other parts of the code;

- the need to increase design flexibility; and
- the need to address existing issues in NCC2016.

Annual Energy and Greenhouse Gas Emissions

This report focuses on putting all the proposed changes to the DTS provisions together to ensure the sum of the individual recommendations provides a stringency that can deliver lower annual emissions outcomes. IES <VE> dynamic thermal simulations provide the means to quantitatively assess the energy performance for buildings compliant to NCC2016 and NCC2019 (proposed) stringencies. It should be noted that the NCC2016 models actually use the NCC2019 illumination power density (IPD) provisions thus they are actually better than NCC2016 compliance models. The results show a significant reduction in energy use across almost all models as shown in Table 2.

Table 2: Change in annual energy use from the impact of increased stringency

Location	3A 30%	9aC 30%	5A 56%[2]	6B 30%	9bH 30%	5A 40%
Climate zone 1	-10%	-21%	-7%	-11%	-26%	-10%
Climate zone 2	-23%	-19%	-11%	-11%	-29%	-14%
Climate zone 3	-19%	-20%	-7%	-12%	-23%	-8%
Climate zone 4	-24%	-12%	-7%	-7%	-23%	-12%
Climate zone 5	-21%	-15%	-12%	-13%	-23%	-16%
Climate zone 6	-25%	7%	-7%	-3%	-23%	-12%
Climate zone 7	-24%	3%	-4%	-3%	-21%	-13%

Expressing the annual energy use in terms of greenhouse gas emissions (kg CO_2 equivalent), the reduction from implementing the proposed NCC2019 stringency is significant, and more consistent than the energy reduction. Table 3 below presents this information.

Table 3: Change in annual greenhouse gas emissions from the impact of increased stringency

Location	3A 30%	9aC 30%	5A 56%	6B 30%	9bH 30%	5A 40%
Climate zone 1	-10%	-21%	-7%	-11%	-26%	-10%
Climate zone 2	-23%	-20%	-9%	-12%	-34%	-12%
Climate zone 3	-19%	-21%	-5%	-14%	-23%	-7%
Climate zone 4	-22%	-18%	-11%	-14%	-22%	-9%
Climate zone 5	-21%	-18%	-12%	-16%	-20%	-12%
Climate zone 6	-23%	-13%	-11%	-15%	-20%	-11%
Climate zone 7	-22%	-22%	-16%	2%	-23%	-11%

[2] climate zone 7 had a WWR of 50% as it was not possible to comply with DtS 2016 glazing requirements with a higher WWR.

On the whole, the interpretation of these results are positive if overall energy and greenhouse gas emissions savings are observed. Where overall energy increases but greenhouse gas emissions decrease (i.e. Class 9aC in Climates Zones 6 and 7), this phenomenon can be explained from the perspective of a fuel change. The sole instance where annual greenhouse gas emissions increase (i.e. Class 6B in climate zone 7) is further investigated below, although the magnitude is negligible.

The less favourable energy and greenhouse gas reductions for small buildings in cooler climates in the above tables is likely attributable to a slightly less stringent façade U-Value modelled in the NCC2019 simulations, for this specific building archetype, compared to NCC2016. While earlier iterations of these proposals did have more stringent (i.e. lower) U-values in climate zones 6, 7 and 8, these were increased post-consultation as there were concerns about the ability of small buildings to comply with Part F4 requirements (that is, minimum window size requirements). There is also an issue with 2016 values being over-stringent. In many of the models of small buildings in cooler climates, no 2016 DTS compliant windows were available (see EA Glazing report REP07830-B-002). This suggests that the current 2016 DTS levels are impractical and needed to be revised, but also explains why the models produce worse results in these circumstances.

In 2016, compliant Retail Display Glazing (common in Class 6 buildings) were especially hard to find or required customised glazing in cooler climates – as the glazing not only needed to meet U-value and SHGC requirements, but also needed to be clear (or, low VLT) in order to be fit-for-purpose.

Further, in this instance the 9aC building modelled has a high surface-to-volume ratio, which accentuates the importance of installing glazing with low U-value and SHGC, particularly in climate zones located in the extremities of the Australian climate. This is because the modelled building has a higher medium of heat transfer (surface area) between the unconditioned ambient conditions and conditioned internal building conditions. Buildings with a low surface-to-volume ratio have been shown to produce more efficient buildings.

The driver of the slightly higher (2%) greenhouse gas emissions modelled in the Class 6B building in climate zone 7 is also related to the change in façade stringency. In this model a higher peak heating load in 2019 shifts the required fan power across the 100W/m^2 threshold in the fan provisions so that a higher W/m^2 value is used to calculate 2019[3] fan power than is used in 2016, even though the peak heating requirements are, in reality, quite close to each other. This leads to the model having much higher energy use from fans than would be expected. Note that when you calculate fan power requirements on a fan coil unit (FCU) by FCU basis as opposed to a whole-of-building average to correct for this result, the 2019 model produces 12% less greenhouse gas emissions.

[3] This 10.3W/m² figure is calculated from the NCC 2019 proposed provisions.

From NCC2016 to NCC2019 there is a shift in the heating and cooling proportions within the models. The NCC2019 provisions increase the proportion of annual heating energy across some climate zones and subsequently reduce the proportion of annual cooling energy. Whilst the annual energy consumption of the models may rise in the heating dominated climate zones mentioned above, the annual greenhouse gas emissions actually decrease for all but one scenario. This is because the National Greenhouse Accounts (NGA) factors weight electricity (typically cooling energy) higher than natural gas (typically heating energy) in terms of their contribution to annual emissions.

Underlying the results above is a transition to a whole-of-façade methodology in 2019 from an individualised assessment of external walls and glazing approach in 2016. The change in glazing methodology is critical and these results must be interpreted through the lens of this change in DtS practice. The move provides greater simplicity for practitioners in demonstrating compliance and also allows for greater design flexibility. The 2019 methodology also places a much higher level of emphasis on the need for a facade to control solar gain (expressed as higher SHGC), than the 2016 provisions, that placed greater emphasis on U-value.

It should be further noted that the new stringency levels for facades was not created in comparison to the 2016 levels, but by taking as its base case the minimum functionality of a window being the provision of a minimum amount of daylight (see EA Glazing report REP07830-B-002). This makes comparing the 2016 glazing and 2019 façade provisions problematic, because as noted above the 2016 provisions had issues with over-stringency in some instances, and because the basis for specifying compliant wall and glazing elements is different.

Construction Costs

The capital cost variation between the NCC2016 and NCC2019 models (Scenario 1[4] analysis only) is presented in Table 4. As NCC2019 suggested a simplified approach to compliant glazing selection, including allowing for trading glazing values between facades, it was possible to maintain both a more uniform WWR and glazing selection for the NCC2019 models. The change in emphasis toward SHGC in the new methodology also results in lower construction costs. As noted in earlier Energy Action reports, the cost of increasing the SHGC of glazing is less than the proportional cost of increasing U-values. This resulted in the ability to select lower cost compliant glazing in many cases.

External wall insulation cost modelling was based on wall insulation that complied with Part C of NCC Volume One, particularly Specification C1.1 that requires non-combustibility. The result was the use of non-combustible glasswool fibre insulation that is significantly cheaper per square meter.

[4] Scenario 1 uses a minimum external wall insulation thickness of 25mm with no upper bounds whereas Scenario 2 restricts external wall insulation thickness in the range of 25mm to 90mm to reflect standard insulation thickness and stud depths.

Table 4: Construction cost variation from the impact of increased stringency

Location	3A 30%	9aC 30%	5A 56%	6B 30%	9bH 30%	5A 40%
Climate zone 1	-7%	3%	-6%	0%	3%	6%
Climate zone 2	2%	2%	3%	2%	10%	2%
Climate zone 3	-1%	0%	28%	5%	6%	7%
Climate zone 4	-1%	5%	-3%	7%	9%	4%
Climate zone 5	3%	5%	5%	3%	10%	8%
Climate zone 6	-1%	8%	-10%	4%	3%	3%
Climate zone 7	-9%	8%	-7%	6%	3%	0%

Table 5: Operational cost variation from the impact of increased stringency

Location	3A 30%	9aC 30%	5A 56%	6B 30%	9bH 30%	5A 40%
Climate zone 1	-7%	-12%	-16%	-7%	-21%	-5%
Climate zone 2	-20%	-10%	-12%	-6%	-21%	-11%
Climate zone 3	-16%	-11%	-7%	-7%	-16%	-4%
Climate zone 4	-18%	-6%	-8%	-5%	-14%	-5%
Climate zone 5	-16%	-7%	-10%	-8%	-11%	-9%
Climate zone 6	-19%	7%	-6%	-4%	-13%	-5%
Climate zone 7	-18%	4%	-5%	2%	-14%	-3%

Table 5 above illustrates that in almost all cases, there is a reduction in operational cost for the archetypes modelled. This is a direct result of higher building performance derived from the NCC2019 provisions. In terms of a benefit-cost ratio, the ratio of incremental lifetime operational costs to the incremental construction costs, Table 6 through to Table 11 below show how the proposed stringency compares.

Table 6: Pricing variation and benefit-cost results for modelling in Model 3A, 30% WWR

Region	Construction Cost Variation	Operational Cost Variation	Benefit-Cost Result
CZ1	-$97,139	-$235,381	negative cost
CZ2	$23,460	-$598,355	25.5
CZ3	-$7,420	-$439,460	negative cost
CZ4	-$9,230	-$475,802	negative cost
CZ5	$41,094	-$440,537	10.7
CZ6	-$6,539	-$488,443	negative cost
CZ7	-$114,964	-$451,866	negative cost

Table 7: Pricing variation and benefit-cost results for modelling in Model 9aC, 30% WWR

Region	Construction Cost Variation	Operational Cost Variation	Benefit-Cost Result
CZ1	$7,499	-$45,321	6.0
CZ2	$3,577	-$26,855	7.5
CZ3	-$652	-$34,898	negative cost
CZ4	$12,577	-$14,762	1.2
CZ5	$11,807	-$15,568	1.3
CZ6	$19,269	$15,517	-0.8
CZ7	$20,420	$9,853	-0.5

Table 8: Pricing variation and benefit-cost results for modelling in Model 5A, 56% WWR

Region	Construction Cost Variation	Operational Cost Variation	Benefit-Cost Result
CZ1	-$124,943	-$473,901	negative cost
CZ2	$51,481	-$277,261	5.4
CZ3	$516,040	-$156,056	0.3
CZ4	-$49,571	-$151,339	negative cost
CZ5	$89,160	-$204,241	2.3
CZ6	-$213,272	-$115,215	negative cost
CZ7	-$130,716	-$95,201	negative cost

Table 9: Pricing variation and benefit-cost results for modelling in Model 6B, 30% WWR

Region	Construction Cost Variation	Operational Cost Variation	Benefit-Cost Result
CZ1	-$224	-$121,803	negative cost
CZ2	$6,647	-$87,609	13.2
CZ3	$22,507	-$113,697	5.1
CZ4	$29,557	-$75,946	2.6
CZ5	$11,327	-$117,542	10.4
CZ6	$15,139	-$63,997	4.2
CZ7	$24,469	$26,447	-1.1

Table 10: Pricing variation and benefit-cost results for modelling in Model 9bH, 30% WWR

Region	Construction Cost Variation	Operational Cost Variation	Benefit-Cost Result
CZ1	$13,836	-$344,870	24.9
CZ2	$49,024	-$209,529	4.3
CZ3	$29,794	-$211,300	7.1
CZ4	$44,411	-$142,141	3.2
CZ5	$45,887	-$93,057	2.0
CZ6	$17,075	-$124,038	7.3
CZ7	$18,135	-$167,208	9.2

Table 11: Pricing variation and benefit-cost results for modelling in Model 5A, 40% WWR.

Region	Construction Cost Variation	Operational Cost Variation	Benefit-Cost Result
CZ1	$78,518	-$124,035	1.6
CZ2	$33,275	-$255,400	7.7
CZ3	$105,660	-$88,205	0.8
CZ4	$58,734	-$90,487	1.5
CZ5	$102,397	-$179,872	1.8
CZ6	$41,789	-$86,123	2.1
CZ7	$4,175	-$58,070	13.9

As discussed above, the increased requirement for general heating energy in Class 9aC and peak load heating in Class 6B in these particular models are due to changes to the façade requirements. The fact that the building has a high surface-to-volume ratio exacerbates this effect and thereby has increased heating energy. In buildings with lower surface-to-volume ratios and higher WWR, it is expected that the increase in building services would be sufficient to offset this impact. Façade performance tends to have less impact on overall energy consumption in buildings with low surface-to-volume ratios. In these buildings, however, the increased services cost and efficiency is insufficient to offset the slightly poorer performing façade in these building archetypes.

While it is may be reasonable to expect the glazing costs to impact chiller construction costs (e.g. typically when glazing costs decrease, chiller costs increase), this assertion does not hold true in all situations. Central plant sizing is dependent on peak requirements which depending on the time of the day when the peak load occurs, climate zone and modelled geometry, may sometimes benefit from having a lower performing façade (higher U-value).

Façade vs Services Contribution:

In order to determine the relative contributions of stringency updates on the façade and services sections of the code and to separate the influence of the changes in methodology from the changes in stringency to reducing energy and emissions, additional 'mixed' models were simulated for climate zones 2, 5 and 6. The mixed models consisted of using a façade construction according to NCC2016 and the services were according to NCC2019 provisions. The WWR ratio was fixed at 30% across all archetypes except for 5A, which was fixed at 40%.

The simulated energy results were compared to the NCC2016 results to determine the services contribution. The façade contribution analysis compared the NCC2019 results with the 'mixed' models. Based on the results, the changes in stringencies for building services were mostly responsible for the reduction in energy and emissions. This finding correlates well with findings in the core modelling, particularly with buildings with a low surface-to-volume ratio.

$$Mixed\ Model - NCC2016 = Services\ Contribution$$

$$NCC2019 - Mixed\ Model = Façade\ Contribution$$

In general, the decomposition results show that building services have significantly better BCRs compared to building façade BCRs. However, when reviewing these BCRs, the high BCRs (relative to target BCRs of 1-1.5) observed in the decomposition results is generally driven by high energy savings with low incremental costs – this is often driven by negative chiller, boilers and fan costs in these situations where increased façade SHGC stringency allows smaller capacity cooling systems.

To understand why the BCRs in the decomposition results might be so high, the reader must be reminded that the methodology undertaken to select boiler stringency needed to ensure that there was sufficient available product in the market at the proposed level. The Energy Action report (REP07830-B-022) states that the stringency levels for boiler thermal efficiency were selected at the point where there was a marked drop in the number of chillers and boilers with a BCR >1.0 across all climate zones, even though the cost-benefit analysis justified a higher level of stringency.

Secondly, the construction costs for HVAC equipment is driven by the need to select a chiller that can meet a building's peak cooling load on the hottest days, which determines what a chiller's capacity needs to be. In this report, chiller cost regression equations were developed based on manufacturers' data. The equations took into account chiller capacity and efficiency (COP/IPLV). Even if the NCC2019 DtS has a higher requirement for chiller efficiency, the façade SHGC improvement could cause the capacity reduction in many cases. Overall this resulted in energy efficiency being achieved at small cost. This in many cases explains the high BCRs for services.

Table 12: Change in annual energy consumption from NCC 2019 to NCC2016 due to services stringencies

Location	3A 30%	9aC 30%	6B 30%	9bH 30%	5A 40%
Climate zone 2	-18%	-17%	-12%	-29%	-10%
Climate zone 5	-17%	-15%	-15%	-26%	-13%
Climate zone 6	-23%	-14%	-12%	-31%	-7%

Table 13: Change in annual energy consumption from NCC 2019 to NCC2016 due to façade stringencies

Location	3A 30%	9aC 30%	6B 30%	9bH 30%	5A 40%
Climate zone 2	-7%	-2%	2%	0%	-4%
Climate zone 5	-5%	1%	3%	4%	-3%
Climate zone 6	-2%	24%	10%	11%	-6%

Table 14: Construction cost variation from the Decomposition Results for Model 3A, 30% WWR[i]

Climate zone	Services %	Façade %	Total %
2	1%	1%	2%
5	9%	-5%	3%
6	2%	-2%	-1%

Table 15: Operational cost variation from the Decomposition Results for Model 3A, 30% WWR

Climate zone	Services %	Façade %	Total %
2	-15%	-7%	-20%
5	-12%	-5%	-16%
6	-18%	-2%	-19%

Table 16: Construction cost variation from the Decomposition Results for Model 5A, 40% WWR

Climate zone	Services %	Façade %	Total %
2	1%	2%	3%
5	6%	1%	8%
6	9%	-5%	3%

Table 17: Operational cost variation from the Decomposition Results for Model 5A, 40% WWR

Climate zone	Services %	Façade %	Total %
2	-7%	-5%	-11%
5	-5%	-4%	-9%
6	-1%	-4%	-5%

Table 18: Construction cost variation from the Decomposition Results for Model 6B, 30% WWR

Climate zone	Services %	Façade %	Total %
2	1%	1%	2%
5	2%	2%	3%
6	3%	1%	4%

Table 19: Operational cost variation from the Decomposition Results for Model 6B, 30% WWR

Climate zone	Services %	Façade %	Total %
2	-7%	1%	-6%
5	-9%	1%	-8%
6	-7%	3%	-4%

Table 20: Construction cost variation from the Decomposition Results for Model 9aC, 30% WWR

Climate zone	Services %	Façade %	Total %
2	4%	-2%	2%
5	4%	1%	5%
6	7%	1%	8%

Table 21: Operational cost variation from the Decomposition Results for Model 9aC, 30% WWR

Climate zone	Services %	Façade %	Total %
2	-9%	-1%	-10%
5	-7%	1%	-7%
6	-4%	11%	7%

Table 22: Construction cost variation from the Decomposition Results for Model 9bH, 30% WWR

Climate zone	Services %	Façade %	Total %
2	5%	5%	11%
5	6%	4%	10%
6	4%	-1%	3%

Table 23: Operational cost variation from the Decomposition Results for Model 9bH, 30% WWR

Climate zone	Services %	Façade %	Total %
2	-21%	0%	-21%
5	-13%	2%	-11%
6	-17%	5%	-13%

Table 24: Benefit-cost results for the façade vs services analysis on Model 3A, 30% WWR

Region	Services	Facade
CZ2	39.0	12.2
CZ5	3.1	negative cost
CZ6	23.7	negative cost

Table 25: Benefit-cost results for the façade vs services analysis on Model 5A, 40% WWR

Region	Services	Facade
CZ2	11.1	3.6
CZ5	1.2	4.0
CZ6	0.1	negative cost

Table 26: Benefit-cost results for the façade vs services analysis for Model 6B, 30% WWR

Region	Services	Facade
CZ2	18.8	-2.6
CZ5	21.1	-1.9
CZ6	8.5	-9.8

Table 27: Benefit-cost results for the façade-services analysis on Model 9aC, 30% WWR

Region	Services	Facade
CZ2	2.8	negative cost
CZ5	1.8	-0.6
CZ6	0.5	-13.6

Table 28: Benefit-cost results for the façade-services analysis on Model 9bH, 30% WWR

Region	Services	Facade
CZ2	8.1	0.0
CZ5	3.9	-0.8
CZ6	7.6	negative cost

Conclusion

Despite the variations between building archetype and climate zone, the results show that, in almost all cases modelled, the proposed NCC2019 DTS provisions lead to reductions in a building's energy use, greenhouse gas emissions and operational costs. This is consistent with earlier modelling results and confirms that the proposals are sound. The small number of scenarios where worse performing outcomes are achieved are primarily explained by the changes in methodology for facades, which corrects over-stringency in the NCC2016 DTS glazing provisions.

1. Introduction

1.1 Overview

As a result of the numerous analyses already carried out as part of this Section J review, recommendations have been provided for a range of provisions relating to building efficiency. The main objective of the Section J revision is to harness higher building performance at lower energy costs and greenhouse gas emissions; through changes in methodology where appropriate. This modelling report establishes that a building based upon the individual NCC2019 stringencies performs greater than a NCC2016 provision and at a suitable benefit-cost trade-off.

1.2 Background

The provisions of Section J – Energy Efficiency were first introduced in 2006 and were last subject to major update in 2009. Energy Action were contracted to revise the current NCC Section J stringency provisions by the Australian Building Codes Board (ABCB) in late 2016. The new Deemed-to-Satisfy provisions were drafted through 2018 after extensive analysis and stakeholder discussion.

In addition to looking at energy benefit, the ABCB finalised the level of each DTS element to take into account:

- the ability of the market to provide product at the level suggested;
- whether provisions could be simplified to increase compliance;
- the need to maintain amenity and be consistent with other parts of the code;
- the need to increase design flexibility; and
- the need to address existing issues in NCC2016 correct any errors of over-stringency or perverse consequences in the 2016 NCC.

This means that, in some cases, the DTS levels were set at an efficiency level below that which was justified solely on energy efficiency grounds in earlier Energy Action reports.

This report demonstrates the simulation work used to test the effectiveness of the proposed provisions. The models can be grouped into two analyses: 2.1 – the impact of increased stringency and 2.2 – (decomposition) to separate the relative impact of the changes to compliance methodologies, services and façade contributions. The 2.1 scope sets out to estimate the impact the proposed NCC2019 measures have on overall energy use and emissions. The 2.2 scope was carried out in addition following feedback received through the Consultation Regulatory Impact Statement to investigate the relative proportion of change from the services and façade provisions.

2. Methodology

2.1 Overview

This section identifies the methodology used to estimate the impact of the proposed NCC2019 provisions on a range of building types and geometries. To obtain comparative energy consumption between NCC2016 and the proposed NCC2019 provisions, the following process was used:

1. NCC2016 baseline models were defined and dynamic thermal simulations were run.
2. NCC2019 test models were created making sure the proposed stringencies were met.
3. Models using the NCC2016 façade and NCC2019 services were created when necessary.

Further to this, a benefit-cost analysis was undertaken of the NCC2019 versus NCC2016 models to understand the holistic impacts of the proposed measures.

Five building class/form combinations were used in the analysis and their physical properties are given in Table 29 below. They include models 3A, 5A, 6B, 9aC and 9bH which represent hotel, office, retail, health care (clinic) and school classroom occupancies respectively.

Table 29: Building geometry details

Building	Conditioned Area (m^2)	Storeys	Occupancy Type	Floor Length (m)	Floor Depth (m)	Floor to Floor Height (m)	Ceiling Height (m)
Model 3A	9,000	10	Hotel	31.6	31.6	3.6	2.7
Model 5A	9,000	10	Office	31.6	31.6	3.6	2.7
Model 6B	1,800	3	Retail	36.5	18.3	3.6	2.7
Model 9aC	950	1	Health Care	31.6	31.6	6	4.8
Model 9bH	2,790	3	School	38.75*	30**	3	3

*Building total East-West dimensions
**Building total North-South dimensions

2.2 Geometries

Screenshots of the models used are given in Figure 1, Figure 2, Figure 3 and Figure 4 below. Note that model 3A and 5A share the same building geometry but differ in the external constructions and internal loads such as equipment, occupancy and lighting densities.

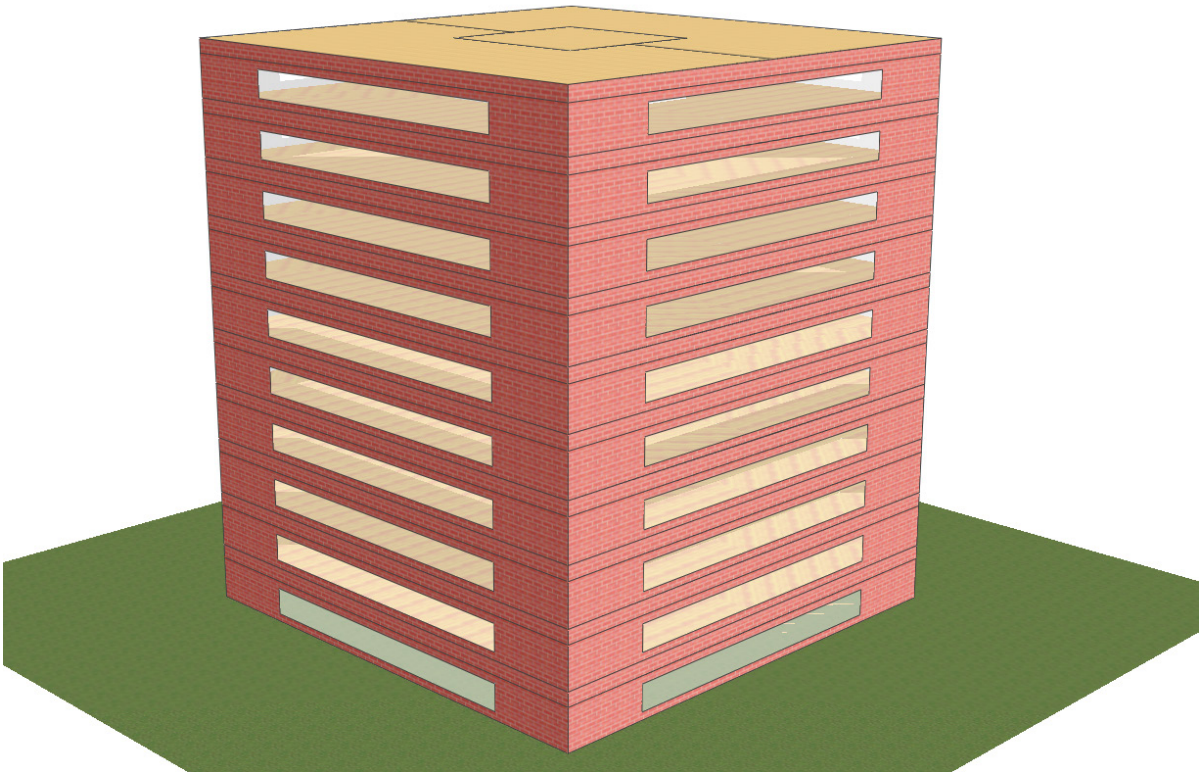

Figure 1: Model 3A and 5A as it sits with a NCC2019 compliant construction.

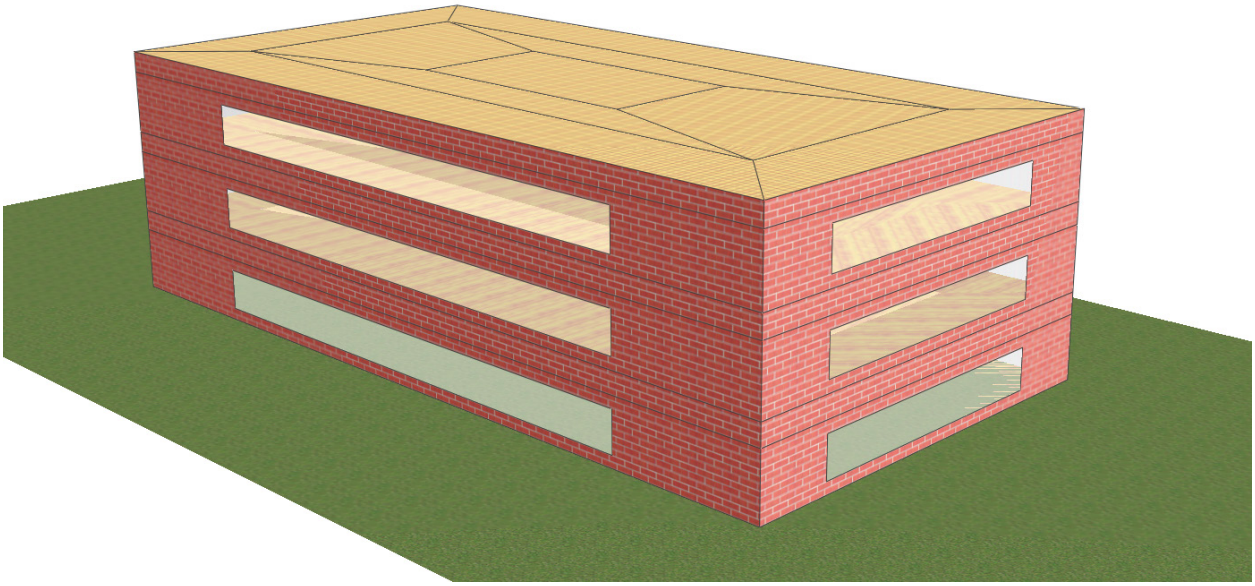

Figure 2: Model 6B as it sits with a NCC2019 compliant construction.

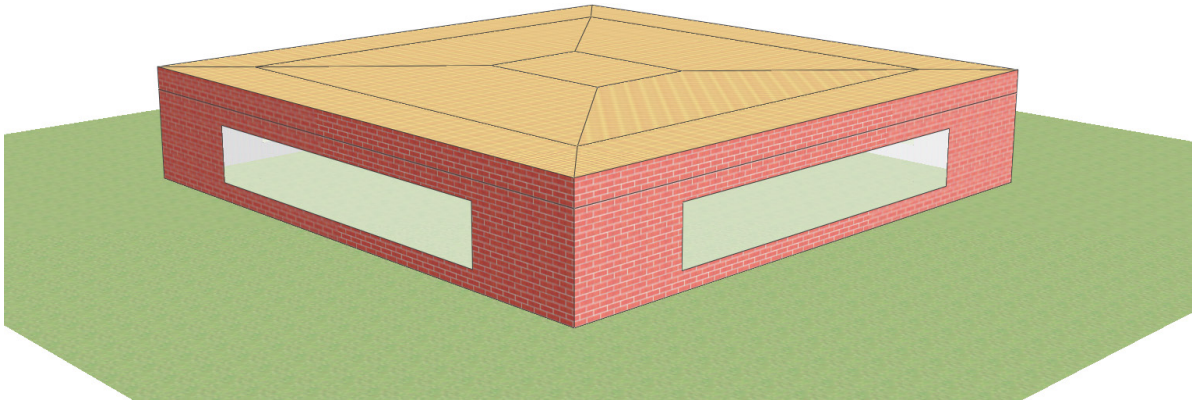

Figure 3: Model 9aC as it sits with a NCC2019 compliant construction.

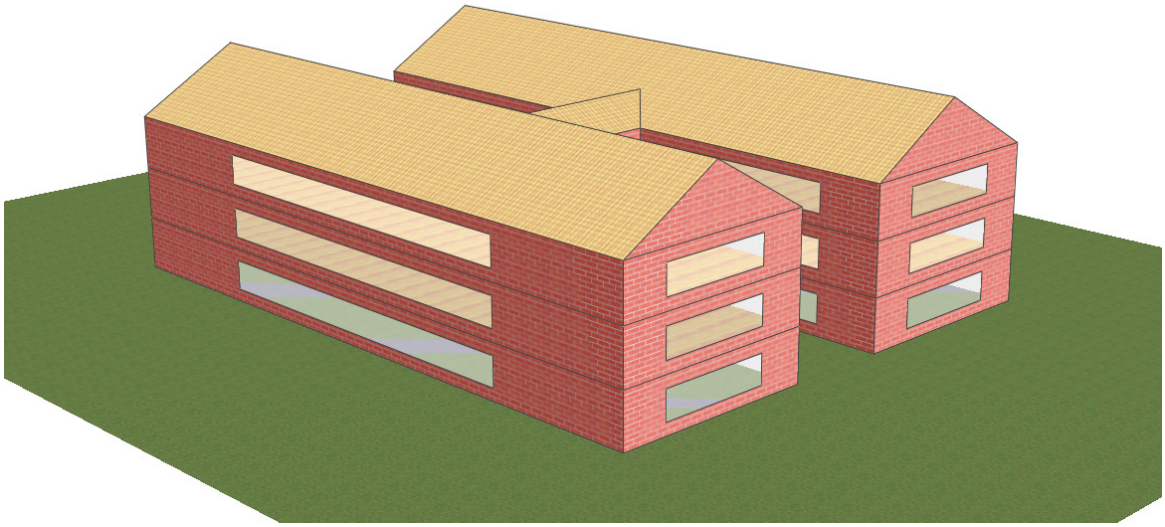

Figure 4: Model 9bH as it sits with a NCC2019 compliant construction.

2.3 Locations & Weather Files

The following centres and weather files were used to represent Australian climate zones 1 to 7 (climate zone 8 was omitted from the analysis due to its relatively low population and to reduce the computational time):

Table 30: Simulation weather file and location summary.

Climate zone	Centre	State/Territory	Weather File
1	Darwin	NT	AUS_NT.Darwin.941200_IWEC.epw
2	Brisbane	QLD	Brisbane_IWEC.fwt
3	Alice Springs	NT	AUS_ALICE-SPRINGS-AP_943260_IW2.EPW
4	Wagga Wagga	NSW	AUS_WAGGA-WAGGA-AMO_949100_IW2.EPW
5	Sydney	NSW	SydneyIWEC.fwt
6	Melbourne	VIC	MelbourneIWEC.fwt
7	Canberra	ACT	AUS_ACT.Canberra.949260_IWEC.epw

2.4 Modelling Scenarios

2.4.1 Impact of Increased Stringency on Daytime and Overnight Buildings

A combination of existing and new models were used in this section of final DTS RIS including:

Table 31: Scope 2.1 new simulations summary.

Model	WWR	NCC2016	NCC2019	Lighting
3A	30%	CZ1-CZ7	CZ1-CZ7	LED
5A	56%	CZ1-CZ7	CZ1-CZ7	LED
9aC	30%	CZ1-CZ7	CZ1-CZ7	LED

Table 32: Scope 2.1 existing simulations summary.

Model	WWR	NCC2016	NCC2019	Lighting
6B	30%	CZ1-CZ7	CZ1-CZ7	LED
5A	40%	CZ1-CZ7	CZ1-CZ7	LED
9bH	30%	CZ1-CZ7	CZ1-CZ7	LED

2.4.2 Façade vs Services Contribution on Daytime and Overnight Buildings

The second component to the final RIS includes the following simulations which use the NCC2016 façade and the NCC2019 services requirements to creating 'mixed' model provisions:

Table 33: Decomposition Results modelling summary.

Model	WWR	Façade	Services
3A	30%	NCC2016	NCC2019
5A	40%	NCC2016	NCC2019
6B	30%	NCC2016	NCC2019
9aC	30%	NCC2016	NCC2019
9bH	30%	NCC2016	NCC2019

3. Simulation Parameters

The core of this project has been a series of stringency studies undertaken around façade, lighting and HVAC systems. These processes are outlined below.

3.1 Building Envelope Provisions

NCC2016 specifies façade construction provisions on a separate wall construction and window construction basis. The wall construction must satisfy a minimum total R-Value as indicated in Figure 5. The window construction must separately pass stringent criteria identified in Part J2 of the NCC. One significant difference that the NCC2019 proposed provisions make is a reference to the entire façade U-Value on an aspect-by-aspect basis. Table 34 and Table 36 below presents the proposed stringency as simulated prior to mid-January 2018.

Deemed-to-Satisfy Provisions

Table J1.5a OPTIONS FOR EACH PART OF AN EXTERNAL WALL THAT IS PART OF AN ENVELOPE

Climate zone	Options
1, 2 and 3	(a) (i) Achieve a minimum *Total R-Value* of 3.3.
4, 5 and 6	(a) (i) Achieve a minimum *Total R-Value* of 2.8.
7	(a) Achieve a minimum *Total R-Value* of 2.8.
8	(a) Achieve a minimum *Total R-Value* of 3.8.

Figure 5: Current NCC2016 provisions regarding external wall minimum R-Values.

Table 34: Maximum U-Value used for the daytime operating buildings.

Climate zone	East	North	South	West
CZ1	2.0	2.0	2.0	2.0
CZ2	2.0	2.0	2.0	2.0
CZ3	2.0	2.0	2.0	2.0
CZ4	2.0	2.0	2.0	2.0
CZ5	2.0	2.0	2.0	2.0
CZ6	2.0	2.0	2.0	2.0
CZ7	2.0	2.0	2.0	2.0
CZ8	2.0	2.0	2.0	2.0

Table 35 Maximum SHGC x WWR used for the daytime operating buildings.

Climate zone	East	North	South	West
CZ1	0.12	0.12	0.12	0.12
CZ2	0.13	0.13	0.13	0.13
CZ3	0.16	0.16	0.16	0.16
CZ4	0.13	0.13	0.13	0.13

Climate zone	East	North	South	West
CZ5	0.13	0.13	0.13	0.13
CZ6	0.13	0.13	0.13	0.13
CZ7	0.13	0.13	0.13	0.13
CZ8	0.20	0.20	0.42	0.36

Table 36: Proposed maximum U-value stringency for NCC2019 overnight operating buildings.

Climate zone	East	North	South	West
CZ1	1.1	1.1	1.1	1.1
CZ2	2.0	2.0	2.0	2.0
CZ3	1.1	1.1	1.1	1.1
CZ4	1.1	1.1	1.1	1.1
CZ5	2.0	2.0	2.0	2.0
CZ6	1.1	1.1	1.1	1.1
CZ7	1.1	1.1	1.1	1.1
CZ8	0.9	0.9	0.9	0.9

Table 37: Proposed maximum SHGC x WWR stringency for NCC 2019 overnight operating buildings.

Climate zone	East	North	South	West
CZ1	0.07	0.07	0.10	0.07
CZ2	0.10	0.10	0.10	0.10
CZ3	0.07	0.07	0.07	0.07
CZ4	0.07	0.07	0.07	0.07
CZ5	0.10	0.10	0.10	0.10
CZ6	0.07	0.07	0.07	0.07
CZ7	0.07	0.07	0.08	0.07
CZ8	0.08	0.08	0.08	0.08

The proposed stringency for retail glazing (model 6B) is defined as follows:

Table 38: Proposed stringency for NCC2019 retail buildings showing glazing U-Value and SHGC requirements.

All Façades (East, North, South, West)	U_Total	SHGC x WWR
CZ1-CZ8	5.8	0.81

For façades with window to wall rations (WWRs) less than 20%, the wall construction minimum R-Value is 1.0 and for WWRs greater than 20%, the wall insulation requirement is as described in Table 39 below.

Table 39: Wall insulation R Value (m^2K/W) requirements for facades with a total glazing area less than 20%.

Climate zone	Daytime	Overnight
Climate zone 1	2.4	3.3
Climate zone 2	1.4	1.4
Climate zone 3	1.4	3.3

Climate zone	Daytime	Overnight
Climate zone 4	1.4	2.8
Climate zone 5	1.4	1.4
Climate zone 6	1.4	2.8
Climate zone 7	1.4	2.8
Climate zone 8	1.4	3.8

3.1.1 Wall Construction

The building envelope stringency proposed for 2019 is for entire building façades as mentioned previously. This contrast to current provisions on the building wall and window constructions has a twofold benefit; minimising the issue with heat loss through poor performing window/wall combinations and greater design flexibility with window/wall combinations. The WWR used for both the NCC2016 and NCC2019 models were kept the constant. Table 40 presents the required wall total R-Value (and U-Value) as required for the NCC2016 models.

Table 40: Wall construction targets used in the NCC2016 simulations as per the NCC requirements.

Climate zone	Total R-Value (m^2K/W)	U-Value (W/m^2K)
1-3	3.3	0.303
4-7	2.8	0.357
8	3.8	0.263

3.1.2 Glazing Construction

The glazing construction used in the NCC2016 compliant cases generally varied for each façade and model. The glazing construction used in the NCC2019 cases was kept, where possible, the same for each façade across the four core class/building form combinations. It should be noted that we have selected the cheapest glazing which complies with the code provision (for NCC2016 and NCC2019 models) using our selection database.

The glazing constructions for NCC2019 simulation models took the following process:

1. When a 30% WWR, for example, was selected for a NCC2019 model, the glass SHGC value was determined by dividing the SHGC x WWR provision by the WWR value. For a north facing, daytime operating façade in climate zone 3, the maximum SHGC value works out as:

$$SHGC = \frac{SHGC * WWR}{WWR} = \frac{0.16}{0.30} = 0.5\dot{3}$$

2. Any glass construction with a SHGC value of less than $0.5\dot{3}$ can be chosen and within the window of compliance.

3. The minimum total U-Value of the wall required to achieve a façade U-Value defined by the stringency was then calculated using the U-Value associated with the selected glass. For a north facing, daytime operating façade in climate zone 3 using a window with U-Value of 2.998, the maximum wall U-Value works out to be:

$$U_{wall} = \frac{U_{facade} - U_{window} * WWR_{window}}{1 - WWR_{wall}}$$

$$U_{wall} = \frac{2.0 - 2.998 * 0.30}{1 - 0.30} = 1.577$$

This result requires the maximum U-Value of 1.0 rule from section 3.1 above to be enforced. To satisfy the NCC2019 provisions, both the required U-Value and SHGC x WWR values must be met whilst ensuring a 5% daylight factor is additionally achieved.

3.1.3 Roof Construction

The roof construction and insulation levels for NCC2019 models remained the same as NCC2016. The external solar absorptance of the NCC2019 roof construction was lowered from 0.7 in NCC2016 models to 0.4 for climate zones 1-7. Climate zone 8 was left with a solar absorptance of 0.7 to retain solar gain. This change should reflect the selection of lighter coloured roofing material during construction.

3.1.4 Floor Construction

The floor construction for NCC2019 models remained the same as NCC2016.

3.2 HVAC Equipment

3.2.1 Chillers

Water cooled chillers with variable speed drive controlled compressors were used in the IES <VE> core modelling for each climate zone. Air-cooled chillers were used for Class 9bH. The in-built water cooled chiller curves in IES were adjusted to match the COP requirement of NCC 2016 and NCC 2019.

Table 41: Water cooled chiller performance requirements for NCC 2016 stringencies

Chiller Capacity (kW)	Rated COP	IPLV
<350	4.2	5.2
>350	MEPS	MEPS

Table 42: Water cooled chiller performance requirements for NCC 2019 stringencies

Chiller Capacity (kW)	Rated COP	IPLV
<528	5.771	6.401

Chiller Capacity (kW)	Rated COP	IPLV
>528 & <1055	5.771	6.401

Table 43: Air cooled chiller performance requirements for NCC 2016 stringencies

Chiller Capacity (kW)	Rated COP	IPLV
<350	2.5	3.4
>350	MEPS	MEPS

Table 44: Air cooled chiller performance requirements for NCC 2019 stringencies

Chiller Capacity (kW)	Rated COP	IPLV
<528	2.985	4.048
>528 & <1055	2.985	4.137

The in-built chiller performance curve takes into account the COP variation which is dependent on the part-load, entering condenser water temperature and chilled water temperature. The chilled water temperature was linearly reset from 6°C to 10°C when the outside air dry bulb drops from 25°C to 10°C. The chilled water pump, condenser water pump and cooling tower fan was sized based on NCC requirements. Figure 6 shows an example chilled water loop.

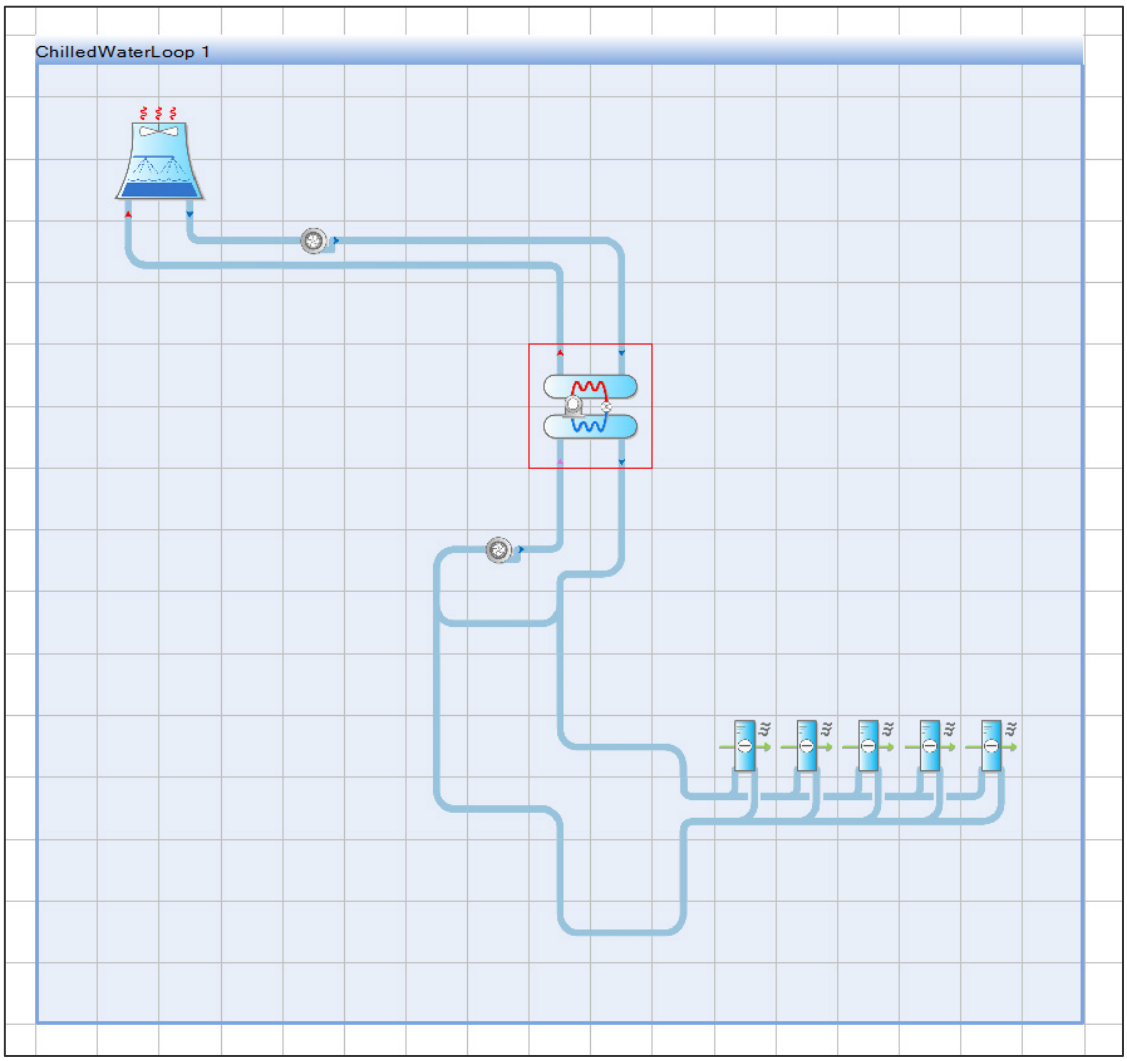

Figure 6: Chilled water loop example showing chiller (centre) cooling tower (top) and cooling coils (bottom).

3.2.2 Boilers

Non-condensing boilers were modelled for the NCC2016 DTS. Heating hot water supply/return temperature was modelled at 80/60 °C with a rated boiler efficiency of 80%.

Condensing boilers were modelled for NCC2019 DTS simulations. The heating hot water temperature reset was modelled to be 80°C when the outside dry bulb is 4°C above design heating temperature, 60°C when the outside dry bulb is 14°C above design heating temperature and linear in between. The rated gross boiler efficiency was modelled to be 90%[5]. Figure 7 shows an example hot water loop used in the simulations.

[5] The efficiency of condensing boilers ranges from about 90% up to 98% or greater.

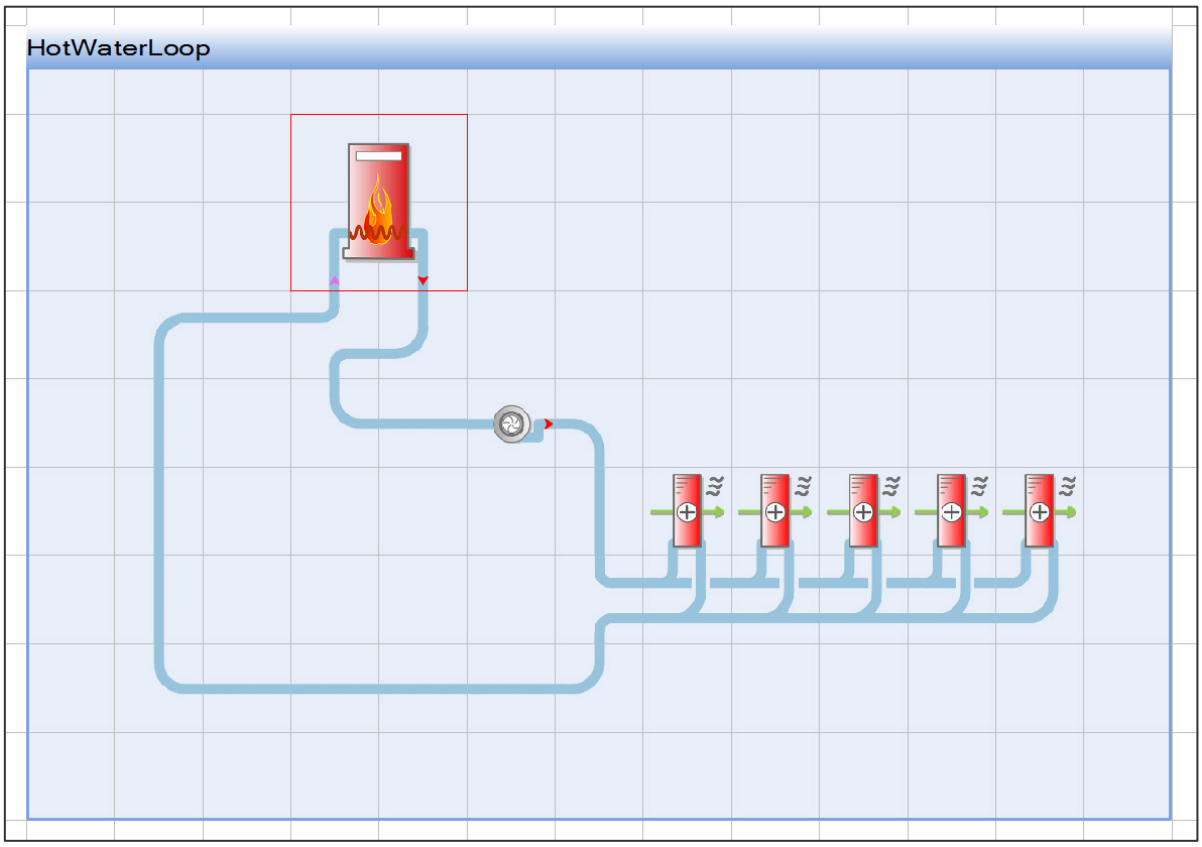

Figure 7: Hot water loop example used in NCC2019 models.

3.2.3 Cooling Towers

Open circuit, induced draft cooling towers were used in both NCC2016 and NCC2019 simulations. The capacity of the cooling towers changed between NCC2016 and NCC2019 as a result of different internal building loads. NCC2016 compliant cooling towers used a different stringency basis to the proposed NCC2019 version. The provision our target cooling tower type was based upon a 310 W maximum fan motor power per L/s of circulated cooling fluid. The NCC2019 stringency set a maximum fan power per kW cooling capacity of 10.4 W/kW.

3.2.4 Air Handling Units & Fan Coil Units

AHUs were used in model 5A and 9aC buildings with 3A, 9bH and 6B models. The AHU and FCU fan power were set up as per the NCC standards. Control parameters were identical for NCC2016 and NCC2019 models. The zone set point was modelled to be 22.5°C with 1°C dead band and 1°C proportional band either side. The cooling supply air temperature was reset from 12°C to 22.5°C when the average zone temperature changes from 24°C to 23°C. The heating supply air temperature was reset from 30°C to 22.5°C when the average zone temperature changes from 21°C to 22°C. The VAV turndown was modelled at 50% for centre zones and 30% for perimeter zones. The FCU was modelled as a constant volume system.

3.2.5 Economy Cycle

An economy cycle was incorporated into the HVAC models where required by NCC2016 and the NCC2019 proposed stringency. Table 45 details the economy cycle analysis and subsequent DTS recommendations used in the NCC2019 simulations. The major change variation between the two stringencies is that the NCC2019 provisions are more relaxed; an economy cycle is not required for climate zones 1-3 and generally for HVAC systems with larger capacities. A dry bulb economy cycle was modelled which mixes the return air and outside air to achieve the desired supply air set point. A dry bulb lockout of 24°C and dew point lockout of 14°C was used. AHU supply air was delivered to the zones via VAV boxes.

Table 45: Economy cycle provisions used in the NCC2019 DTS modelling update.

Region	Total Air Flow Requiring an Economy Cycle (L/s)
Climate zones 1-3	-
Climate zone 4	5,500
Climate zone 5	3,500
Climate zone 6	2,500
Climate zone 7	3,000
Climate zone 8	7,500

3.2.6 Outside Air (Heat Exchanger or CO_2 Control)

CO_2 control was used in the building simulations where instructed by NCC2016 and NCC2019 proposed stringencies. The NCC2019 provisions are based upon a climate zone specified AHU flow rate as seen in Table 46 below. The CO_2 control proportionally varies the outside air supply based on CO_2 readings for each floor of the building. CO_2 levels are controlled between 700 and 900 ppm using 50% outside air as supply at the lower value and 100% outside air used as supply for the higher level. A heat exchanger was used where appropriate for 3A models according to the NCC2019 stringency.

Table 46: NCC2019 outside air provisions used for the DTS modelling update.

Region	HX / CO_2	Outside Air Flow
Climate zone 1	CO_2	>500 L/s
Climate zone 2	Not Required	Not Required
Climate zone 3	CO_2	>1,000 L/s
Climate zone 4	HX or CO_2	>500 L/s
Climate zone 5	HX or CO_2	>1,000 L/s
Climate zone 6	HX or CO_2	>500 L/s
Climate zone 7	HX or CO_2	>250 L/s
Climate zone 8	HX or CO_2	>250 L/s

3.3 Lighting

The incremental costs and energy savings for lighting were excluded from the RIS modelling. This is because the use of efficient lighting technologies to the level proposed by DtS 2019 regulation is already considered to be generally representative of industry practice. That is, industry is already at or exceeds the levels set in 2019 for lighting. The lighting heat gain applied to the simulation models is as given in Table 47. NCC2019 has approximately half the internal heat gain from lighting compared to NCC2016 as a result of the recommended reduction in IPD from the Section J revision.

Table 47: LED internal heat gain for both NCC 2016 and NCC 2019 for the simulations based on lighting loads.

Building Class/Form	IPD (W/m^2)
3A	2.5
5A	4.5
6B	16
9aC	4.5
9bH	4.5

This heat gain is split 50%/50% to the air conditioned zone being served by the lighting and the ceiling space above the light (unconditioned) for all models with plenums. For 9bH, the IPD is provided entirely to the conditioned space.

3.4 Lifts

Lift energy was not modelled with the simulation software. The same energy consumption for NCC2019 and NCC2016 models were applied as a spreadsheet exercise, removing lift energy improvements from the cost benefit analysis. While minimum energy efficiency standards are being proposed for lifts for the first time, the proposed minimum standard is below current industry practice, similar to lighting technologies.

4. Simulation Results

4.1 Impact of Increased Stringency (Scope 2.1) Simulation Results

The dynamic thermal simulations performed in IES <VE> show that a significant reduction in annual energy consumption can be attributed to a tightening in NCC provisions. The degree of reduction in energy consumption is dependent on building type, building construction and climate zone. Table 48 through Table 53 present the annual energy savings of the NCC2019 models compared to NCC2016 along with the reduction in energy expressed as a percentage. A breakdown of the energy consumption (gas and electricity) for the various sub-systems present in each of the models is presented in Appendix B.

Table 48: Annual energy consumption from new simulation for Model 3A, 30% WWR

Climate zone	NCC 2016 (MWh)	NCC 2019 (MWh)	Difference (MWh)	Difference (%)
Climate zone 1	1035.10	933.55	-101.56	-10%
Climate zone 2	942.75	724.45	-218.31	-23%
Climate zone 3	869.37	703.23	-166.14	-19%
Climate zone 4	823.58	623.70	-199.88	-24%
Climate zone 5	854.99	676.87	-178.13	-21%
Climate zone 6	810.93	610.60	-200.33	-25%
Climate zone 7	797.79	608.35	-189.44	-24%

Table 49: Annual energy consumption from new simulation for Model 9aC, 30% WWR

Climate zone	NCC 2016 (MWh)	NCC 2019 (MWh)	Difference (MWh)	Difference (%)
Climate zone 1	100.00	79.32	-20.68	-21%
Climate zone 2	61.20	49.77	-11.44	-19%
Climate zone 3	79.32	63.28	-16.03	-20%
Climate zone 4	67.36	59.17	-8.20	-12%
Climate zone 5	53.92	45.88	-8.03	-15%
Climate zone 6	54.11	57.86	3.75	7%
Climate zone 7	62.18	63.89	1.71	3%

Table 50: Annual energy consumption from new simulation for Model 5A, 56% WWR

Climate zone	NCC 2016 (MWh)	NCC 2019 (MWh)	Difference (MWh)	Difference (%)
Climate zone 1	684.18	635.54	-48.64	-7%
Climate zone 2	552.77	494.62	-58.15	-11%
Climate zone 3	544.07	505.96	-38.12	-7%
Climate zone 4	445.43	413.26	-32.17	-7%
Climate zone 5	477.42	418.96	-58.46	-12%
Climate zone 6	420.46	389.91	-30.55	-7%

Climate zone	NCC 2016 (MWh)	NCC 2019 (MWh)	Difference (MWh)	Difference (%)
Climate zone 7	410.65	392.89	-17.75	-4%

Table 51: Annual energy consumption from existing simulation for Model 6B, 30% WWR

Climate zone	NCC 2016 (MWh)	NCC 2019 (MWh)	Difference (MWh)	Difference (%)
Climate zone 1	440.71	392.22	-48.49	-11%
Climate zone 2	320.05	285.50	-34.55	-11%
Climate zone 3	384.32	337.52	-46.80	-12%
Climate zone 4	383.06	355.23	-27.82	-7%
Climate zone 5	346.01	302.60	-43.41	-13%
Climate zone 6	364.81	352.51	-12.29	-3%
Climate zone 7	365.59	354.54	-11.05	-3%

Table 52: Annual energy consumption from existing simulation for Model 9bH, 30% WWR

Climate zone	NCC 2016 (MWh)	NCC 2019 (MWh)	Difference (MWh)	Difference (%)
Climate zone 1	530.50	393.57	-136.92	-26%
Climate zone 2	294.59	209.43	-85.15	-29%
Climate zone 3	415.81	320.24	-95.57	-23%
Climate zone 4	355.05	274.08	-80.97	-23%
Climate zone 5	243.36	188.58	-54.78	-23%
Climate zone 6	333.39	257.19	-76.20	-23%
Climate zone 7	427.97	337.96	-90.01	-21%

Table 53: Annual energy consumption from existing simulation for Model 5A, 40% WWR

Climate zone	NCC 2016 (MWh)	NCC 2019 (MWh)	Difference (MWh)	Difference (%)
Climate zone 1	686.98	620.40	-66.58	-10%
Climate zone 2	564.49	487.41	-77.09	-14%
Climate zone 3	558.94	515.36	-43.59	-8%
Climate zone 4	463.19	405.29	-57.89	-12%
Climate zone 5	492.97	416.26	-76.70	-16%
Climate zone 6	421.16	369.07	-52.10	-12%
Climate zone 7	443.97	386.49	-57.49	-13%

On the whole, the interpretation of these results are positive and support the proposed change in stringency. The less favourable energy reductions for small buildings in cooler climates in the above tables is likely attributable to a slightly less stringent façade U-Value modelled in the NCC2019 simulations, for this specific building archetype, compared to NCC2016. A higher façade U-Value allows for greater heat transfer, which can lead to a reduction in cooling energy when the outside air temperature is lower than the inside air temperature. Climate zones which are not cooling dominated, such as 6 and 7, do not respond to the U-Value changes in the same manner and the net result is a slight increase in the annual energy consumption. While earlier iterations of these proposals did have more stringent U-values in climate zones 6, 7 and 8, these were increased post-consultation as there were concerns about the ability of small buildings to comply with Part F4 requirements (that is, minimum window size requirements). There is also an issue with 2016 values being over-stringent. In many of the models of small buildings in cooler climates, no 2016 DTS compliant windows were available (see EA Glazing report REP07830-B-002). This suggests that the current 2016 DTS levels are impractical and needed to be revised, but also explains why the models produce worse results in these circumstances.

The issue with over-stringency of display glazing provisions in 2016 must also be considered. Compliant Retail Display Glazing (common in Class 6 buildings) windows were hard to find or required customised glazing in certain cooler climates – specifically as display glazing with high WWR in cooler climates and small buildings. This is because the glazing not only needed to meet U-value and SHGC requirements, but also needed to be clear (or, low VLT) in order to be fit-for-purpose.

Further, in this instance the 6B building modelled has a high surface-to-volume ratio, which accentuates the importance of installing glazing with low U-value and SHGC, particularly in climate zones located in the extremities of Australian climate. This is because the modelled building has a higher medium of heat transfer (surface area) between the unconditioned ambient conditions and conditioned internal building conditions. Buildings with a low surface-to-volume ratio have been shown to produce more efficient buildings. In the Class 6B model in climate zone 7, a slightly higher peak heating load in 2019 affects the required fan coil unit capacity, increasing the annual fan energy consumption. Comparing the energy consumption for the new and existing simulations across all climate zones produces the following plots below:

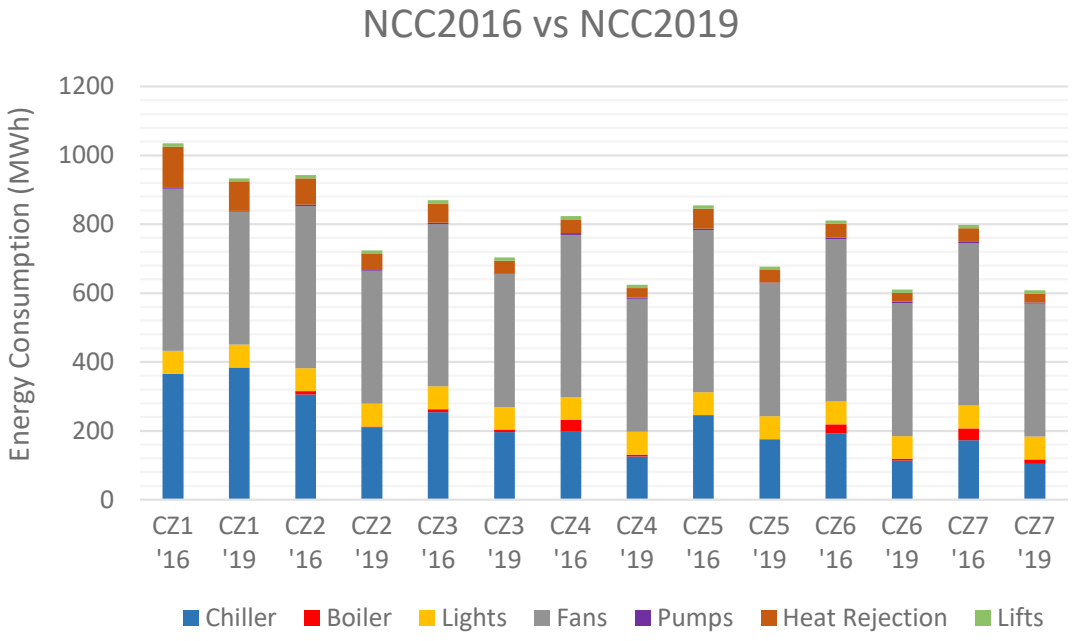

Figure 8: Comparison of annual energy consumption for model 3A 30% WWR.

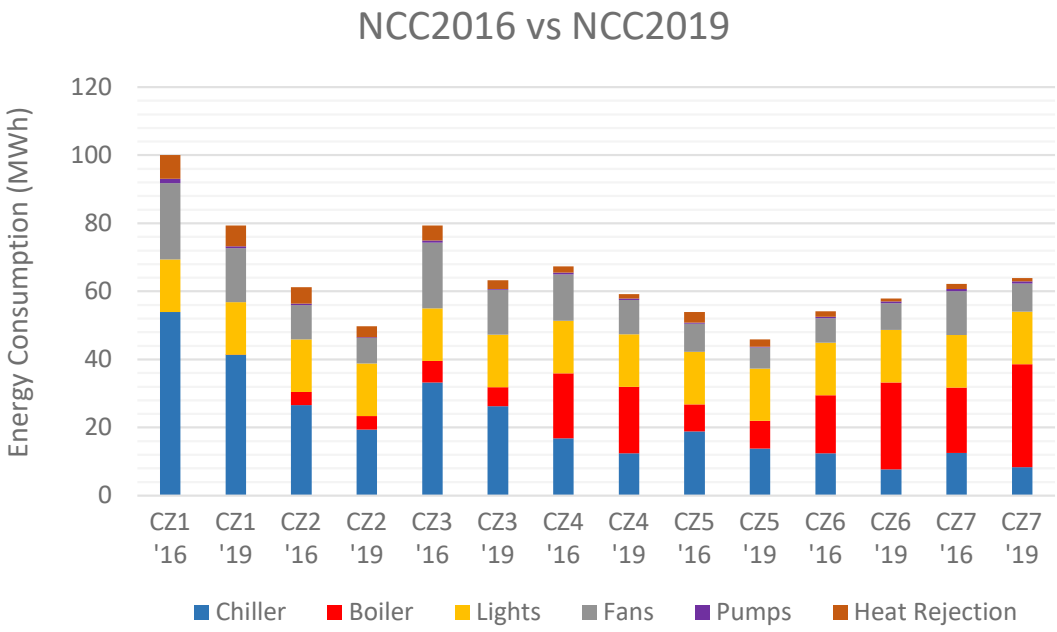

Figure 9: Comparison of annual energy consumption for model 9aC 30% WWR.

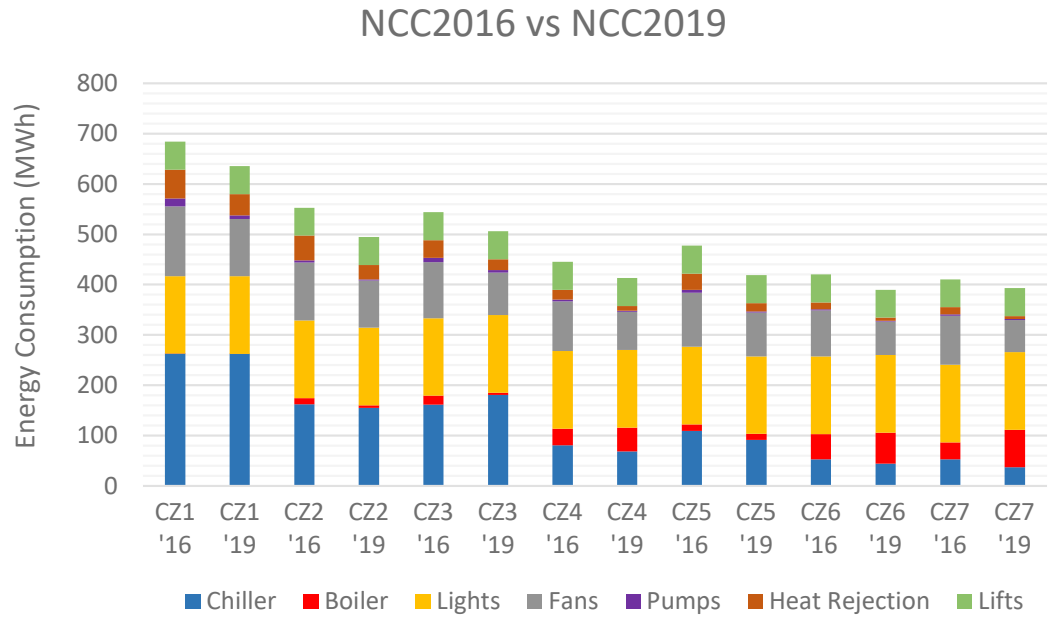

Figure 10: Comparison of annual energy consumption for model 5A 56% WWR.

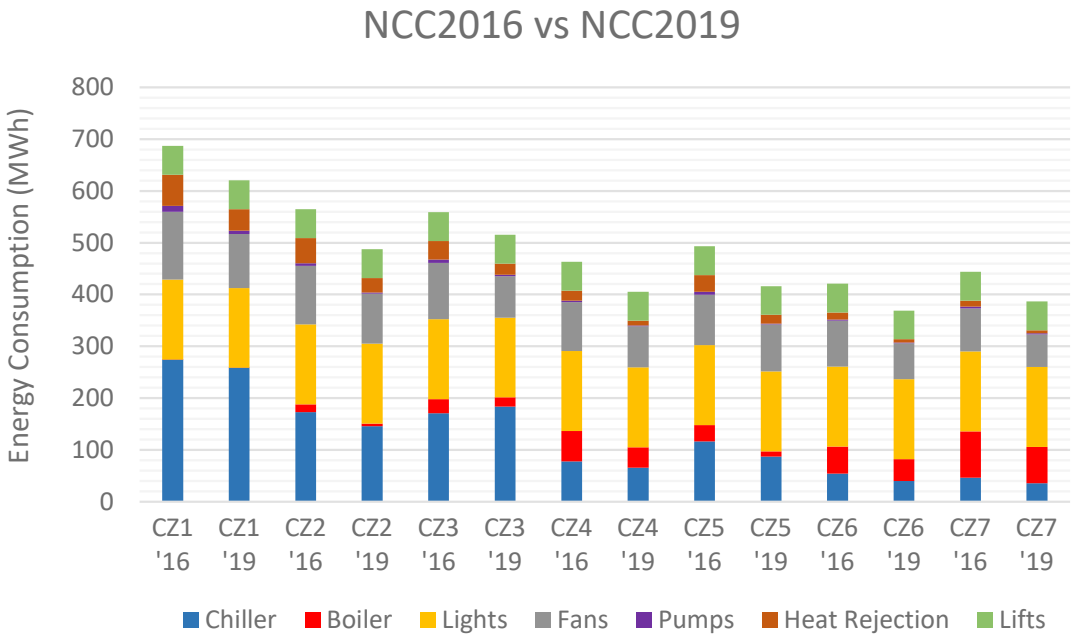

Figure 11: Comparison of annual energy consumption for model 5A 40% WWR.

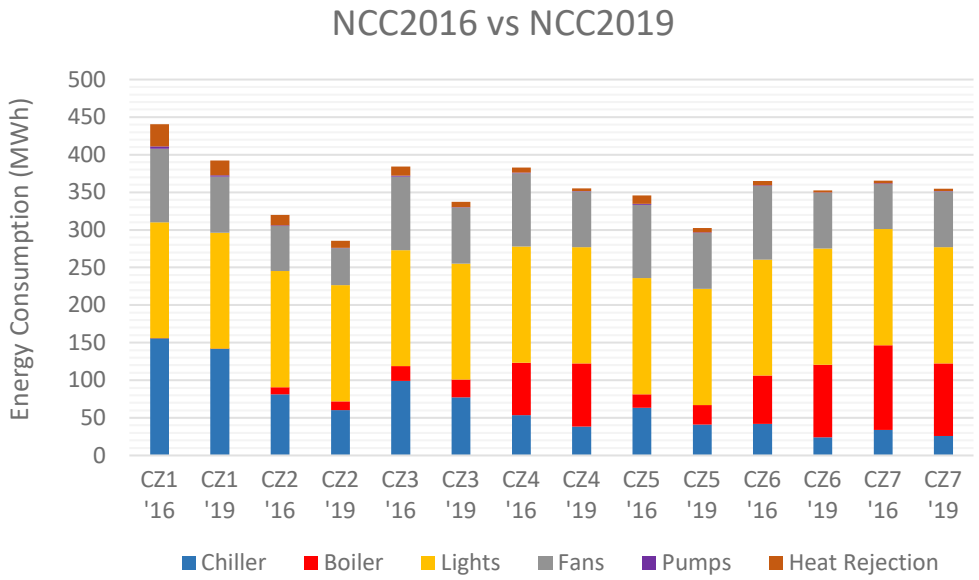

Figure 12: Comparison of annual energy consumption for model 6B 30% WWR.

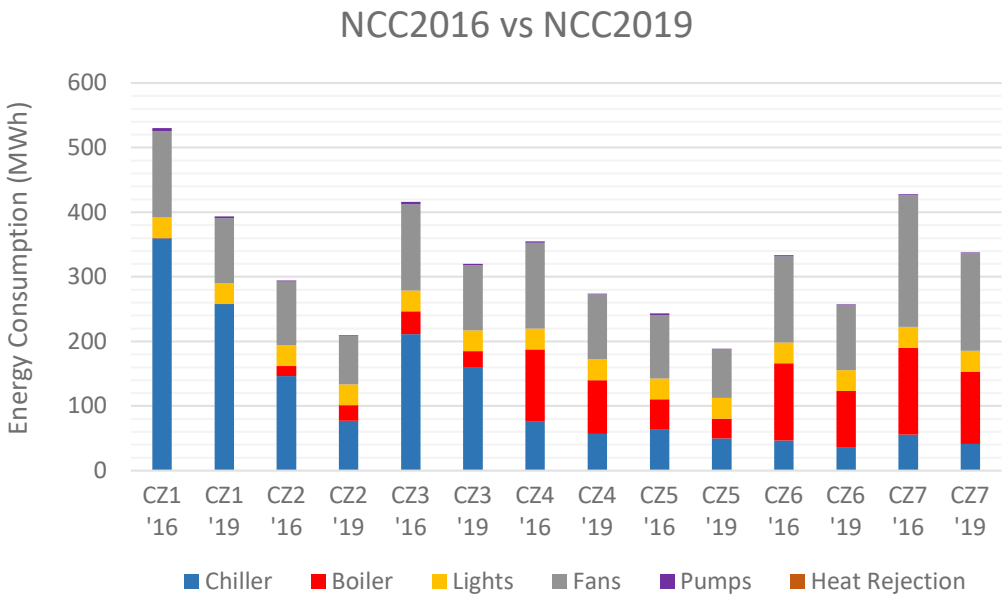

Figure 13: Comparison of annual energy consumption for model 9bH 30% WWR.

The net change in annual energy for all models in all climate zones ranges between a 29% reduction (CZ2 building 9bH) and a 7% increase (CZ6 building 9aC). Expressing the reduction in terms of greenhouse gas emissions gives an idea of the scale of impact possible with the new DTS provisions. Table 54 below presents the conversion values used to translate the annual energy consumption to greenhouse gas equivalent emissions for all models.

Table 54: Values used to convert energy consumption to equivalent GHG emissions.

Region	Electricity (kg CO_2 eq/kWh)	Gas (kg CO_2 eq/GJ)
CZ1 / NT	0.73	0.1855
CZ2 / QLD	0.93	0.2168
CZ3 / NT	0.73	0.1855
CZ4 / NSW	0.95	0.2316
CZ5 / NSW	0.95	0.2316
CZ6 / VIC	1.18	0.1995
CZ7 / ACT	0.95	0.2316

Table 55 through Table 60 present the change in annual greenhouse gas emissions for all models and climate zones. There is a significant reduction in kg CO_2 equivalent emissions across the range of simulations, validating the proposed DTS provisions.

Table 55: Annual greenhouse gas emissions expressed in equivalent kg CO_2 for the newly simulated Model 3A, 30% WWR

Climate zone	NCC 2016	NCC 2019	Difference (%)
Climate zone 1	755,626	681,488	-10%
Climate zone 2	867,712	670,412	-23%
Climate zone 3	628,689	508,055	-19%
Climate zone 4	749,487	587,217	-22%
Climate zone 5	810,065	641,655	-21%
Climate zone 6	926,617	714,543	-23%
Climate zone 7	724,991	565,314	-22%

Table 56: Annual greenhouse gas emissions expressed in equivalent kg CO_2 for the newly simulated Model 9aC, 30% WWR

Climate zone	NCC 2016	NCC 2019	Difference (%)
Climate zone 1	73,000	57,898	-21%
Climate zone 2	53,332	42,505	-20%
Climate zone 3	53,254	42,087	-21%
Climate zone 4	45,872	37,686	-18%
Climate zone 5	43,678	35,918	-18%
Climate zone 6	43,719	38,240	-13%
Climate zone 7	40,849	32,017	-22%

Table 57: Annual greenhouse gas emissions expressed in equivalent kg CO_2 for the newly simulated Model 5A, 56% WWR

Climate zone	NCC 2016	NCC 2019	Difference (%)
Climate zone 1	499,448	463,934	-7%
Climate zone 2	502,590	455,275	-9%
Climate zone 3	384,284	366,359	-5%
Climate zone 4	391,798	348,267	-11%
Climate zone 5	441,104	387,044	-12%
Climate zone 6	436,869	387,503	-11%
Climate zone 7	358,508	302,647	-16%

Table 58: Annual greenhouse gas emissions expressed in equivalent kg CO_2 for the existing Model 6B, 30% WWR

Climate zone	NCC 2016	NCC 2019	Difference (%)
Climate zone 1	321,716	286,295	-11%
Climate zone 2	288,884	254,700	-12%
Climate zone 3	266,270	229,241	-14%
Climate zone 4	297,920	257,565	-14%
Climate zone 5	311,764	262,935	-16%
Climate zone 6	354,653	302,220	-15%
Climate zone 7	240,424	245,388	2%

Table 59: Annual greenhouse gas emissions expressed in equivalent kg CO_2 for the existing Model 9bH, 30% WWR

Climate zone	NCC 2016	NCC 2019	Difference (%)
Climate zone 1	387,058	287,252	-26%
Climate zone 2	259,454	172,402	-34%
Climate zone 3	277,921	215,082	-23%
Climate zone 4	231,885	181,112	-22%
Climate zone 5	187,610	150,309	-20%
Climate zone 6	252,243	200,726	-20%
Climate zone 7	279,206	214,845	-23%

Table 60: Annual greenhouse gas emissions expressed in equivalent kg CO_2 for the existing Model 5A, 40% WWR

Climate zone	NCC 2016	NCC 2019	Difference (%)
Climate zone 1	501,480	452,885	-10%
Climate zone 2	511,193	448,900	-12%
Climate zone 3	388,505	363,247	-7%
Climate zone 4	384,179	347,705	-9%
Climate zone 5	438,357	385,920	-12%
Climate zone 6	435,208	385,985	-11%

Climate zone	NCC 2016	NCC 2019	Difference (%)
Climate zone 7	336,634	300,602	-11%

4.2 Façade vs Services Contribution (Decomposition Results) Simulation Results

The annual energy comparison for the façade vs services analysis is given below for climate zones 2, 5 and 6. The total percentage compares the NCC2019 model energy with the NCC2016 using a façade construction according to NCC2016 and the services according to NCC2019 provisions.

$$Mixed\ Model - NCC2016 = Services\ Contribution$$

$$NCC2019 - Mixed\ Model = Façade\ Contribution$$

The results effectively show the relative contributions of updates on the façade and services sections of the code to stringency isolated from the impact of the effect of the methodology changes.

Table 61: Energy summary for the 'mixed' model scenarios – 3A 30% WWR with LED lighting.

Model 3A	NCC2016	Mixed	NCC2019	Services %	Façade %	Total %
Climate zone 2	942.75	777.30	724.45	-18%	-7%	-23%
Climate zone 5	854.99	708.98	676.87	-17%	-5%	-21%
Climate zone 6	810.93	622.34	610.60	-23%	-2%	-25%

Table 62: Energy summary for the 'mixed' model scenarios – 5A 40% WWR with LED lighting.

Model 5A	NCC2016	Mixed	NCC2019	Services %	Façade %	Total %
Climate zone 2	564.49	506.31	487.41	-10%	-4%	-14%
Climate zone 5	492.97	429.94	416.26	-13%	-3%	-16%
Climate zone 6	421.16	391.48	369.07	-7%	-6%	-12%

Table 63: Energy summary for the 'mixed' model scenarios – 6B 30% WWR with LED lighting.

Model 6B	NCC2016	Mixed	NCC2019	Services %	Façade %	Total %
Climate zone 2	320.05	281.27	285.50	-12%	2%	-11%
Climate zone 5	346.01	294.70	302.60	-15%	3%	-13%
Climate zone 6	364.81	319.65	352.51	-12%	10%	-3%

Table 64: Energy summary for the 'mixed' model scenarios – 9aC 30% WWR with LED lighting.

Model 9aC	NCC2016	Mixed	NCC2019	Services %	Façade %	Total %
Climate zone 2	61.20	50.55	49.77	-17%	-2%	-19%
Climate zone 5	53.92	45.62	45.88	-15%	1%	-15%
Climate zone 6	54.11	46.53	57.86	-14%	24%	7%

Table 65: Energy summary for the 'mixed' model scenarios – 9bH 30% WWR with LED lighting.

Model 9bH	NCC2016	Mixed	NCC2019	Services %	Façade %	Total %
Climate zone 2	294.59	209.13	209.43	-29%	0%	-29%
Climate zone 5	243.36	181.10	188.58	-26%	4%	-23%
Climate zone 6	333.39	231.10	257.19	-31%	11%	-23%

The following tables compare the services vs façade contribution in terms of greenhouse gas emissions using the emissions factors from section 4.1 above.

Table 66: GHG summary for the 'mixed' model scenarios – 3A 30% WWR with LED lighting.

Model 3A	NCC2016	Mixed	NCC2019	Services %	Façade %	Total %
Climate zone 2	867,712	711,480	670,412	-18%	-6%	-23%
Climate zone 5	810,065	665,398	641,655	-18%	-4%	-21%
Climate zone 6	926,617	722,804	714,543	-22%	-1%	-23%

Table 67: GHG summary for the 'mixed' model scenarios – 5A 40% WWR with LED lighting.

Model 5A	NCC2016	Mixed	NCC2019	Services %	Façade %	Total %
Climate zone 2	511,193	460,411	448,900	-10%	-3%	-12%
Climate zone 5	438,357	384,312	385,920	-12%	0%	-12%
Climate zone 6	435,208	392,715	385,985	-10%	-2%	-11%

Table 68: GHG summary for the 'mixed' model scenarios – 6B 30% WWR with LED lighting.

Model 6B	NCC2016	Mixed	NCC2019	Services %	Façade %	Total %
Climate zone 2	288,884	253,719	254,700	-12%	0%	-12%
Climate zone 5	311,764	262,847	262,935	-16%	0%	-16%
Climate zone 6	354,653	303,491	302,220	-14%	0%	-15%

Table 69: GHG summary for the 'mixed' model scenarios – 9aC 30% WWR with LED lighting.

Model 9aC	NCC2016	Mixed	NCC2019	Services %	Façade %	Total %
Climate zone 2	53,332	43,651	42,505	-18%	-3%	-20%
Climate zone 5	43,678	36,439	35,918	-17%	-1%	-18%
Climate zone 6	43,719	35,571	38,240	-19%	8%	-13%

Table 70: GHG summary for the 'mixed' model scenarios – 9bH 30% WWR with LED lighting.

Model 9bH	NCC2016	Mixed	NCC2019	Services %	Façade %	Total %
Climate zone 2	259,454	180,572	172,402	-30%	-5%	-34%
Climate zone 5	187,610	150,787	150,309	-20%	0%	-20%

Model 9bH	NCC2016	Mixed	NCC2019	Services %	Façade %	Total %
Climate zone 6	252,243	201,031	200,726	-20%	0%	-20%

5. Benefit-Cost Methodology

The benefit-cost analysis compares the four NCC2016 compliant buildings with equivalent NCC2019 buildings set to the proposed provisions. The lifetime of the building envelope was set to 40 years with a discount rate of 7%. The lifetime of individual pieces of equipment were often much less than 40 years, meaning their replacement needed to be considered over the 40 year period.

5.1 Pricing Overview

The benefit cost analysis requires use of either the incremental cost between NCC2019 and NCC2016 constructions if it is known, or the total price of the constructions, which enables the incremental cost to be calculated.

Three costs are required in order to carry out a benefit cost analysis:

1. A construction cost or the capital expenditure for the building.
2. Operational costs associated with energy consumption.
3. Operational costs that don't include energy consumption i.e. maintenance and replacing equipment.

The benefit cost ratio can be expressed in the following relationship:

$$Benefit\ Cost\ Ratio = \frac{-\ Incremental\ Operational\ Cost}{Incremental\ Construction\ Cost}$$

Three main results are expected from the benefit cost ratio analysis; 'Negative Cost' will be displayed when the incremental construction cost between NCC2019 and NCC2016 is negative. A result between zero and one identifies a situation that is beneficial on an energy basis, but not economically viable over the lifetime of the analysis. A result greater than one identifies a scenario that is both economically viable and has a positive impact on energy performance.

5.2 System Pricing

5.2.1 Building Envelope

5.2.1.1 Wall Construction

The wall construction cost is based on pricing obtained for glass wool batts and framing board products. The framing board insulation was used for model 9aC with discrete wall insulation thicknesses shown in Table 71 with glass wool batts used for the remainder of the models. The insulation chosen for both NCC2016 and NCC2019 models was the minimum thickness available which complied with the relevant stringency (NCC2016/2019) for each climate zone. Typically, the wall construction cost for NCC2019 models was less than NCC2016.

Table 71: Framing board insulation range of thicknesses

Product	R value (m^2KW^{-1})	Thickness (mm)
Framing Board Insulation	1.19	25
Framing Board Insulation	1.9	40
Framing Board Insulation	2.5	50
Framing Board Insulation	3	60
Framing Board Insulation	3.5	70
Framing Board Insulation	4	80
Framing Board Insulation	4.5	90
Framing Board Insulation	5	100

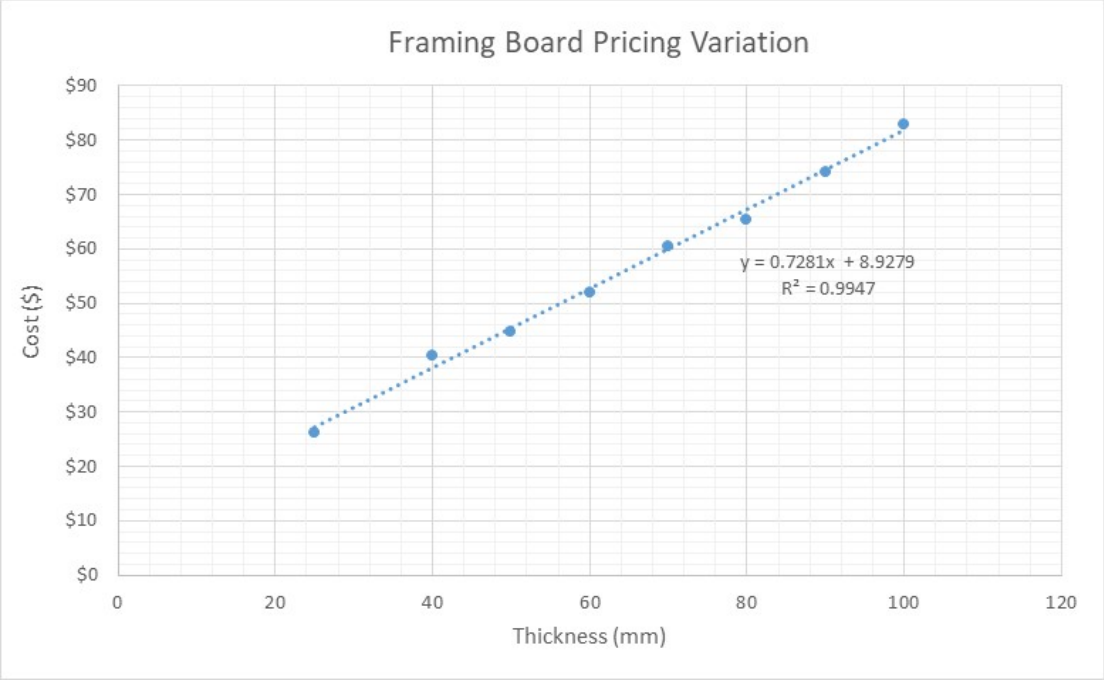

Figure 14: Wall insulation (framing board) construction cost variation with insulation thickness.

Table 72: Wall Batts range of thicknesses.

Product	R value (m^2KW^{-1})	Size (m^2)	Thickness (mm)
Glass Wool Wall Batts	1.5	10.9	50
Glass Wool Wall Batts	1.5	9.7	50
Glass Wool Wall Batts	2.2	7.3	75
Glass Wool Wall Batts	2.2	6.5	75
Glass Wool Wall Batts	2.7	7.3	90
Glass Wool Wall Batts	2.7	6.5	90

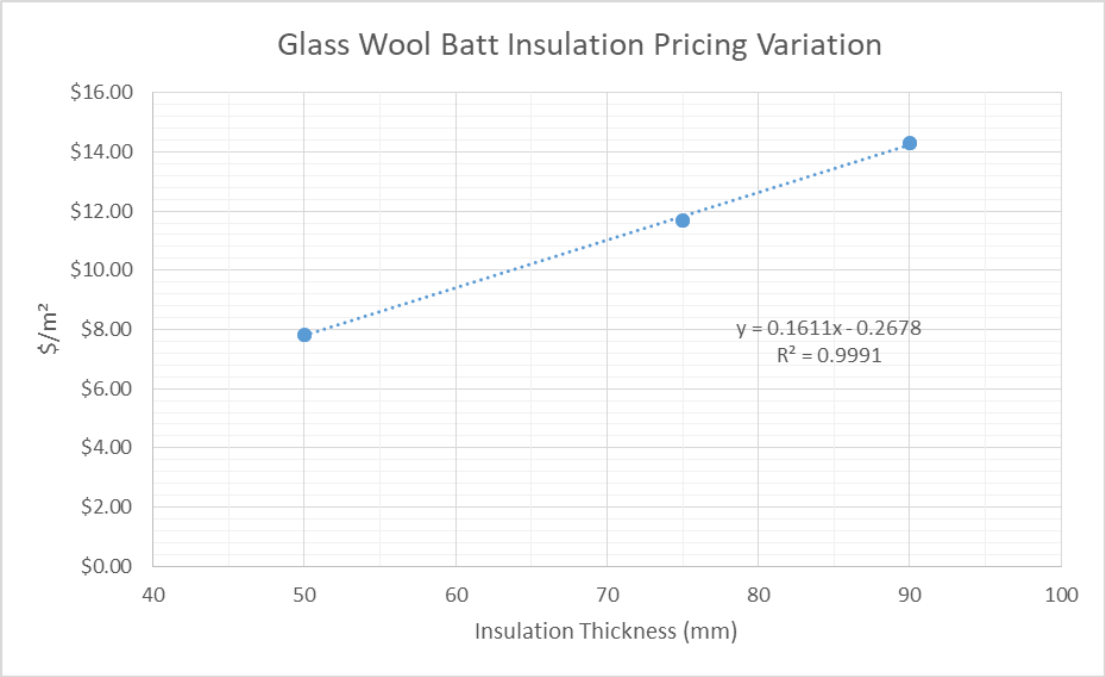

Figure 15: Wall construction cost variation with insulation thickness

5.2.1.2 Glazing Construction

The glazing construction for NCC2019 varies with respect to the NCC2016 baseline due to the different methodologies used to determine the provisions. Appendix D presents the glazing assignment for each façade of each model.

5.2.1.3 Roof Construction

There is no change in cost for roof constructions between NCC2016 and NCC2019 as a result of the provisions for roof insulation remaining the same.

5.2.1.4 Floor Construction

There is no change in cost for floor constructions between NCC2016 and NCC2019 as a result of the provisions for floor insulation remaining the same.

5.2.2 HVAC Equipment

The various HVAC equipment types used in the simulations were priced using figures provided by industry. Typically, these figures were normalised with respect to the capacity of the equipment, a $/kW value for example, before the capital cost of the equipment over a range of sizes could be estimated. The lifetime of equipment such as boilers, chillers etc. was set at 25 years (out of a 40 year benefit cost analysis) and other equipment such as CO_2 control and economy cycle systems had a lifetime of 15 years. To address the requirement that equipment is replaced, an annual non-energy cost was produced. This cost is based on the price of each piece of HVAC equipment used in each model divided by their respective lifetime. Table 73 through Table 78 below present the annual non-energy costs for replacing HVAC equipment at their end of life.

Table 73: Annual non-energy costs for Model 3A, 30% WWR

Location	NCC2016 ($)	NCC2019 ($)	Variation (%)
CZ1	$18,803	$21,040	12%
CZ2	$22,625	$19,895	-12%
CZ3	$21,750	$21,280	-2%
CZ4	$21,053	$21,243	1%
CZ5	$20,311	$22,086	9%
CZ6	$20,466	$20,764	1%
CZ7	$18,766	$19,578	4%

Table 74: Annual non-energy costs for Model 9aC, 30% WWR

Location	NCC2016 ($)	NCC2019 ($)	Variation (%)
CZ1	$4,321	$4,970	15%
CZ2	$4,135	$4,384	6%
CZ3	$4,977	$5,415	9%
CZ4	$4,978	$5,520	11%
CZ5	$4,267	$4,685	10%
CZ6	$4,787	$6,157	29%
CZ7	$5,227	$6,869	31%

Table 75: Annual non-energy costs for Model 9bH, 30% WWR

Location	NCC2016 ($)	NCC2019 ($)	Variation (%)
CZ1	$10,759	$11,713	9%
CZ2	$9,322	$11,250	21%
CZ3	$10,517	$12,305	17%
CZ4	$10,814	$12,860	19%
CZ5	$9,378	$11,343	21%
CZ6	$10,555	$12,453	18%
CZ7	$12,066	$14,601	21%

Table 76: Annual non-energy costs for Model 5A, 56% WWR

Location	NCC2016 ($)	NCC2019 ($)	Variation (%)
CZ1	$17,867	$23,404	31%
CZ2	$22,582	$19,457	-14%
CZ3	$24,941	$26,203	5%
CZ4	$21,404	$24,936	17%
CZ5	$18,952	$21,941	16%
CZ6	$19,945	$25,572	28%
CZ7	$20,771	$28,762	38%

Table 77: Annual non-energy costs for Model 5A, 40% WWR

Location	NCC2016 ($)	NCC2019 ($)	Variation (%)
CZ1	$18,594	$22,301	20%
CZ2	$23,364	$18,238	-22%
CZ3	$26,331	$27,225	3%
CZ4	$21,003	$23,312	11%
CZ5	$21,492	$20,598	-4%
CZ6	$20,150	$22,689	13%
CZ7	$23,251	$27,876	20%

Table 78: Annual non-energy costs for Model 6B, 30% WWR

Location	NCC2016 ($)	NCC2019 ($)	Variation (%)
CZ1	$9,880	$10,254	4%
CZ2	$9,049	$9,501	5%
CZ3	$9,855	$10,941	11%
CZ4	$9,911	$11,330	14%
CZ5	$9,381	$9,985	6%
CZ6	$9,545	$10,814	13%
CZ7	$9,678	$11,939	23%

5.2.2.1 Chillers

In order to calculate the chiller cost difference between 2016 and 2019 models, cost regression equations were developed based on manufacturers' data. Two equations were formed; one for water cooled chillers and one for air cooled chillers as seen below. The normalised ($/kW) price for water cooled chillers is then multiplied by the rated capacity to find the chiller price.

$$Water\ cooled\ chiller\ normalised\ unit\ cost\ \left(\frac{\$}{kW}\right) = -195.2 + 3497.303 \times Capacity^{-0.411} + 13.9296 \times COP + 12.02705 \times e^{(0.2 \times IPLV)}$$

$$Air\ cooled\ chiller\ unit\ cost\ (\$) = -159254 + 162.406 \times Capacity + 65556.8 \times COP$$

Figure 16 and Figure 17 demonstrates the chiller price based on the above equations over a range of capacities and performance levels.

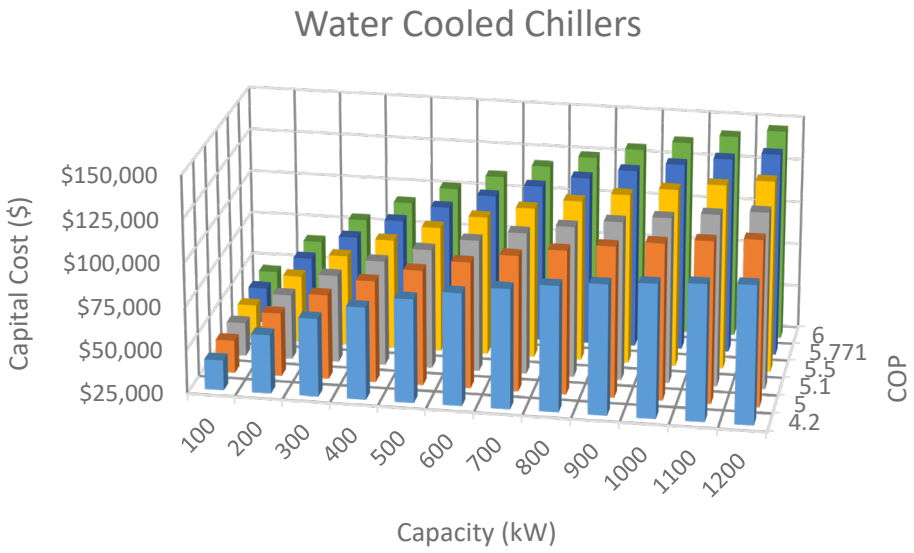

Figure 16: NCC2016 and NCC2019 compliant water cooled chiller pricing.

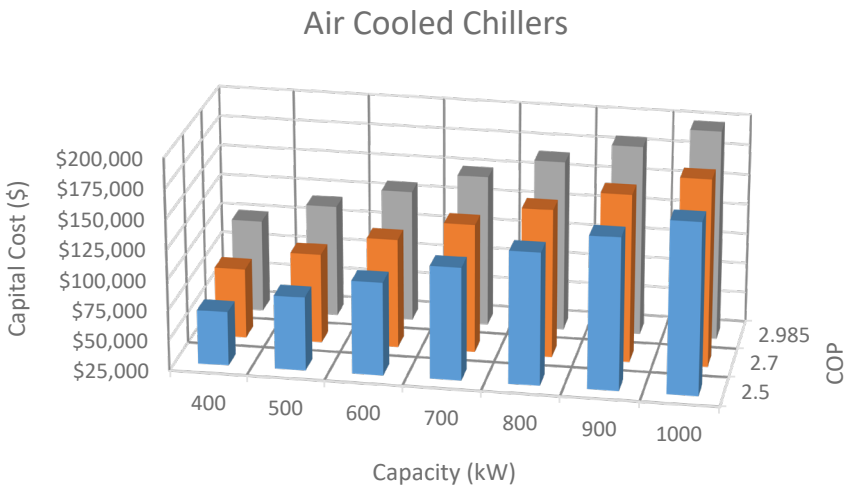

Figure 17: NCC2016 and NCC2019 compliant air cooled chiller pricing.

5.2.2.2 Boilers

Non-condensing boilers were used in NCC2016 compliant models with condensing boilers applied to all NCC2019 models. NCC2016 boilers with a capacity of less than 200 kW_{th} output were given a 32% lower $/kW value than NCC2019 for the same capacity, see Figure 18 below which compares these trends. Typically boilers with a capacity less than 200 kW were found in 6B or 9aC models.

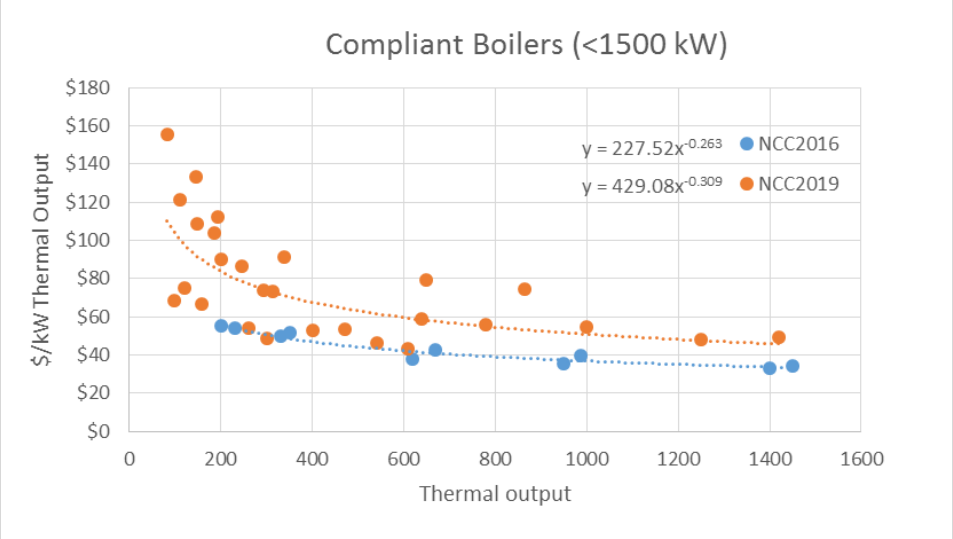

Figure 18: Comparison of compliant boilers for NCC2016 and NCC2019.

5.2.2.3 Cooling Towers

After comparing the $/kW cooling capacity for NCC2016 and NCC2019 models (Figure 19) a 10% incremental difference for the price of cooling towers below 385 kW cooling capacity was applied to NCC2019 equipment.

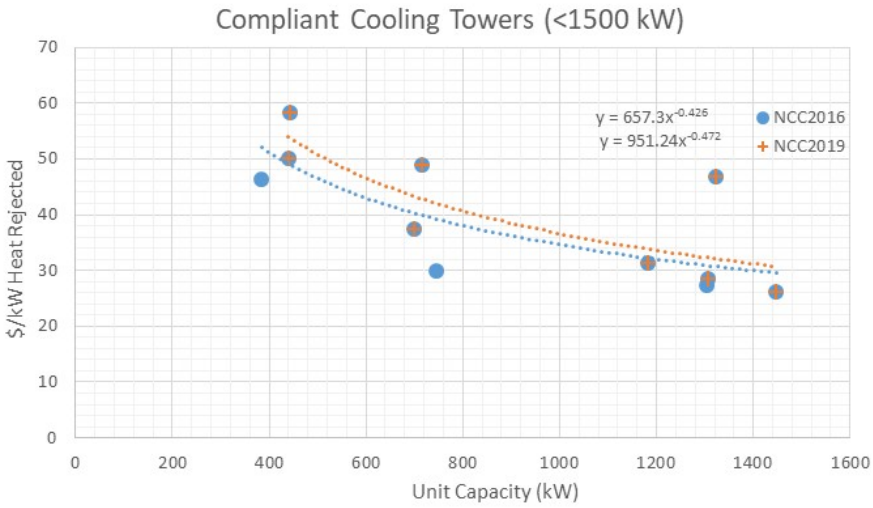

Figure 19: Cooling tower $/kW comparison for NCC0216 and NCC2019.

5.2.2.4 Air Handling Units & Fan Coil Units

AHU prices were obtained using the capital cost supplied for a few example systems. The prices for the AHUs included the unit and associated ductwork for an example system that meets the set stringency. The total construction cost was turned to a specific cost in terms of AHU capacity, $/(L/s). Both NCC2016 and NCC2019 compliant systems were converted to a $/(L/s) value to get the incremental price associated with the piece of equipment.

The capital cost of the AHU systems varied slightly depending on the annual hours of operation. Each of the 5 model types in the DTS simulations have set occupancy hours depending on the building use. The annual hours of operation for the five archetypes were matched with the trend in capital cost (Figure AHU Price Variation, below) of the AHU systems to get a construction cost. The buildings modelled are in operation for the hours listed in Table 79 below.

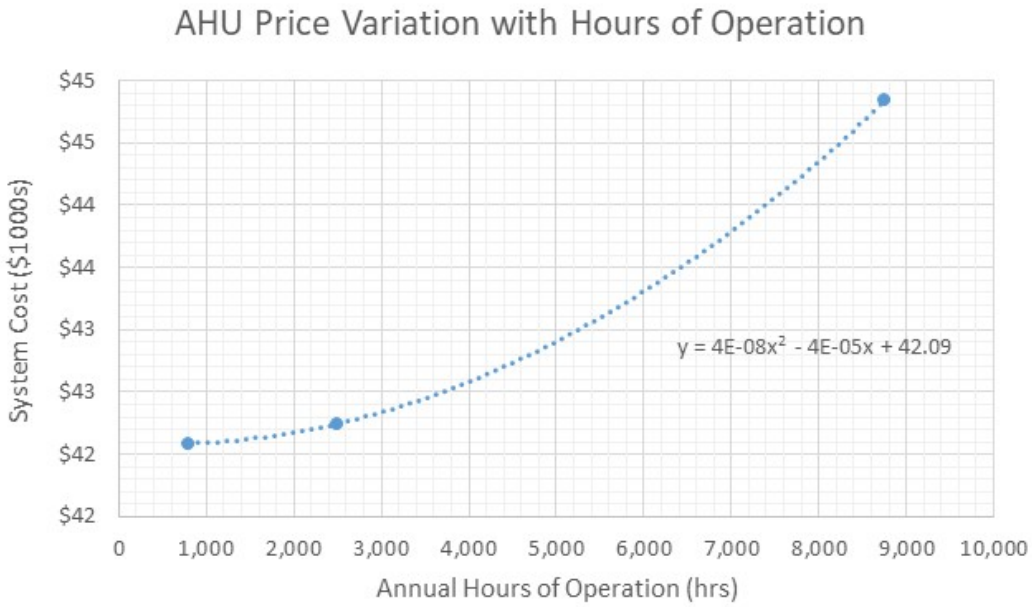

Figure 20: Variation in construction cost based on annual hours of operation.

Table 79: Daily and annual hours equivalence of building use assumed for the simulations.

Model	Daily Hours (average with weekends)	Annual Hours
3A	7.25	2,650
5A	9.4	3,430
6B	13.2	4,820
9aC	9.4	3,430
9bH	7.14	2,607

Looking at the AHU buildings only, 5A and 9aC, a $/(L/s) value can be assigned to calculate the system cost for each simulated model.

Table 80: System cost and $/(L/s) value used to calculate total system cost.

NCC	Model	Construction Cost	Hours of Operation	Unit Capacity	$/(L/s)
NCC2016	5A/9aC	$34,849	-	5,921	$5.885
NCC2019	5A	$42,431	3430	5,921	$7.166
NCC2019	9aC	$42,431	3430	5,921	$7.166

FCU prices were obtained by comparing prices obtained from a quantity surveyor with a few examples from Rawlinson's Australian Construction Handbook. The trend in specific cost, $/(L/s), from Rawlinson's lined up well with the few examples DCWC supplied pricing for (Figure 21). The two data groups were combined to give the pricing trend for the FCUs used in models 3A and 6B.

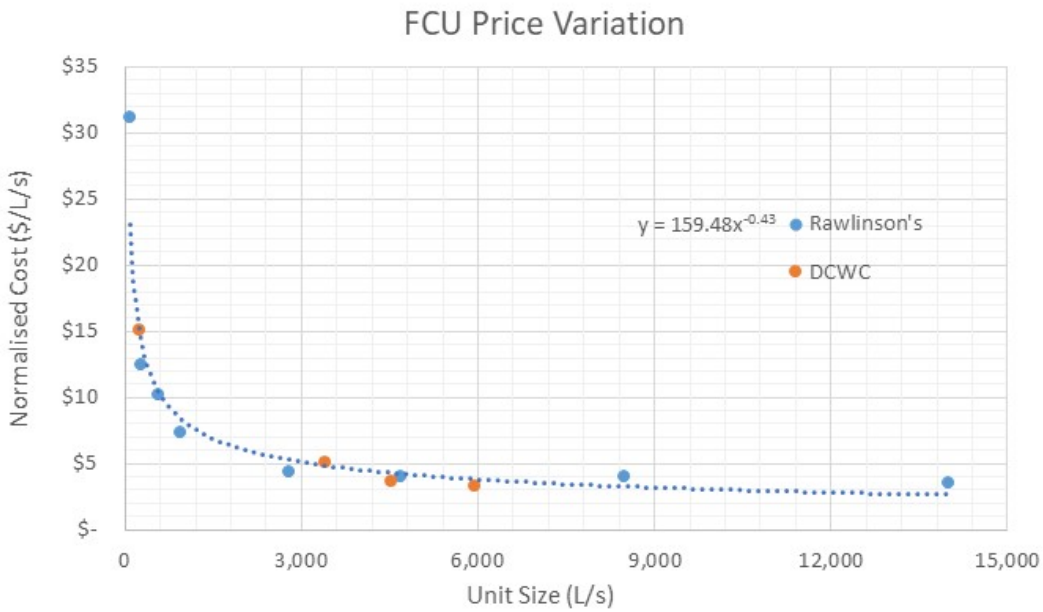

Figure 21: Variation in construction cost with unit capacity.

Economy cycles associated with the outside air supply for the various AHU systems was also taken into account during the analysis. Figure 22, sourced using quantity surveyor pricing, was used to estimate the capital cost for hardware related to an economy cycle; mixing dampers, outside air louvres and ductwork etc. The difference in price between systems with and without an economy cycle stems from the need for greater air movement in systems with, hence bigger ductwork, louvres and mixing dampers.

CO_2 control units were placed on each floor in all models to comply with both NCC2016 and NCC2019 stringencies. Each unit was priced at $1,835 which includes the sensor, BMS connection and other installation expenses. Air to air, plate heat exchangers used in model 3A of the core simulations were priced using the data obtained from the same quantity surveying firm. The capital cost for these units were normalised based upon the air flow of the unit to be able to estimate the capital cost for the capacities modelled in the simulations.

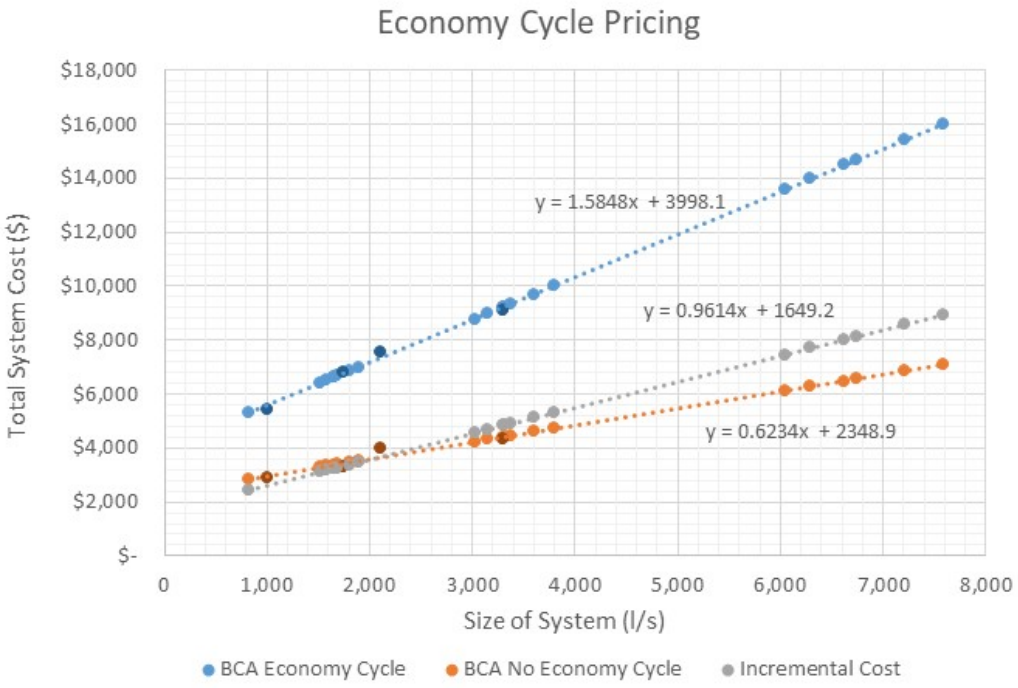

Figure 22: Air delivery system (excluding AHU) pricing variation with capacity and economy cycle inclusion.

5.2.3 Lighting

The lighting prices are based on fluorescent and LED types for NCC2016 and NCC2019 core models respectively. Table 81 and Table 82 provide a $/m^2 (floor area) cost that was applied to the models to calculate the lighting construction cost (Table 83 on the following page).

Table 81: 160 lux LED lighting normalised construction costs taken from Section J revision

Model	Area (m^2)	Cost ($)	$/m^2
Model 14	1,000	10,472	10.472
Model 15	1,000	9,996	9.996
Model 16	1,000	9,996	9.996
Average			10.15

Table 82: 320 lux LED lighting normalised construction costs taken from Section J revision

Model	Area (m^2)	Cost ($)	$/m^2
Model 14	1,000	19,040	19.04
Model 15	1,000	19,040	19.04
Model 16	1,000	19,040	19.04
Average			19.04

A 30% learning rate to the capital cost of LED lights was used with a 22% learning rate applied to performance costs. A discount rate of 7% was also used in pricing the lighting used in all simulated models. Annual non-energy costs were derived to include the replacement of luminaires and maintenance costs. Table 84 provides the values used in the benefit cost analysis for lighting annual non-energy costs.

Table 83: Construction costs for the models – consistent across NCC2016 and NCC2019 models.

Building Class/Form	NLA (m^2)	Lighting Type	IPD (W/m^2)	$/$m^2$	Construction Cost ($)
3A	9,000	LED	2.5	10.15	$ 91,392
5A	9,000	LED	4.5	19.04	$ 171,360
6B	1,800	LED	16	19.04	$ 34,272
9aC	950	LED	4.5	19.04	$ 18,088
9bH	2,790	LED	4.5	19.04	$ 53,319

Table 84: Annual non-energy costs used for the core modelling include maintenance and unit replacement.

Climate zone	3A 30% WWR	9aC 30% WWR	9bH 30% WWR	5A 56% WWR	5A 40% WWR	6B 30% WWR
CZ1	$15,010	$3,506	$9,442	$35,060	$35,060	$35,099
CZ2	$15,010	$3,506	$9,442	$35,060	$35,060	$35,099
CZ3	$15,010	$3,506	$9,442	$35,060	$35,060	$35,099
CZ4	$15,010	$3,506	$9,442	$35,060	$35,060	$35,099
CZ5	$15,010	$3,506	$9,442	$35,060	$35,060	$35,099
CZ6	$15,010	$3,506	$9,442	$35,060	$35,060	$35,099
CZ7	$15,010	$3,506	$9,442	$35,060	$35,060	$35,099

5.3 Impact of Increased Stringency (Core Modelling) Associated Costs

5.3.1 Construction Costs

Two 'Scenarios' were employed to understand the impact of increased stringency; Scenario 1 uses a minimum insulation thickness of 25mm with no upper bounds whereas Scenario 2 restricts insulation thickness in the range of 25mm to 90mm. A comparison of the construction costs for each core model over all climate zones is given in Table 85 through Table 90 below. For all models that have a reduction in capital cost between NCC2016 and NCC2019, they will consequently have a benefit cost value of "negative cost".

5.3.1.1 Scenario 1 (Insulation Thickness >=25mm)

Table 85: Construction cost variation for Model 3A, 30% WWR

Location	NCC2016 ($)	NCC2019 ($)	Variation (%)
CZ1	$1,303,897	$1,206,758	-7%
CZ2	$1,161,342	$1,184,802	2%
CZ3	$1,232,413	$1,224,993	-1%
CZ4	$1,222,727	$1,213,497	-1%
CZ5	$1,187,913	$1,229,007	3%
CZ6	$1,208,056	$1,201,517	-1%
CZ7	$1,286,821	$1,171,857	-9%

Table 86: Construction cost variation for Model 9aC, 30% WWR

Location	NCC2016 ($)	NCC2019 ($)	Variation (%)
CZ1	$237,708	$245,207	3%
CZ2	$226,979	$230,556	2%
CZ3	$247,310	$246,658	0%
CZ4	$246,369	$258,946	5%
CZ5	$226,266	$238,073	5%
CZ6	$251,730	$270,998	8%
CZ7	$266,341	$286,761	8%

Table 87: Construction cost variation for Model 9bH, 30% WWR

Location	NCC2016 ($)	NCC2019 ($)	Variation (%)
CZ1	$518,212	$532,048	3%
CZ2	$478,801	$527,825	10%
CZ3	$508,670	$538,464	6%
CZ4	$516,321	$560,731	9%
CZ5	$476,921	$522,808	10%
CZ6	$533,487	$550,563	3%
CZ7	$586,128	$604,262	3%

Table 88: Construction cost variation for Model 5A, 56% WWR

Location	NCC2016 ($)	NCC2019 ($)	Var (%)
CZ1	$1,951,081	$1,826,138	-6%
CZ2	$1,688,220	$1,739,700	3%
CZ3	$1,813,275	$2,329,316	28%
CZ4	$1,878,970	$1,829,399	-3%
CZ5	$1,670,264	$1,759,424	5%
CZ6	$2,057,461	$1,844,189	-10%
CZ7	$1,933,880	$1,803,165	-7%

Table 89: Construction cost variation for Model 5A, 40% WWR

Location	NCC2016 ($)	NCC2019 ($)	Var (%)
CZ1	$1,417,114	$1,495,632	6%
CZ2	$1,373,005	$1,406,281	2%
CZ3	$1,475,431	$1,581,092	7%
CZ4	$1,429,865	$1,488,598	4%
CZ5	$1,322,735	$1,425,132	8%
CZ6	$1,431,895	$1,473,685	3%
CZ7	$1,589,819	$1,593,994	0%

Table 90: Construction cost variation for Model 6B, 30% WWR

Location	NCC2016 ($)	NCC2019 ($)	Var (%)
CZ1	$415,726	$415,502	0%
CZ2	$390,036	$396,683	2%
CZ3	$410,180	$432,688	5%
CZ4	$412,833	$442,391	7%
CZ5	$397,457	$408,784	3%
CZ6	$414,359	$429,498	4%
CZ7	$425,823	$450,292	6%

Detailed construction cost breakdowns are provided in Appendix E. Graphical representations of the construction costs for each model in 2016 and 2019 are given in the plots below.

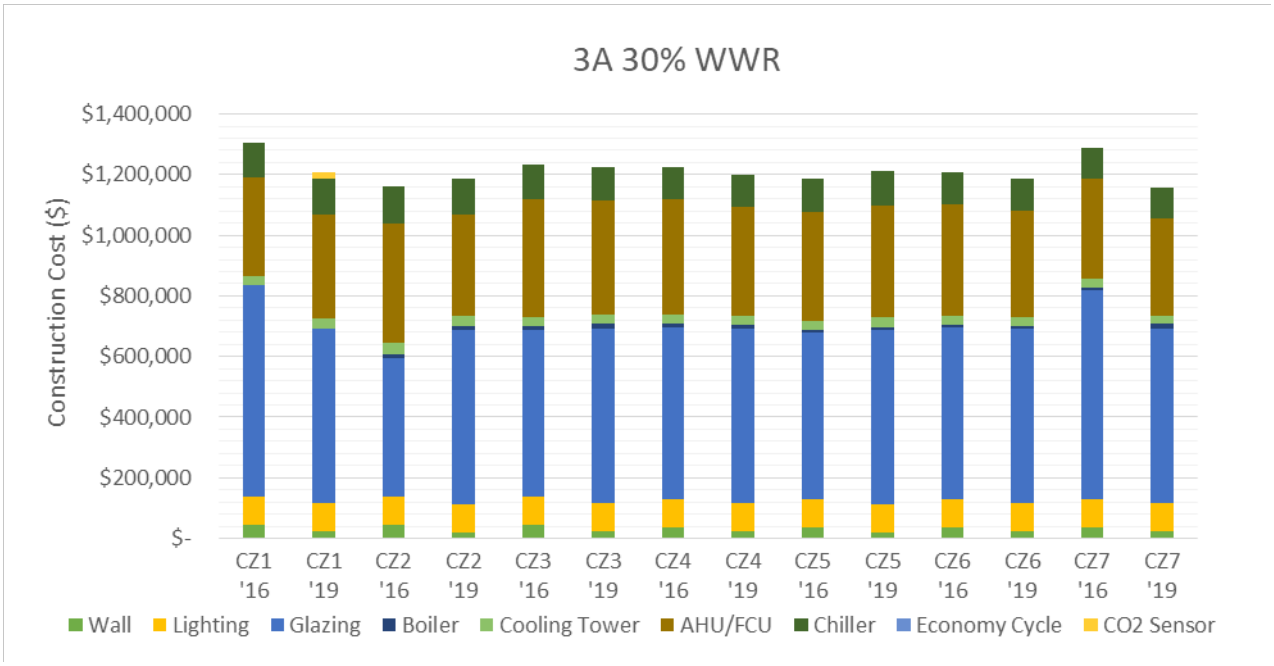

Figure 23: Comparison of initial construction cost for model 3A (30% WWR).

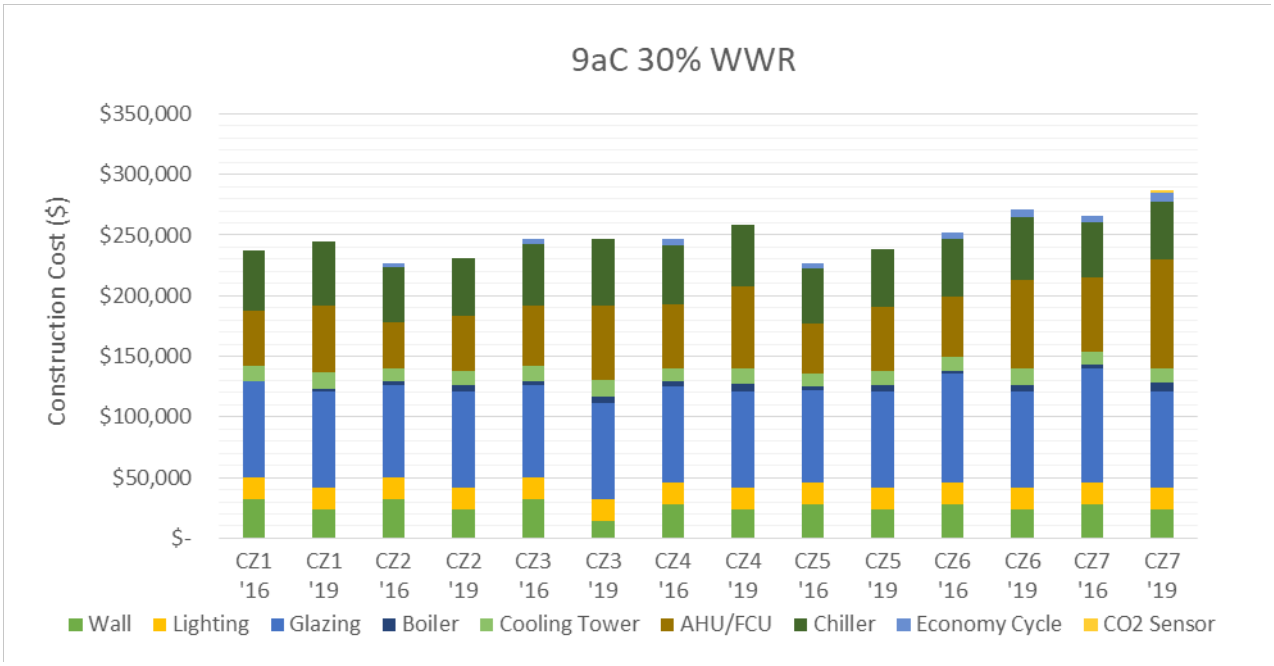

Figure 24: Comparison of initial construction cost for model 9aC (30% WWR).

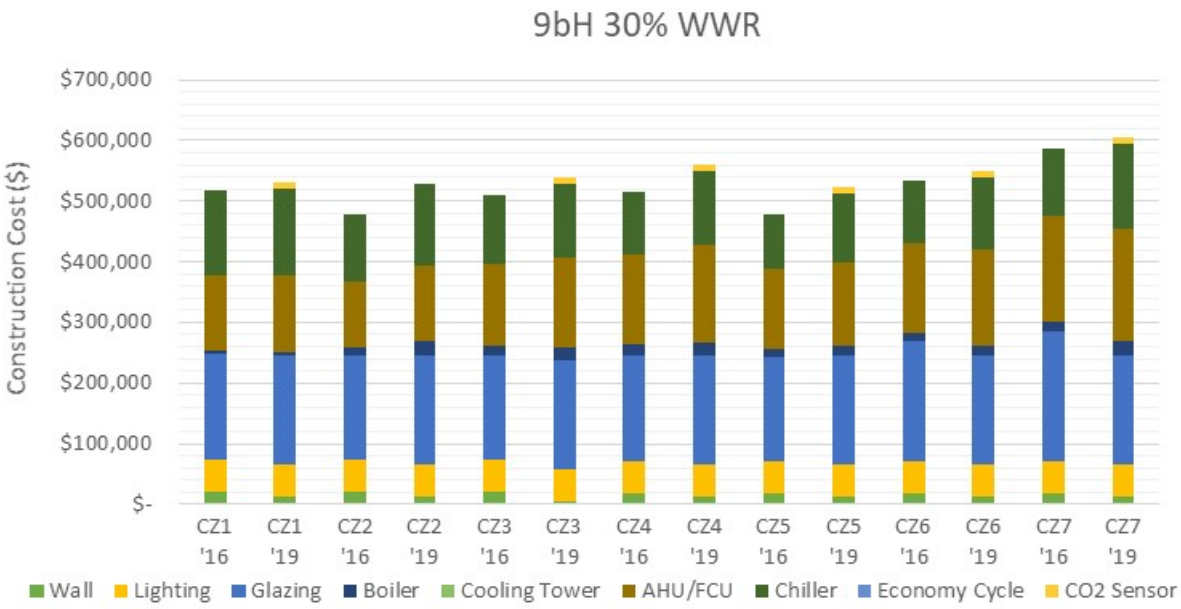

Figure 25: Comparison of initial construction cost for model 9bH (30% WWR).

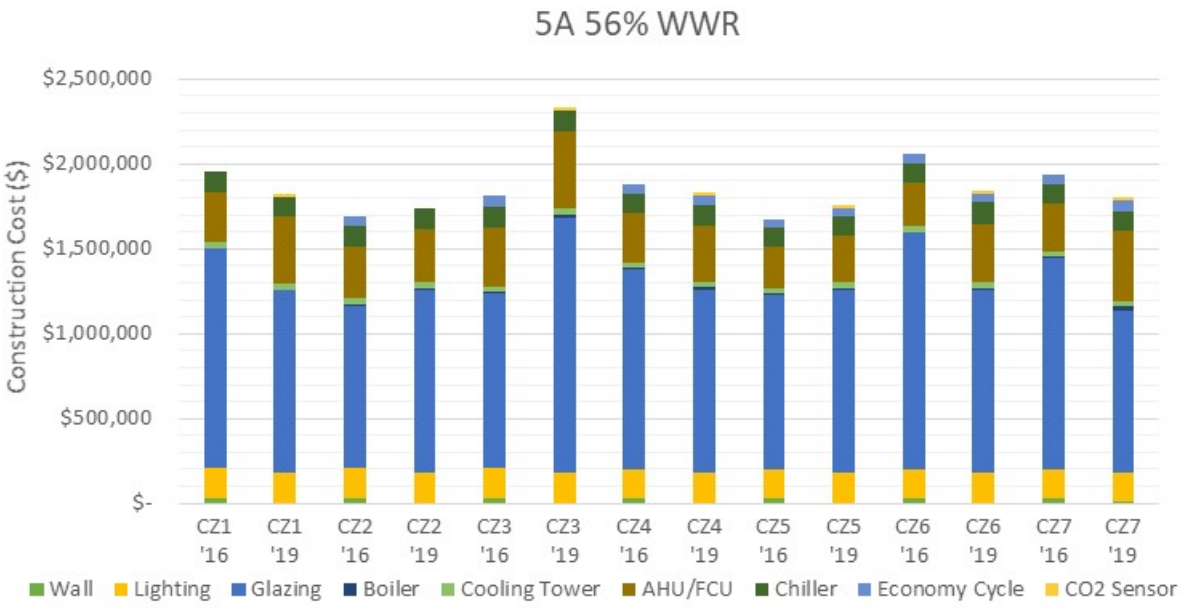

Figure 26: Comparison of initial construction cost for model 5A (56% WWR).

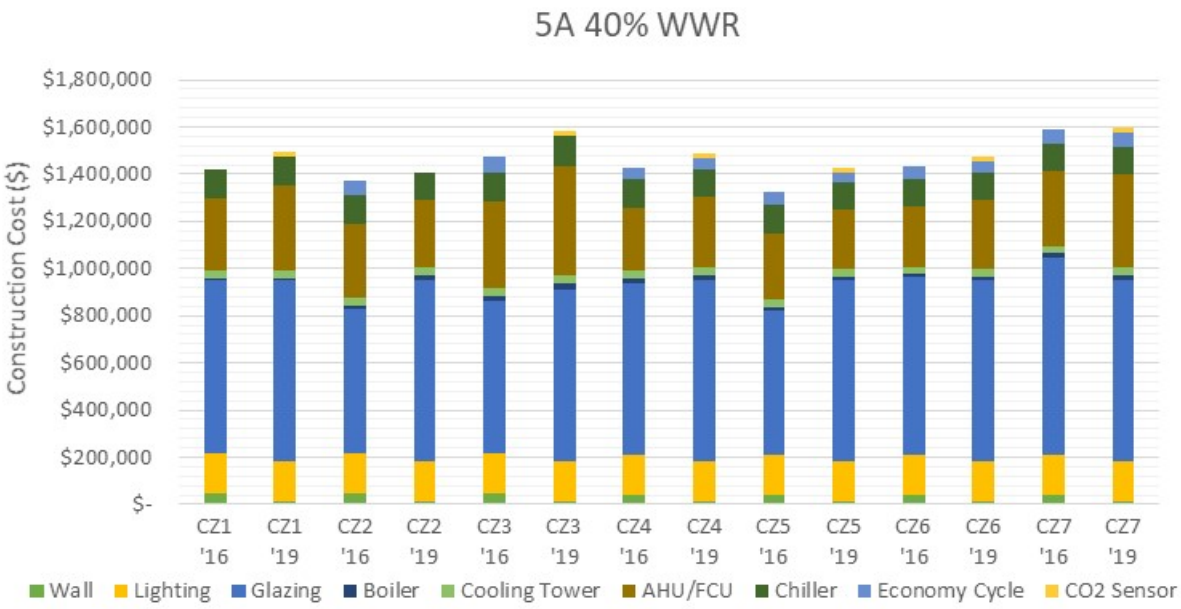

Figure 27: Comparison of initial construction cost for model 5A (40% WWR).

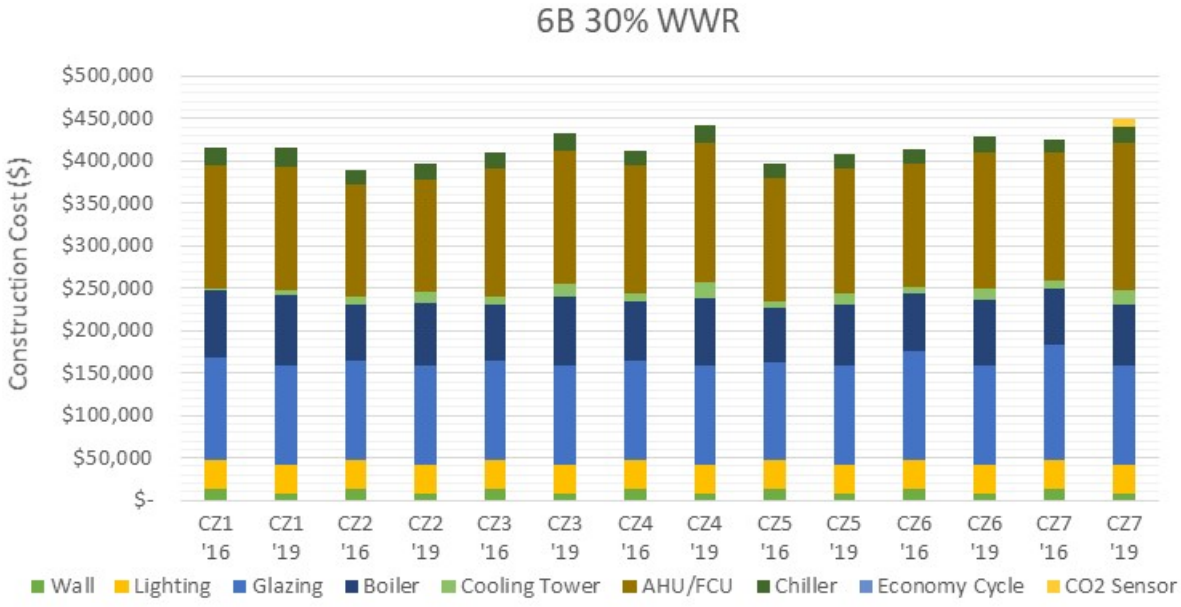

Figure 28: Comparison of initial construction cost for model 6B (30%WWR).

5.3.1.2 Scenario 2 (Insulation Thickness 25mm-90mm)

Table 91: Construction cost variation for Model 3A, 30% WWR

Location	NCC2016 ($)	NCC2019 ($)	Variation (%)
CZ1	$1,302,563	$1,206,758	-7%
CZ2	$1,160,008	$1,184,802	2%
CZ3	$1,231,079	$1,224,993	0%
CZ4	$1,222,727	$1,213,497	-1%
CZ5	$1,187,913	$1,229,007	3%
CZ6	$1,208,056	$1,201,517	-1%
CZ7	$1,286,821	$1,171,857	-9%

Table 92: Construction cost variation for Model 9bH, 30% WWR

Location	NCC2016 ($)	NCC2019 ($)	Variation (%)
CZ1	$514,686	$532,048	3%
CZ2	$475,275	$527,825	11%
CZ3	$505,144	$538,464	7%
CZ4	$516,060	$560,731	9%
CZ5	$476,661	$522,808	10%
CZ6	$533,227	$550,563	3%
CZ7	$585,867	$604,262	3%

Table 93: Construction cost variation for Model 5A, 56% WWR

Location	NCC2016 ($)	NCC2019 ($)	Var (%)
CZ1	$1,945,275	$1,827,961	-6%
CZ2	$1,682,414	$1,741,523	4%
CZ3	$1,807,470	$2,331,138	29%
CZ4	$1,878,541	$1,831,222	-3%
CZ5	$1,669,835	$1,761,246	5%
CZ6	$2,057,032	$1,846,012	-10%
CZ7	$1,933,393	$1,805,235	-7%

Table 94: Construction cost variation for Model 5A, 40% WWR

Location	NCC2016 ($)	NCC2019 ($)	Var (%)
CZ1	$1,409,197	$1,495,632	6%
CZ2	$1,365,088	$1,406,281	3%
CZ3	$1,467,514	$1,581,092	8%
CZ4	$1,429,280	$1,488,598	4%
CZ5	$1,322,150	$1,425,132	8%
CZ6	$1,431,310	$1,473,685	3%
CZ7	$1,589,234	$1,593,994	0%

Table 95: Construction cost variation for Model 6B, 30% WWR

Location	NCC2016 ($)	NCC2019 ($)	Var (%)
CZ1	$413,577	$415,502	0%
CZ2	$387,887	$396,683	2%
CZ3	$408,031	$432,688	6%
CZ4	$410,684	$442,391	8%
CZ5	$395,308	$408,784	3%
CZ6	$412,210	$429,498	4%
CZ7	$423,674	$450,292	6%

Detailed construction cost breakdowns are provided in Appendix E. Graphical representations of the construction costs for each model are given in the plots below.

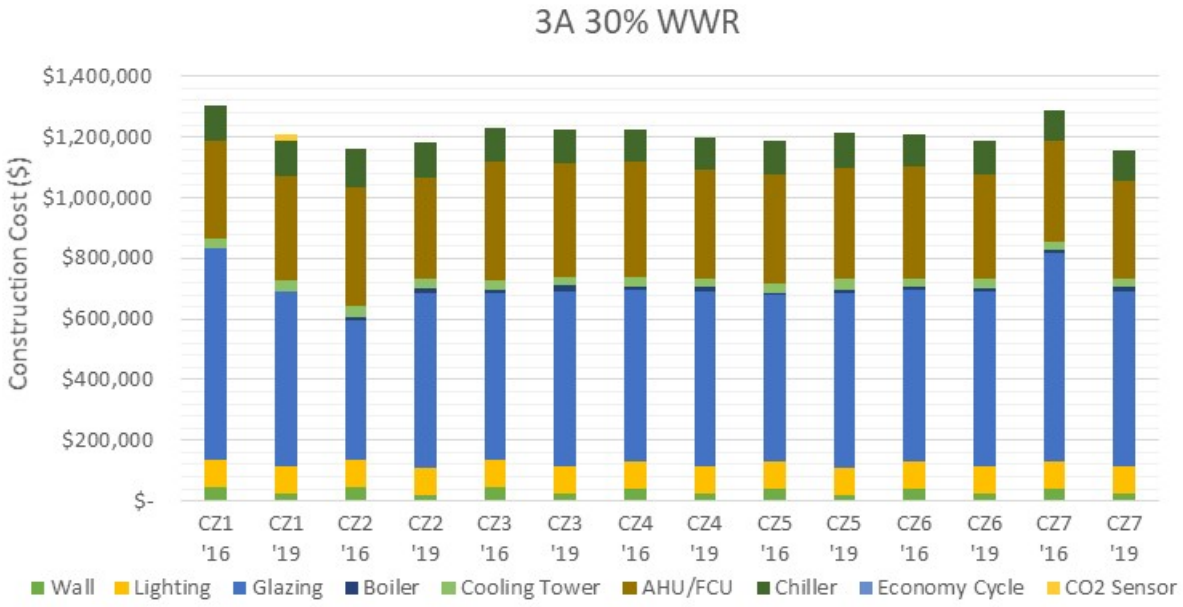

Figure 29: Comparison of initial construction cost for model 3A (30% WWR).

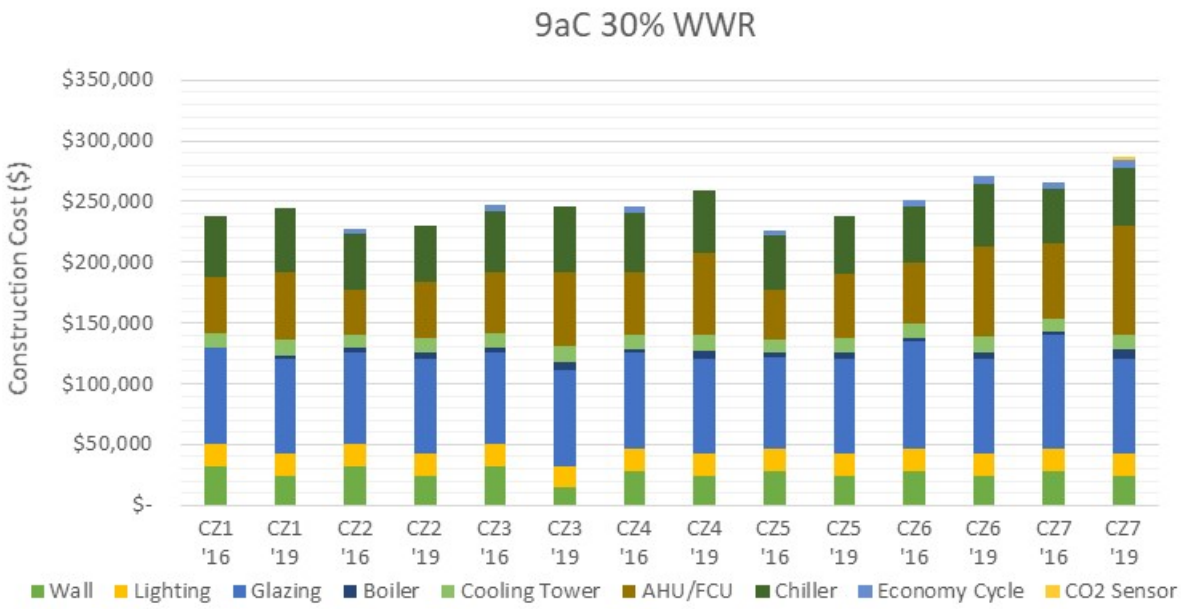

Figure 30: Comparison of initial construction cost for model 9aC (30% WWR).

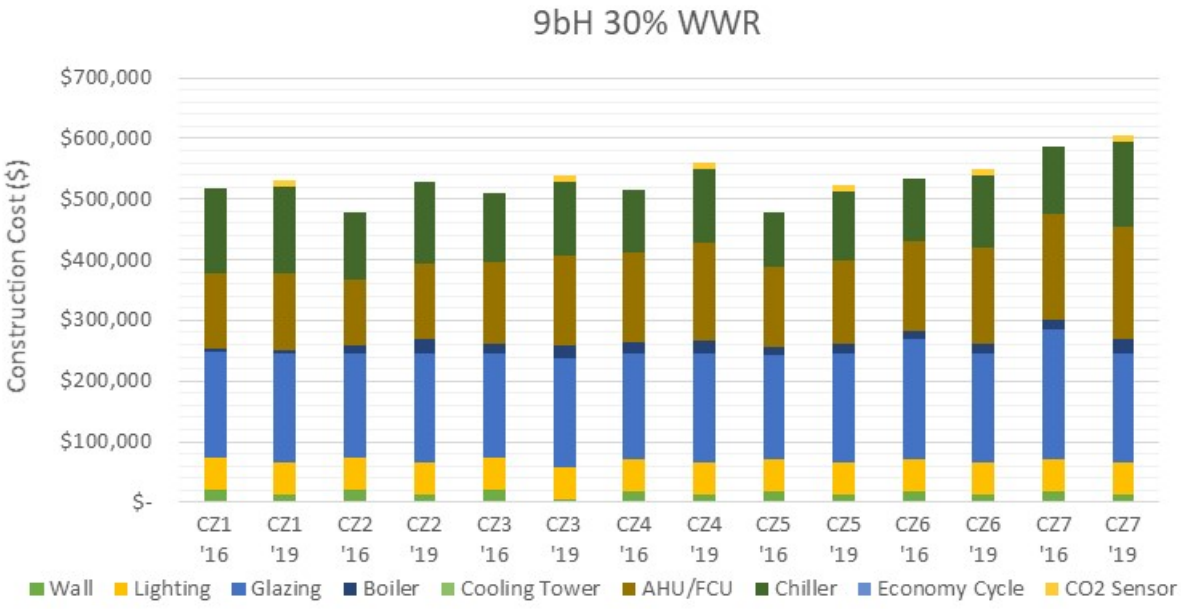

Figure 31: Comparison of initial construction cost for model 9bH (30% WWR).

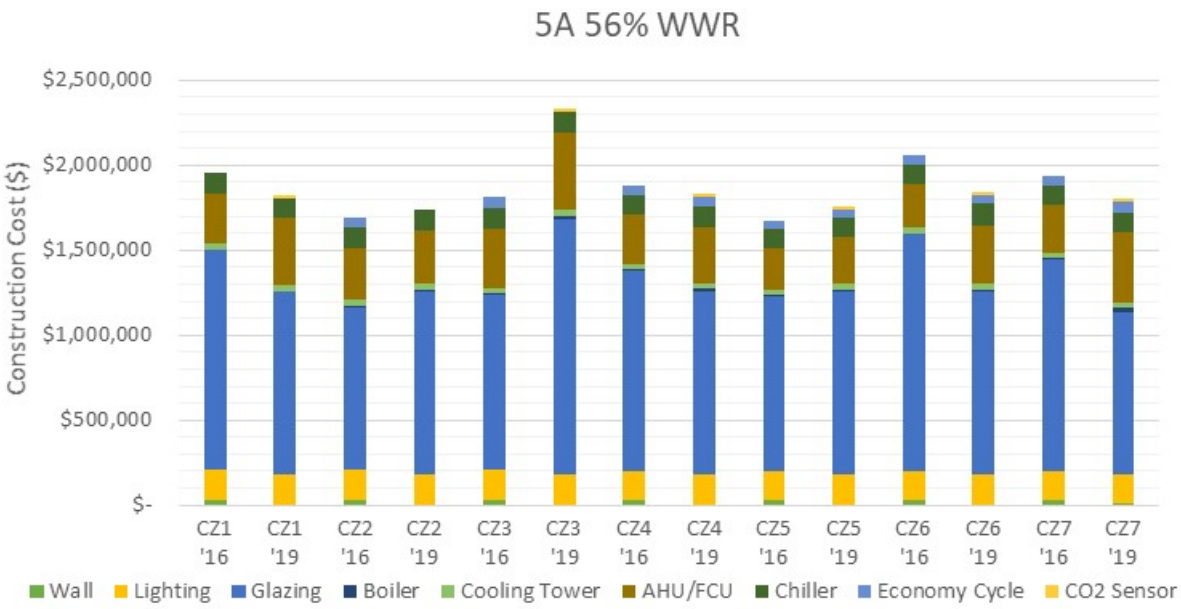

Figure 32: Comparison of initial construction cost for model 5A (56% WWR).

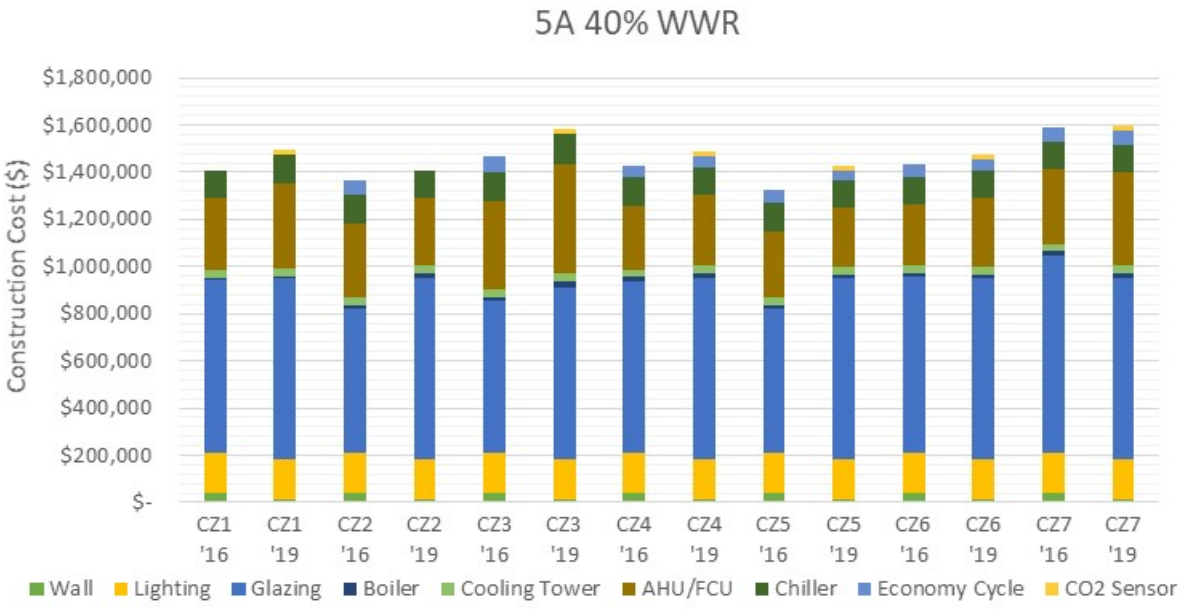

Figure 33: Comparison of initial construction cost for model 5A (40% WWR).

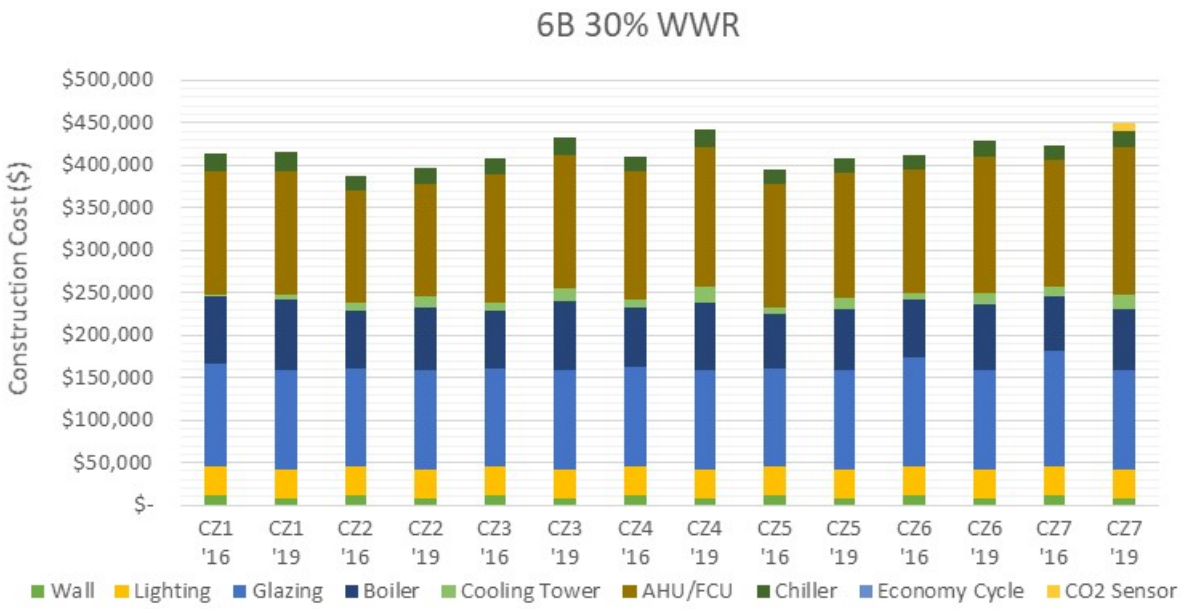

Figure 34: Comparison of initial construction cost for model 6B (30%WWR).

5.3.1.3 Discussion

In general, the incremental construction cost differences are fairly consistent across climate zones and building classes – that is, façade costs are similar or slightly lower, based on the change in emphasis to façade SHGC over U-value discussed above. This means that in general, façade costs were lower even as SHGC values increased and U-value requirements decreased. Building services costs are similar or slightly higher reflecting the general proposition that on the whole, more efficient services have a price premium (although this varies depending on element), offset by the higher SHGC façade requirement allowing lower capacity services, such as chillers in NCC2019 models. There are some variations to this general finding in Class 3A and 5A buildings, discussed below.

In Class 3A, climate zones 2, 3, 4, 6 and 7 observe a reduction in services cost instead of an increase. All climate zones above have smaller FCU capacities in 2019 compared to 2016 and have more stringent facades (lower U-value, lower SHGC). As such, the differential cost between 2016 and 2019 accordingly shows a 'reverse' trend from other climate zones – that is, a lower services cost, higher façade costs. The higher façade costs in these buildings are driven by the need for glazing with more stringent U-value (which as discussed above is more costly than lowering SHGC). This facade (lower U-value, lower SHGC) then reduced the required capacity of HVAC services. This was especially the case in climate zone 2 where the energy index value/coefficient used in the 2016 glazing calculator was *significantly less* stringent compared to the other climate zones.

In Class 5A 40% WWR, climate zones 2 and 5 have a lower services cost. For climate zone 2, the elimination of regulated economy cycle capability in humid and mild climates in 2019 was one of the drivers for the reduction in services cost. The benefit of economy cycle is greatly reduced in humid climates as the enthalpy of ambient air is fairly high and thereby does not present as much energy savings compared to drier climates. climate zone 5 cooling and air handling capacities decreased significantly due to the requirement of a more efficient building shell reducing the required capacity (in terms of peak load sizing requirements) and run time of HVAC services. Both climate zones 2 and 5 have a higher façade cost, mainly driven by increased façade U-value requirements relative to 2016. Looking deeper into the energy index value/coefficient used in the 2016 glazing calculator for climate zones 2 and 5 were *significantly less* stringent compared to the other climate zones (much higher U-value, higher SHGC). As such, the differential cost between 2016 and 2019 accordingly shows a 'reverse' trend from other climate zones – that is, lower services cost, higher façade costs.

Based on the results for Class 5A 56% WWR (or 50% WWR in climate zone 7), it is clear that the impact of façade performance is increasingly important as the amount of glazing increases relative to opaque wall elements. climate zones 1, 4, 5, 6 and 7 all have lower façade (glazing and insulation) costs in NCC2019 whilst climate zones 2 and 3 have higher façade (glazing and insulation) costs. The building services costs contrastingly increase for climate zones 1, 3, 4, 5, 6 and 7 in NCC2019 models whereas climate zone 2 has seen a reduction. This trend illustrates that a less energy efficient façade typically requires a higher capacity (in terms of peak load sizing requirements) and run time of HVAC services. The exception is climate zone 3 (see below).

More importantly, the observations above confirm that when the approach to glazing selection is *cheapest* and *compliant*, the 2016 glazing calculator appears to require highly variable glazing stringencies across climate zones, while 2019 generally has consistent glazing costs and requirements across the climate zones. As such, the cheapest compliant window across climate zones in 2019 is same window model; whereas in 2016, windows matching the 'cheapest and compliant' criteria is different across different climate zones and orientations. This is important as it identifies why there is a variation in building services costs across climate zones; the relative glazing selection between NCC2016 and NCC2019 is a big influence on any building services related variation. It also highlights a simplification benefit that comes from the proposed change to whole-of-facade methodology as a DTS compliance pathway. Presently buildings would often need to use JV3 Verification methodology to comply having the same window selected on all aspects.

The HVAC equipment cost could increase or decrease from 2016 models to 2019 models. This is because peak thermal load is impacted by the building façade. The proposed NCC2019 window-wall system DtS provision uses a completely different methodology from NCC2016 DtS provisions for wall and glazing. NCC2016 glazing stringencies are different across the climate zones and orientations. NCC2019 glazing stringencies are different across the climate zones but the same across the orientations (except climate zone 8) based on the draft provisions used to develop these models. Additionally, we have selected the cheapest compliant glazing in our database, as requested by the CIE, rather than the glazing that is on the boundary of the stringency. The above reasons result in inconsistencies in the HVAC equipment cost variation pattern from NCC2016 to NCC2019.

While it may be reasonable to expect the glazing costs to impact chiller construction costs (e.g. when glazing costs increase, chiller costs decreases), this assertion does not hold true in all situations. For example, this phenomenon was observed in climate zone 3 for Class 5A 56% WWR – glazing costs increased, but chiller costs also increased in 2019. Looking deeper into the glazing changes, it was found that the U-value of the glazing selected had decreased in 2019 compared to 2016, driving the glazing cost increase. However, in these climate zones, the peak cooling load occurred in the early morning (before 8am). At these hours, the building cooling load is driven by U-value, not SHGC. As such, having a lower heat transfer across the building fabric (that is, lower U-value / higher performing glazing) reduces passive cool down of the building. As chiller sizing and costing is dependent on peak capacity required rather than average energy across the year, chiller construction costs increased in 2019 relative to 2016. In a nutshell, central plant sizing is dependent on peak requirements which depend on the time of the day when the peak load occurs, climate zone, modelled geometry and may sometimes benefit from having a lower performing façade (U-value or SHGC).

Comparing the energy saving results in Class 5A buildings at a 40% WWR compared with 56% we find that the 56% WWR 2019 models save less energy proportionally than 40% WWR 2019 models. This result is explained by the respective choices made for glazing in each building wherein the glazing used for the 56% WWR 2016 models is closer to the corresponding 2019 models than 40% WWR 2016 models. That is, the glazing selections are closer together in terms of SHGC and U-value at 56% WWR than 40%.

5.3.2 Operational Costs

The 40 year operational costs comparison for the impact on increased stringency scope of analysis is provided in the tables below. Operational costs are the same for both wall insulation scenarios.

Table 96: Operational cost summary for Model 3A, 30% WWR

Location	NCC2016 ($)	NCC2019 ($)	Var (%)
CZ1	$3,163,381	$2,928,000	-7%
CZ2	$2,958,648	$2,360,294	-20%
CZ3	$2,757,344	$2,317,884	-16%
CZ4	$2,587,791	$2,111,989	-18%
CZ5	$2,709,246	$2,268,708	-16%
CZ6	$2,560,501	$2,072,058	-19%
CZ7	$2,489,479	$2,037,613	-18%

Table 97: Operational cost summary for Model 9aC, 30% WWR

Location	NCC2016 ($)	NCC2019 ($)	Var (%)
CZ1	$367,181	$321,861	-12%
CZ2	$257,340	$230,484	-10%
CZ3	$312,255	$277,357	-11%
CZ4	$261,629	$246,867	-6%

Location	NCC2016 ($)	NCC2019 ($)	Var (%)
CZ5	$233,838	$218,270	-7%
CZ6	$227,478	$242,994	7%
CZ7	$251,277	$261,130	4%

Table 98: Operational cost summary for Model 9bH, 30% WWR

Location	NCC2016 ($)	NCC2019 ($)	Var (%)
CZ1	$1,659,589	$1,314,720	-21%
CZ2	$999,923	$790,394	-21%
CZ3	$1,303,338	$1,092,038	-16%
CZ4	$1,032,800	$890,658	-14%
CZ5	$820,559	$727,502	-11%
CZ6	$959,508	$835,470	-13%
CZ7	$1,205,169	$1,037,960	-14%

Table 99: Operational cost summary for Model 5A, 56% WWR

Location	NCC2016 ($)	NCC2019 ($)	Var (%)
CZ1	$2,925,220	$2,451,319	-16%
CZ2	$2,299,059	$2,021,798	-12%
CZ3	$2,300,080	$2,144,024	-7%
CZ4	$1,970,957	$1,819,618	-8%
CZ5	$2,051,863	$1,847,622	-10%
CZ6	$1,859,726	$1,744,511	-6%
CZ7	$1,871,056	$1,775,855	-5%

Table 100: Operational cost summary for Model 5A, 40% WWR

Location	NCC2016 ($)	NCC2019 ($)	Var (%)
CZ1	$2,520,873	$2,396,838	-5%
CZ2	$2,242,414	$1,987,014	-11%
CZ3	$2,249,779	$2,161,574	-4%
CZ4	$1,878,592	$1,788,105	-5%
CZ5	$2,004,613	$1,824,740	-9%
CZ6	$1,767,024	$1,680,901	-5%
CZ7	$1,811,695	$1,753,625	-3%

Table 101: Operational cost summary for Model 6B, 30% WWR

Location	NCC2016 ($)	NCC2019 ($)	Var (%)
CZ1	$1,748,607	$1,626,804	-7%
CZ2	$1,407,495	$1,319,886	-6%
CZ3	$1,570,978	$1,457,281	-7%
CZ4	$1,492,371	$1,416,425	-5%
CZ5	$1,467,038	$1,349,497	-8%

Location	NCC2016 ($)	NCC2019 ($)	Var (%)
CZ6	$1,447,663	$1,383,666	-4%
CZ7	$1,377,908	$1,404,354	2%

5.4 Façade vs Services (Decomposition Results) Associated Costs

5.4.1 Construction Costs

The construction costs for the façade vs services modelling scenarios are provided below. The results show how the change in emphasis toward SHGC in the new methodology also results in lower construction costs. As noted in earlier, the material cost of increasing the SHGC of glazing is less than the proportional cost of increasing its U-Values. This is because to increase SHGC tints or films are added to windows, while increasing U-value requires the use of double glazing and higher performing frames. These resulted in the ability to select lower cost compliant glazing in many cases in NCC2019 vs NCC2016.

Table 102: Construction cost summary for the Decomposition Results in Model 3A, 30% WWR[6]

Climate zone	NCC2016	Mixed	NCC2019	Services %	Façade %	Total %
2	$1,160,008	$1,171,053	$1,184,802	1%	1%	2%
5	$1,187,913	$1,293,275	$1,229,007	9%	-5%	3%
6	$1,208,056	$1,227,170	$1,201,517	2%	-2%	-1%

Table 103: Construction cost summary for the Decomposition Results in Model 5A, 40% WWR

Climate zone	NCC2016	Mixed	NCC2019	Services %	Façade %	Total %
2	$1,365,088	$1,379,575	$1,406,281	1%	2%	3%
5	$1,322,150	$1,406,088	$1,425,132	6%	1%	8%
6	$1,431,310	$1,554,483	$1,473,685	9%	-5%	3%

Table 104: Construction cost summary for the Decomposition Results in Model 6B, 30% WWR

Climate zone	NCC2016	Mixed	NCC2019	Services %	Façade %	Total %
2	$387,887	$393,047	$396,683	1%	1%	2%
5	$395,308	$401,510	$408,784	2%	2%	3%
6	$412,210	$424,980	$429,498	3%	1%	4%

Table 105: Construction cost summary for the Decomposition Results in Model 9aC, 30% WWR

Climate zone	NCC2016	Mixed	NCC2019	Services %	Façade %	Total %
2	$226,979	$235,616	$230,556	4%	-2%	2%
5	$226,266	$235,670	$238,073	4%	1%	5%
6	$251,730	$269,163	$270,998	7%	1%	8%

Table 106: Construction cost summary for the Decomposition Results in Model 9bH, 30% WWR

Climate zone	NCC2016	Mixed	NCC2019	Services %	Façade %	Total %
2	$475,275	$500,921	$527,825	5%	5%	11%
5	$476,661	$504,148	$522,808	6%	4%	10%

[6] Note that % figures in this section are rounded

Climate zone	NCC2016	Mixed	NCC2019	Services %	Façade %	Total %
6	$533,227	$554,532	$550,563	4%	-1%	3%

5.4.2 Operational Costs

The lifetime operational costs comparisons for the additional modelling are provided in Table 107 through Table 111.

Table 107: Operational cost summary for the Decomposition Results in Model 3A, 30% WWR

Climate zone	NCC2016	Mixed	NCC2019	Services %	Façade %	Total %
2	$2,958,648	$2,528,076	$2,360,294	-15%	-7%	-20%
5	$2,709,246	$2,380,482	$2,268,708	-12%	-5%	-16%
6	$2,560,501	$2,107,545	$2,072,058	-18%	-2%	-19%

Table 108: Operational cost summary for the Decomposition Results in Model 5A, 40% WWR

Climate zone	NCC2016	Mixed	NCC2019	Services %	Façade %	Total %
2	$2,242,414	$2,082,237	$1,987,014	-7%	-5%	-11%
5	$2,004,613	$1,901,048	$1,824,740	-5%	-4%	-9%
6	$1,767,024	$1,754,358	$1,680,901	-1%	-4%	-5%

Table 109: Operational cost summary for the Decomposition Results in Model 6B, 30% WWR

Climate zone	NCC2016	Mixed	NCC2019	Services %	Façade %	Total %
2	$1,407,495	$1,310,353	$1,319,886	-7%	1%	-6%
5	$1,467,038	$1,335,971	$1,349,497	-9%	1%	-8%
6	$1,447,663	$1,339,260	$1,383,666	-7%	3%	-4%

Table 110: Operational cost summary for the Decomposition Results in Model 9aC, 30% WWR

Climate zone	NCC2016	Mixed	NCC2019	Services %	Façade %	Total %
2	$257,340	$233,130	$230,484	-9%	-1%	-10%
5	$233,838	$216,799	$218,270	-7%	1%	-7%
6	$227,478	$218,108	$242,994	-4%	11%	7%

Table 111: Operational cost summary for the Decomposition Results in Model 9bH, 30% WWR

Climate zone	NCC2016	Mixed	NCC2019	Services %	Façade %	Total %
2	$999,923	$791,274	$790,394	-21%	0%	-21%
5	$820,559	$712,384	$727,502	-13%	2%	-11%
6	$959,508	$797,245	$835,470	-17%	5%	-13%

5.5 Benefit-Cost Results

5.5.1 Impact of Increased Stringency (Scope 2.1) Modelling Scenarios

The benefit-cost ratio is calculated by dividing the incremental operational cost by the incremental construction cost. A 'Negative Cost' results listed means the NCC2019 scenario has a lower construction cost than NCC2016. A benefit-cost ratio greater than 1 identifies situations where there is a positive operational improvement with an economic return over the lifetime of the model. A positive benefit-cost ratio less than 1 identifies an improvement in operational performance but not on an acceptable economic basis. A negative benefit-cost ratio identifies situations where the operational cost is greater under the new modelling parameters in addition to an increase in construction cost.

5.5.1.1 Scenario 1 (Insulation Thickness >=25mm)

The Class 9aC and Class 6B models have low window to wall ratios and also less stringent (and less expensive) façades. The fact that these buildings have a high surface-to-volume ratio exacerbates this effect and as a result, there is an increase in energy consumption used for heating, while its cooling requirements are lower. In buildings with lower surface-to-volume ratios and higher window wall ratios, it would be expected that the increase in building services would be enough to offset this impact. This is because the lower the surface-to-volume ratio is, the less impact façade performance has on overall energy consumption. However, in such buildings, the increased services cost and resulting efficiency sometimes is not enough to offset the poorer performing façade.

Table 112: Pricing variation and benefit-cost results for the impact of increased stringency modelling in Model 3A, 30% WWR

Region	Construction Cost Variation	Operational Cost Variation	Benefit-Cost Result
CZ1	-$97,139	-$235,381	negative cost
CZ2	$23,460	-$598,355	25.5
CZ3	-$7,420	-$439,460	negative cost
CZ4	-$9,230	-$475,802	negative cost
CZ5	$41,094	-$440,537	10.7
CZ6	-$6,539	-$488,443	negative cost
CZ7	-$114,964	-$451,866	negative cost

Table 113: Pricing variation and benefit-cost results for the impact of increased stringency modelling in Model 9aC, 30% WWR

Region	Construction Cost Variation	Operational Cost Variation	Benefit-Cost Result
CZ1	$7,499	-$45,321	6.0
CZ2	$3,577	-$26,855	7.5
CZ3	-$652	-$34,898	negative cost
CZ4	$12,577	-$14,762	1.2
CZ5	$11,807	-$15,568	1.3
CZ6	$19,269	$15,517	-0.8

Region	Construction Cost Variation	Operational Cost Variation	Benefit-Cost Result
CZ7	$20,420	$9,853	-0.5

Table 114: Pricing variation and benefit-cost results for the impact of increased stringency modelling in Model 5A, 56% WWR

Region	Construction Cost Variation	Operational Cost Variation	Benefit-Cost Result
CZ1	-$124,943	-$473,901	negative cost
CZ2	$51,481	-$277,261	5.4
CZ3	$516,040	-$156,056	0.3
CZ4	-$49,571	-$151,339	negative cost
CZ5	$89,160	-$204,241	2.3
CZ6	-$213,272	-$115,215	negative cost
CZ7	-$130,716	-$95,201	negative cost

Table 115: Pricing variation and benefit-cost results for the impact of increased stringency modelling in Model 6B, 30% WWR

Region	Construction Cost Variation	Operational Cost Variation	Benefit-Cost Result
CZ1	-$224	-$121,803	negative cost
CZ2	$6,647	-$87,609	13.2
CZ3	$22,507	-$113,697	5.1
CZ4	$29,557	-$75,946	2.6
CZ5	$11,327	-$117,542	10.4
CZ6	$15,139	-$63,997	4.2
CZ7	$24,469	$26,447	-1.1

Table 116: Pricing variation and benefit-cost results for the impact of increased stringency modelling in Model 9bH, 30% WWR

Region	Construction Cost Variation	Operational Cost Variation	Benefit-Cost Result
CZ1	$13,836	-$344,870	24.9
CZ2	$49,024	-$209,529	4.3
CZ3	$29,794	-$211,300	7.1
CZ4	$44,411	-$142,141	3.2
CZ5	$45,887	-$93,057	2.0
CZ6	$17,075	-$124,038	7.3
CZ7	$18,135	-$167,208	9.2

Table 117: Pricing variation and benefit-cost results for the impact of increased stringency modelling in Model 5A, 40% WWR

Region	Construction Cost Variation	Operational Cost Variation	Benefit-Cost Result
CZ1	$78,518	-$124,035	1.6
CZ2	$33,275	-$255,400	7.7
CZ3	$105,660	-$88,205	0.8
CZ4	$58,734	-$90,487	1.5

Region	Construction Cost Variation	Operational Cost Variation	Benefit-Cost Result
CZ5	$102,397	-$179,872	1.8
CZ6	$41,789	-$86,123	2.1
CZ7	$4,175	-$58,070	13.9

5.5.1.2 Scenario 2 (Insulation Thickness 25mm-90mm)

Table 118: Pricing variation and benefit-cost results for the impact of increased stringency modelling for Model 3A, 30% WWR

Region	Construction Cost Variation	Operational Cost Variation	Benefit-Cost Result
CZ1	-$95,805	-$235,381	negative cost
CZ2	$24,794	-$598,355	24.1
CZ3	-$6,086	-$439,460	negative cost
CZ4	-$9,230	-$475,802	negative cost
CZ5	$41,094	-$440,537	10.7
CZ6	-$6,539	-$488,443	negative cost
CZ7	-$114,964	-$451,866	negative cost

Table 119: Pricing variation and benefit-cost results for the impact of increased stringency modelling for Model 5A, 56% WWR

Region	Construction Cost Variation	Operational Cost Variation	Benefit-Cost Result
CZ1	-$117,314	-$473,901	negative cost
CZ2	$59,109	-$277,261	4.7
CZ3	$523,668	-$156,056	0.3
CZ4	-$47,320	-$151,339	negative cost
CZ5	$91,412	-$204,241	2.2
CZ6	-$211,020	-$115,215	negative cost
CZ7	-$128,157	-$95,201	negative cost

Table 120: Pricing variation and benefit-cost results for the impact of increased stringency modelling for Model 6B, 30% WWR

Region	Construction Cost Variation	Operational Cost Variation	Benefit-Cost Result
CZ1	$1,925	-$121,803	63.3
CZ2	$8,796	-$87,609	10.0
CZ3	$24,656	-$113,697	4.6
CZ4	$31,706	-$75,946	2.4
CZ5	$13,476	-$117,542	8.7
CZ6	$17,288	-$63,997	3.7
CZ7	$26,618	$26,447	-1.0

Table 121: Pricing variation and benefit-cost results for the impact of increased stringency modelling for Model 9bH, 30% WWR

Region	Construction Cost Variation	Operational Cost Variation	Benefit-Cost Result
CZ1	$17,361	-$344,870	19.9
CZ2	$52,550	-$209,529	4.0
CZ3	$33,320	-$211,300	6.3
CZ4	$44,671	-$142,141	3.2

Region	Construction Cost Variation	Operational Cost Variation	Benefit-Cost Result
CZ5	$46,147	-$93,057	2.0
CZ6	$17,336	-$124,038	7.2
CZ7	$18,395	-$167,208	9.1

Table 122: Pricing variation and benefit-cost results for the impact of increased stringency modelling for Model 5A, 40% WWR

Region	Construction Cost Variation	Operational Cost Variation	Benefit-Cost Result
CZ1	$86,435	-$124,035	1.4
CZ2	$41,192	-$255,400	6.2
CZ3	$113,578	-$88,205	0.8
CZ4	$59,319	-$90,487	1.5
CZ5	$102,982	-$179,872	1.7
CZ6	$42,374	-$86,123	2.0
CZ7	$4,760	-$58,070	12.2

5.5.2 Façade vs Services Contribution (Decomposition Results) Modelling Scenarios

The resulting benefit-cost ratios for the decomposition results analysis is as follows:

Table 123: Benefit-cost results for the façade vs services analysis in Model 3A, 30% WWR

Subject Area	Region	Construction Cost Variation	Operational Cost Variation	Benefit-Cost Result
Services	CZ2	$11,045	-$430,572	39.0
Facade	CZ2	$13,750	-$167,782	12.2
Services	CZ5	$105,362	-$328,764	3.1
Facade	CZ5	-$64,267	-$111,774	negative cost
Services	CZ6	$19,114	-$452,956	23.7
Façade	CZ6	-$25,653	-$35,487	negative cost

Table 124: Benefit-cost results for the façade vs services analysis in Model 5A, 40% WWR

Subject Area	Region	Construction Cost Variation	Operational Cost Variation	Benefit-Cost Result
Services	CZ2	$14,487	-$160,177	11.1
Facade	CZ2	$26,706	-$95,223	3.6
Services	CZ5	$83,938	-$103,565	1.2
Facade	CZ5	$19,044	-$76,307	4.0
Services	CZ6	$123,173	-$12,665	0.1
Façade	CZ6	-$80,799	-$73,457	negative cost

Table 125: Benefit-cost results for the façade vs services analysis in Model 6B, 30% WWR

Subject Area	Region	Construction Cost Variation	Operational Cost Variation	Benefit-Cost Result
Services	CZ2	$5,161	-$97,142	18.8
Facade	CZ2	$3,635	$9,533	-2.6
Services	CZ5	$6,202	-$131,067	21.1
Facade	CZ5	$7,274	$13,525	-1.9
Services	CZ6	$12,769	-$108,403	8.5
Façade	CZ6	$4,519	$44,406	-9.8

Table 126: Benefit-cost results for the façade vs services analysis in Model 9aC, 30% WWR

Subject Area	Region	Construction Cost Variation	Operational Cost Variation	Benefit-Cost Result
Services	CZ2	$8,637	-$24,209	2.8
Facade	CZ2	-$5,060	-$2,646	negative Cost
Services	CZ5	$9,404	-$17,039	1.8
Facade	CZ5	$2,403	$1,471	-0.6
Services	CZ6	$17,434	-$9,370	0.5
Façade	CZ6	$1,835	$24,886	-13.6

Table 127: Benefit-cost results for the façade vs services analysis in Model 9bH, 30% WWR

Subject Area	Region	Construction Cost Variation	Operational Cost Variation	Benefit-Cost Result
Services	CZ2	$25,646	-$208,649	8.1
Facade	CZ2	$26,904	-$880	0.0
Services	CZ5	$27,488	-$108,175	3.9
Facade	CZ5	$18,660	$15,118	-0.8
Services	CZ6	$21,305	-$162,263	7.6
Façade	CZ6	-$3,969	$38,225	negative cost

In general, the decomposition results show that building services have significantly better BCRs compared to building façade results. However, when reviewing these BCRs, it is important to keep in mind that the DtS 2016 models disregard lighting and lift costs, so any cost variation needs to caveat that it is not a genuine apples-for-apples comparison. The high BCRs (relative to target BCRs of 1-1.5) observed in the decomposition results is generally driven by high energy savings with low incremental costs – this is often driven by chiller, boilers and fan costs in these situations.

To understand why the BCRs in the decomposition results might be so high, the reader must be reminded that the methodology undertaken to select boiler stringency needed to ensure that there was sufficient available product in the market at the proposed level. The Energy Action report (REP07830-B-022) states that the stringency levels for boiler thermal efficiency were selected at the point where there was a marked drop in number of chillers and boilers with BCR >1.0 across all climate zones, even though the cost-benefit analysis justified a higher level of stringency.

Secondly, the construction costs for HVAC equipment is driven by building peak load which may be very different from the building energy consumed. HVAC equipment may be similarly sized or have a smaller capacity in 2019 compared to 2016 (hence resulting in low incremental construction costs), but have very different energy profiles at part load performance. Calculated based on our chiller cost regression equations, the differential costs are very small in most cases. This may be another driver for why BCRs can seem deceptively high due to a small cost difference and high operational energy differences.

These issues taken together mean that in many instances the cost of a chiller selected to comply with 2019 provisions was only slightly different to that of a 2016 compliant chiller, despite being more efficient, resulting in high BCRs.

6. Conclusion

6.1 Discussion

The results presented in this report demonstrate that the NCC2019 provisions reduce greenhouse gas emissions and operational costs for various building archetypes. Table 128 presents the emissions variation for each archetype and climate zone modelled in the impact of increased stringency analysis. The operational cost variation is similarly presented in Table 129 below before the benefit cost ratios for the impact of increased stringency analysis.

Table 128: Change in annual greenhouse gas emissions from the impact of increased stringency scope of analysis.

Location	3A 30%	9aC 30%	5A 56%	6B 30%	9bH 30%	5A 40%
Climate zone 1	-10%	-21%	-7%	-11%	-26%	-10%
Climate zone 2	-23%	-20%	-9%	-12%	-34%	-12%
Climate zone 3	-19%	-21%	-5%	-14%	-23%	-7%
Climate zone 4	-22%	-18%	-11%	-14%	-22%	-9%
Climate zone 5	-21%	-18%	-12%	-16%	-20%	-12%
Climate zone 6	-23%	-13%	-11%	-15%	-20%	-11%
Climate zone 7	-22%	-22%	-16%	2%	-23%	-11%

Table 129: Operational cost variation from the impact of increased stringency scope of analysis.

Location	3A 30%	9aC 30%	5A 56%	6B 30%	9bH 30%	5A 40%
Climate zone 1	-7%	-12%	-16%	-7%	-21%	-5%
Climate zone 2	-20%	-10%	-12%	-6%	-21%	-11%
Climate zone 3	-16%	-11%	-7%	-7%	-16%	-4%
Climate zone 4	-18%	-6%	-8%	-5%	-14%	-5%
Climate zone 5	-16%	-7%	-10%	-8%	-11%	-9%
Climate zone 6	-19%	7%	-6%	-4%	-13%	-5%
Climate zone 7	-18%	4%	-5%	2%	-14%	-3%

Table 130: Benefit cost ratios for the impact of increased stringency scope of analysis (Scenario 1 analysis).

Location	3A 30%	9aC 30%	5A 56%	6B 30%	9bH 30%	5A 40%
Climate zone 1	negative cost	6.0	negative cost	negative cost	24.9	1.6
Climate zone 2	25.5	7.5	6.3	13.2	4.3	7.7
Climate zone 3	negative cost	negative cost	0.3	5.1	7.1	0.8
Climate zone 4	negative cost	1.2	negative cost	2.6	3.2	1.5
Climate zone 5	10.7	1.3	2.4	10.4	2.0	1.8
Climate zone 6	negative cost	-0.8	negative cost	4.2	7.3	2.1
Climate zone 7	negative cost	-0.5	negative cost	-1.1	9.2	13.9

In all but three of the models, buildings constructed using the NCC2019 DTS outperform those using DTS NCC2016 by having lower energy use and greenhouse gas emissions, and in many cases have lower construction costs. Negative benefit-cost ratios were found for Class 6B (retail) for climate zone 7 and Class 9aC (clinic) in climate zones 6 and 7. This is primarily due to apparent over-stringency in these climate zones in NCC 2016, weaker façade provisions for display glazing and a high surface-to-volume ratio for the Class 9aC building archetype. A high surface-to-volume ratio building places higher reliance on high performance building façades. This archetype resulted in higher energy consumption for these cooler climate zones. Construction costs for these negative BCR scenarios are both driven by increased services construction costs; façade construction costs have decreased across the board. In particular, Fan Coil Units in the 6B model in climate zone 7 which, as noted above, were required to have a higher capacity due to peak load heating requirements. This is due to the display glazing in 2019 being less stringent than 2016, leading to a higher peak load. As discussed previously, the over-stringent glazing in 2016 has been resolved in the proposed 2019 provisions. It should be noted that the internal heat gains from computers, equipment and lighting etc. between 2016 and 2019 models are identical. The modelling generally supports the reliance of NCC2019 provisions and principles but places less emphasis on less important factors relative to performance.

The results from the analysis of increased stringency show the NCC2019 proposed provisions produce a net benefit relative to the NCC2016 provisions. The decomposition results show that the NCC2019 HVAC services provisions typically have the greater impact on building energy improvement compared to the façade provisions. The proposed stringency for services generally increase the construction cost and reduce the operation cost to greater degrees than the façade updates.

6.2 Conclusion

Based on the results presented in this report it can be concluded that no reduction in the NCC 2019 propsed stringency is required to the DTS measures to ensure a satisfactory outcome on a whole-of-building basis. Despite the variations depending on building archetype and climate zone, the results show that, in almost all cases modelled, the proposed DTS provisions lead to reductions in a building's energy use, greenhouse gas emissions and reductions in operational costs. This is consistent with earlier modelling results and confirm that the proposals are sound. The small number of scenarios where worse performing outcomes are achieved are primarily explained by the changes in methodology for facades, which corrects over-stringency in the 2016 DTS glazing provisions.

A. Appendix – Simulation Results

A.I NCC2016 Modelling Scenarios – Impact of Increased Stringency

A.I.I Model 3A 30 WWR

Table 131: Simulation results for climate zone 1 NCC2016 3A with 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone1-Class3A-FCU-Base Case-DTS Update.aps	Zone1-Class3A-FCU-Base Case-DTS Update.aps	Zone1-Class3A-FCU-Base Case-DTS Update.aps	Zone1-Class3A-FCU-Base Case-DTS Update.aps	Zone1-Class3A-FCU-Base Case-DTS Update.aps	Zone1-Class3A-FCU-Base Case-DTS Update.aps
Jan 01-31	35.7968	0	40.1107	0.4651	10.5514	5.6106
Feb 01-28	31.7045	0	36.1518	0.3923	9.5101	5.0677
Mar 01-31	36.0442	0	39.9613	0.4627	10.5122	5.6106
Apr 01-30	30.9221	0	38.6915	0.3691	9.8087	5.4297
May 01-31	28.9694	0	40.1107	0.345	10.0198	5.6106
Jun 01-30	23.1802	0	38.6915	0.2641	7.869	5.4297
Jul 01-31	24.0436	0	40.036	0.2859	8.5131	5.6106
Aug 01-31	25.2316	0	40.036	0.3043	9.846	5.6106
Sep 01-30	28.0737	0	38.6915	0.3212	10.1782	5.4297
Oct 01-31	32.2429	0	40.1107	0.3812	10.3862	5.6106
Nov 01-30	34.1615	0	38.6915	0.435	10.1781	5.4297
Dec 01-31	35.5361	0	39.9613	0.4388	10.512	5.6106
Summed total	365.9064	0	471.2444	4.4648	117.8847	66.0609

When 9.54MWh is added for the lifts, this results in a total of 1035.10MWh[7].

Table 132: Simulation results for climate zone 2 NCC2016 3A with 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone2-Class3A-FCU-Base Case-DTS Update.aps	Zone2-Class3A-FCU-Base Case-DTS Update.aps	Zone2-Class3A-FCU-Base Case-DTS Update.aps	Zone2-Class3A-FCU-Base Case-DTS Update.aps	Zone2-Class3A-FCU-Base Case-DTS Update.aps	Zone2-Class3A-FCU-Base Case-DTS Update.aps
Jan 01-31	33.1475	0	40.1177	0.3268	11.2889	5.6106
Feb 01-28	29.6796	0	36.1582	0.2984	9.8959	5.0677
Mar 01-31	29.1737	0	39.9683	0.2773	9.1801	5.6106
Apr 01-30	26.3266	0.0298	38.6982	0.2613	6.1933	5.4297
May 01-31	24.8401	0.4338	40.1177	0.3012	4.7966	5.6106
Jun 01-30	18.3898	1.76	38.6982	0.5979	3.0561	5.4297
Jul 01-31	15.8181	4.3125	40.043	0.678	2.6284	5.6106
Aug 01-31	19.2148	3.1453	40.043	0.5599	3.2525	5.6106
Sep 01-30	24.5964	0.0539	38.6982	0.2723	4.2545	5.4297
Oct 01-31	26.9502	0.001	40.1177	0.2405	5.4472	5.6106
Nov 01-30	27.8874	0	38.6982	0.2606	7.2253	5.4297

[7] In this and subsequent tables the annual lift energy use is provided separately for the purpose of completeness, as the Simulation results in Chapter 4 of this document include lift energy use.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Dec 01-31	29.8066	0	39.9683	0.2839	8.677	5.6106
Summed total	305.8309	9.7364	471.3267	4.3581	75.8958	66.0609

When 9.54MWh is added for the lifts, this results in a total of 942.75MWh.

Table 133: Simulation results for climate zone 3 NCC2016 3A with 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone3-Class3A-FCU-Base Case-DTS Update.aps	Zone3-Class3A-FCU-Base Case-DTS Update.aps	Zone3-Class3A-FCU-Base Case-DTS Update.aps	Zone3-Class3A-FCU-Base Case-DTS Update.aps	Zone3-Class3A-FCU-Base Case-DTS Update.aps	Zone3-Class3A-FCU-Base Case-DTS Update.aps
Jan 01-31	26.6857	0	40.1038	0.349	6.8894	5.6106
Feb 01-28	24.2098	0	36.1458	0.3083	5.7718	5.0677
Mar 01-31	24.5622	0	39.9545	0.2998	5.3679	5.6106
Apr 01-30	22.2516	0	38.6849	0.2715	4.8088	5.4297
May 01-31	17.9739	0.8192	40.1038	0.381	3.6159	5.6106
Jun 01-30	14.3549	2.024	38.6849	0.4612	2.908	5.4297
Jul 01-31	13.5341	3.4511	40.0292	0.437	2.7336	5.6106
Aug 01-31	17.4106	1.7367	40.0292	0.3703	3.4858	5.6106
Sep 01-30	21.1245	0.1055	38.6849	0.316	4.0957	5.4297
Oct 01-31	22.5891	0.0235	40.1038	0.2937	4.472	5.6106
Nov 01-30	24.0797	0	38.6849	0.3059	5.6583	5.4297
Dec 01-31	25.895	0	39.9545	0.3257	5.8449	5.6106
Summed total	254.671	8.16	471.1645	4.1193	55.6521	66.0609

When 9.54MWh is added for the lifts, this results in a total of 869.37MWh.

Table 134: Simulation results for climate zone 4 NCC2016 3A with 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone4-Class3A-FCU-Base Case-DTS Update.aps	Zone4-Class3A-FCU-Base Case-DTS Update.aps	Zone4-Class3A-FCU-Base Case-DTS Update.aps	Zone4-Class3A-FCU-Base Case-DTS Update.aps	Zone4-Class3A-FCU-Base Case-DTS Update.aps	Zone4-Class3A-FCU-Base Case-DTS Update.aps
Jan 01-31	24.6964	0	40.1112	0.2973	5.1293	5.6106
Feb 01-28	22.3254	0	36.1524	0.2899	5.0452	5.0677
Mar 01-31	23.0012	0	39.9618	0.2706	4.5951	5.6106
Apr 01-30	19.3554	0.2214	38.692	0.3215	3.8652	5.4297
May 01-31	14.2049	3.0437	40.1112	0.4314	2.8739	5.6106
Jun 01-30	6.8161	8.2706	38.692	0.5465	1.3839	5.4297
Jul 01-31	3.8556	12.2238	40.0365	0.5741	0.785	5.6106
Aug 01-31	7.6777	6.5156	40.0365	0.6572	1.5551	5.6106
Sep 01-30	11.8307	3.9176	38.692	0.5463	2.3962	5.4297
Oct 01-31	18.7821	0.4459	40.1112	0.4097	3.7783	5.6106
Nov 01-30	21.0304	0.0362	38.692	0.2652	4.1789	5.4297
Dec 01-31	23.4548	0	39.9618	0.2681	4.5537	5.6106

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Summed total	197.0307	34.6747	471.2508	4.8779	40.1399	66.0609

When 9.54MWh is added for the lifts, this results in a total of 823.58MWh.

Table 135: Simulation results for climate zone 5 NCC2016 3A with 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone5-Class3A-FCU-Base Case-DTS Update.aps	Zone5-Class3A-FCU-Base Case-DTS Update.aps	Zone5-Class3A-FCU-Base Case-DTS Update.aps	Zone5-Class3A-FCU-Base Case-DTS Update.aps	Zone5-Class3A-FCU-Base Case-DTS Update.aps	Zone5-Class3A-FCU-Base Case-DTS Update.aps
Jan 01-31	23.2043	0	40.105	0.2566	6.3157	5.6106
Feb 01-28	21.8273	0	36.1468	0.246	6.9	5.0677
Mar 01-31	23.0896	0	39.9557	0.2515	6.4604	5.6106
Apr 01-30	21.0715	0	38.6861	0.2086	4.7356	5.4297
May 01-31	20.5446	0.0252	40.105	0.2382	4.2733	5.6106
Jun 01-30	16.5653	0.2597	38.6861	0.4884	3.3953	5.4297
Jul 01-31	14.191	1.6432	40.0304	0.6108	2.9045	5.6106
Aug 01-31	17.2331	0.3407	40.0304	0.5019	3.5236	5.6106
Sep 01-30	19.4626	0.0229	38.6861	0.2442	4.0123	5.4297
Oct 01-31	21.5971	0.0041	40.105	0.2248	4.662	5.6106
Nov 01-30	21.354	0	38.6861	0.2139	5.0263	5.4297
Dec 01-31	23.2428	0	39.9557	0.2459	6.5924	5.6106
Summed total	243.3832	2.2958	471.1783	3.7309	58.8014	66.0609

When 9.54MWh is added for the lifts, this results in a total of 854.99MWh.

Table 136: Simulation results for climate zone 6 NCC2016 3A with 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone6-Class3A-FCU-Base Case-DTS Update.aps	Zone6-Class3A-FCU-Base Case-DTS Update.aps	Zone6-Class3A-FCU-Base Case-DTS Update.aps	Zone6-Class3A-FCU-Base Case-DTS Update.aps	Zone6-Class3A-FCU-Base Case-DTS Update.aps	Zone6-Class3A-FCU-Base Case-DTS Update.aps
Jan 01-31	22.9172	0	40.1177	0.2378	4.726	5.6106
Feb 01-28	21.6106	0	36.1582	0.2374	4.9176	5.0677
Mar 01-31	22.171	0.0073	39.9683	0.2436	4.5321	5.6106
Apr 01-30	18.6554	0.2388	38.6982	0.3526	3.7202	5.4297
May 01-31	14.2814	1.7883	40.1177	0.5179	2.8593	5.6106
Jun 01-30	6.6026	5.069	38.6982	0.7921	1.3247	5.4297
Jul 01-31	4.3089	9.9505	40.043	0.6959	0.8655	5.6106
Aug 01-31	8.9286	5.5918	40.043	0.629	1.7887	5.6106
Sep 01-30	13.5251	2.3756	38.6982	0.5794	2.7048	5.4297
Oct 01-31	18.3203	0.55	40.1177	0.4284	3.6506	5.6106
Nov 01-30	19.9294	0.1024	38.6982	0.3141	3.9844	5.4297
Dec 01-31	22.2238	0.0049	39.9683	0.238	4.5082	5.6106
Summed total	193.4745	25.6785	471.3266	5.2663	39.5821	66.0609

When 9.54MWh is added for the lifts, this results in a total of 810.93MWh.

Table 137: Simulation results for climate zone 7 NCC2016 3A with 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone7-Class3A-FCU-Base Case-DTS Update.aps	Zone7-Class3A-FCU-Base Case-DTS Update.aps	Zone7-Class3A-FCU-Base Case-DTS Update.aps	Zone7-Class3A-FCU-Base Case-DTS Update.aps	Zone7-Class3A-FCU-Base Case-DTS Update.aps	Zone7-Class3A-FCU-Base Case-DTS Update.aps
Jan 01-31	21.2469	0	40.1162	0.2788	4.6314	5.6106
Feb 01-28	19.3833	0	36.157	0.2633	4.5785	5.0677
Mar 01-31	19.666	0	39.9668	0.2415	4.4136	5.6106
Apr 01-30	16.3772	0.3092	38.6969	0.3407	3.759	5.4297
May 01-31	11.7424	3.0683	40.1162	0.396	2.728	5.6106
Jun 01-30	5.6087	9.2985	38.6969	0.4347	1.3081	5.4297
Jul 01-31	3.4562	13.3314	40.0415	0.4028	0.8058	5.6106
Aug 01-31	7.2384	5.6169	40.0415	0.6665	1.6874	5.6106
Sep 01-30	12.2112	2.4575	38.6969	0.4125	2.8304	5.4297
Oct 01-31	16.4291	0.5865	40.1162	0.3365	3.7605	5.6106
Nov 01-30	19.0662	0.0011	38.6969	0.2326	4.2794	5.4297
Dec 01-31	20.224	0	39.9668	0.2499	4.5169	5.6106
Summed total	172.6497	34.6694	471.3098	4.2559	39.299	66.0609

When 9.54MWh is added for the lifts, this results in a total of 804.20MWh.

A.I.II Model 5A Sensitivity 56 WWR for CZ 1-6 and 50 WWR for CZ 7

Table 138: Simulation results for climate zone 1 NCC 2016 5A Sensitivity 56 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone1-Class5A-VAV-Base Case-Final RIS-R1.aps	Zone1-Class5A-VAV-Base Case-Final RIS-R1.aps	Zone1-Class5A-VAV-Base Case-Final RIS-R1.aps	Zone1-Class5A-VAV-Base Case-Final RIS-R1.aps	Zone1-Class5A-VAV-Base Case-Final RIS-R1.aps	Zone1-Class5A-VAV-Base Case-Final RIS-R1.aps
Jan 01-31	24.64	-	11.77	1.59	4.76	12.59
Feb 01-28	23.31	-	11.07	1.49	4.53	11.83
Mar 01-31	27.10	-	12.88	1.74	5.21	13.47
Apr 01-30	22.22	-	11.67	1.38	4.91	12.92
May 01-31	20.09	-	10.99	1.23	4.69	12.59
Jun 01-30	16.16	0.00	10.77	0.77	4.09	12.92
Jul 01-31	16.75	-	10.67	0.81	4.41	13.03
Aug 01-31	17.92	0.00	10.96	0.96	4.68	13.03
Sep 01-30	20.70	-	11.22	1.23	4.99	12.92
Oct 01-31	21.86	-	11.17	1.44	4.70	12.59
Nov 01-30	25.79	-	12.49	1.73	4.99	12.92
Dec 01-31	26.25	-	12.68	1.68	5.21	13.47
Summed total	262.79	0.00	138.33	16.05	57.17	154.30

When 55.54MWh is added for the lifts, this results in a total of 684.18MWh.

Table 139: Simulation results for climate zone 2 NCC 2016 5A Sensitivity 56 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone2-Class5A-VAV-Base Case-DTS Update.aps	Zone2-Class5A-VAV-Base Case-DTS Update.aps	Zone2-Class5A-VAV-Base Case-DTS Update.aps	Zone2-Class5A-VAV-Base Case-DTS Update.aps	Zone2-Class5A-VAV-Base Case-DTS Update.aps	Zone2-Class5A-VAV-Base Case-DTS Update.aps
Jan 01-31	20.65	0.01	0.84	10.84	5.95	12.59
Feb 01-28	19.98	0.01	0.84	10.33	5.64	11.83
Mar 01-31	18.35	0.00	0.52	11.02	6.26	13.47
Apr 01-30	14.26	0.34	0.31	9.79	4.62	12.92
May 01-31	10.11	1.03	0.20	8.27	3.26	12.59
Jun 01-30	6.14	2.89	0.19	7.33	1.60	12.92
Jul 01-31	4.87	4.26	0.23	7.00	1.22	13.03
Aug 01-31	7.85	2.63	0.19	8.38	2.11	13.03
Sep 01-30	11.16	0.73	0.17	9.48	3.21	12.92
Oct 01-31	12.42	0.32	0.26	9.56	3.63	12.59
Nov 01-30	16.93	0.09	0.51	11.02	5.14	12.92
Dec 01-31	19.58	0.05	0.67	11.58	6.10	13.47
Summed total	162.29	12.36	4.93	114.61	48.73	154.30

When 55.54MWh is added for the lifts, this results in a total of 552.77MWh.

Table 140: Simulation results for climate zone 3 NCC 2016 5A Sensitivity 56 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Lights electricity (MWh)
Model	Zone3-Class5A-VAV-Base Case-DTS Update.aps	Zone3-Class5A-VAV-Base Case-DTS Update.aps	Zone3-Class5A-VAV-Base Case-DTS Update.aps	Zone3-Class5A-VAV-Base Case-DTS Update.aps	Zone3-Class5A-VAV-Base Case-DTS Update.aps	Zone3-Class5A-VAV-Base Case-DTS Update.aps
Jan 01-31	21.33	0.05	10.86	1.38	4.82	12.59
Feb 01-28	19.94	0.09	10.28	1.25	4.36	11.83
Mar 01-31	18.35	0.39	11.19	0.92	3.77	13.47
Apr 01-30	14.67	0.87	9.90	0.60	3.38	12.92
May 01-31	6.76	2.36	7.41	0.23	1.58	12.59
Jun 01-30	3.61	4.32	6.34	0.24	0.89	12.92
Jul 01-31	4.52	4.72	6.83	0.22	1.09	13.03
Aug 01-31	5.86	3.14	7.19	0.21	1.32	13.03
Sep 01-30	13.09	0.84	9.86	0.49	2.68	12.92
Oct 01-31	12.54	0.67	9.09	0.52	2.67	12.59
Nov 01-30	19.75	0.10	10.95	1.10	4.43	12.92
Dec 01-31	21.02	0.12	11.57	1.26	4.26	13.47
Summed total	161.44	17.67	111.45	8.43	35.24	154.30

When 55.54MWh is added for the lifts, this results in a total of 544.07MWh.

Table 141: Simulation results for climate zone 4 NCC 2016 5A Sensitivity 56 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone4-Class5A-VAV-Base Case-DTS Update.aps	Zone4-Class5A-VAV-Base Case-DTS Update.aps	Zone4-Class5A-VAV-Base Case-DTS Update.aps	Zone4-Class5A-VAV-Base Case-DTS Update.aps	Zone4-Class5A-VAV-Base Case-DTS Update.aps	Zone4-Class5A-VAV-Base Case-DTS Update.aps
Jan 01-31	14.23	0.24	11.11	0.61	3.48	12.59
Feb 01-28	14.44	0.24	10.13	0.75	3.61	11.83
Mar 01-31	12.12	0.36	10.94	0.38	2.95	13.47
Apr 01-30	6.92	0.94	8.54	0.22	1.66	12.92
May 01-31	2.13	3.04	5.97	0.12	0.57	12.59
Jun 01-30	0.40	7.79	5.69	0.15	0.11	12.92
Jul 01-31	0.04	9.27	5.61	0.15	0.01	13.03
Aug 01-31	0.79	6.34	5.71	0.13	0.21	13.03
Sep 01-30	1.05	3.12	5.64	0.09	0.27	12.92
Oct 01-31	5.63	0.93	7.90	0.16	1.44	12.59
Nov 01-30	8.74	0.46	9.95	0.21	2.14	12.92
Dec 01-31	14.02	0.30	11.67	0.53	3.23	13.47
Summed total	80.52	33.04	98.84	3.51	19.68	154.30

When 55.54MWh is added for the lifts, this results in a total of 445.43MWh.

Table 142: Simulation results for climate zone 5 NCC 2016 5A Sensitivity 56 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone5-Class5A-VAV-Base Case-DTS Update.aps	Zone5-Class5A-VAV-Base Case-DTS Update.aps	Zone5-Class5A-VAV-Base Case-DTS Update.aps	Zone5-Class5A-VAV-Base Case-DTS Update.aps	Zone5-Class5A-VAV-Base Case-DTS Update.aps	Zone5-Class5A-VAV-Base Case-DTS Update.aps
Jan 01-31	15.11	0.02	11.15	0.65	4.56	12.59
Feb 01-28	15.03	0.05	10.77	0.67	4.39	11.83
Mar 01-31	15.74	0.05	11.54	0.66	4.92	13.47
Apr 01-30	10.80	0.26	9.91	0.47	3.34	12.92
May 01-31	5.31	0.98	6.64	0.37	1.58	12.59
Jun 01-30	2.11	3.16	5.45	0.27	0.59	12.92
Jul 01-31	1.18	4.70	5.64	0.26	0.33	13.03
Aug 01-31	3.85	2.41	7.03	0.27	1.06	13.03
Sep 01-30	5.67	0.79	7.78	0.41	1.61	12.92
Oct 01-31	8.33	0.50	9.08	0.43	2.33	12.59
Nov 01-30	11.31	0.16	10.71	0.47	3.34	12.92
Dec 01-31	14.98	0.06	11.29	0.64	4.45	13.47
Summed total	109.42	13.11	107.00	5.56	32.50	154.30

When 55.54MWh is added for the lifts, this results in a total of 477.42MWh.

Table 143: Simulation results for climate zone 6 NCC 2016 5A Sensitivity 56 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone6-Class5A-VAV-Base Case-DTS.aps	Zone6-Class5A-VAV-Base Case-DTS.aps	Zone6-Class5A-VAV-Base Case-DTS.aps	Zone6-Class5A-VAV-Base Case-DTS.aps	Zone6-Class5A-VAV-Base Case-DTS.aps	Zone6-Class5A-VAV-Base Case-DTS.aps
Jan 01-31	10.18	0.26	9.93	0.25	2.76	12.59
Feb 01-28	10.99	0.27	9.53	0.38	2.83	11.83
Mar 01-31	9.62	0.62	9.91	0.26	2.51	13.47
Apr 01-30	3.31	1.80	6.94	0.12	0.84	12.92
May 01-31	0.84	5.54	5.37	0.12	0.22	12.59
Jun 01-30	-	11.69	6.02	0.17	-	12.92
Jul 01-31	-	13.41	6.52	0.19	-	13.03
Aug 01-31	-	8.97	5.81	0.13	-	13.03
Sep 01-30	0.92	4.29	5.85	0.11	0.24	12.92
Oct 01-31	2.80	2.05	6.68	0.11	0.70	12.59
Nov 01-30	6.06	0.87	8.83	0.18	1.49	12.92
Dec 01-31	8.19	0.47	10.09	0.22	2.09	13.47
Summed total	52.92	50.26	91.48	2.27	13.69	154.30

When 55.54MWh is added for the lifts, this results in a total of 420.46MWh.

Table 144: Simulation results for climate zone 7 NCC 2016 5A Sensitivity 50 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone7-Class5A-VAV-Base Case-DTS Update.aps	Zone7-Class5A-VAV-Base Case-DTS Update.aps	Zone7-Class5A-VAV-Base Case-DTS Update.aps	Zone7-Class5A-VAV-Base Case-DTS Update.aps	Zone7-Class5A-VAV-Base Case-DTS Update.aps	Zone7-Class5A-VAV-Base Case-DTS Update.aps
Jan 01-31	10.17	0.32	10.80	0.41	2.53	12.59
Feb 01-28	11.77	0.18	9.76	0.65	2.98	11.83
Mar 01-31	7.06	0.34	10.24	0.23	1.88	13.47
Apr 01-30	3.94	0.97	7.75	0.14	1.09	12.92
May 01-31	0.22	3.50	5.41	0.09	0.06	12.59
Jun 01-30	0.11	8.18	6.16	0.13	0.03	12.92
Jul 01-31	-	10.51	6.52	0.16	-	13.03
Aug 01-31	0.00	5.59	5.89	0.09	0.00	13.03
Sep 01-30	0.78	2.15	6.22	0.08	0.23	12.92
Oct 01-31	3.03	0.91	7.44	0.13	0.85	12.59
Nov 01-30	6.48	0.32	9.97	0.24	1.76	12.92
Dec 01-31	9.62	0.32	11.48	0.37	2.54	13.47
Summed total	53.18	33.30	97.65	2.73	13.95	154.30

When 55.54MWh is added for the lifts, this results in a total of 410.65MWh.

A.I.III Model 5A 40 WWR

Table 145: Simulation results for climate zone 1 NCC 2016 5A 40 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone1-Class5A-VAV-Base Case-DTS Update.aps	Zone1-Class5A-VAV-Base Case-DTS Update.aps	Zone1-Class5A-VAV-Base Case-DTS Update.aps	Zone1-Class5A-VAV-Base Case-DTS Update.aps	Zone1-Class5A-VAV-Base Case-DTS Update.aps	Zone1-Class5A-VAV-Base Case-DTS Update.aps
Jan 01-31	25.91	-	10.76	1.26	5.05	12.59
Feb 01-28	24.50	-	10.21	1.18	4.81	11.83
Mar 01-31	28.31	-	11.83	1.34	5.53	13.47
Apr 01-30	23.19	0.00	11.11	1.01	5.16	12.92
May 01-31	20.65	0.00	10.52	0.86	4.92	12.59
Jun 01-30	16.64	0.01	10.44	0.51	4.12	12.92
Jul 01-31	17.29	0.00	10.36	0.55	4.51	13.03
Aug 01-31	18.49	0.00	10.68	0.66	4.86	13.03
Sep 01-30	21.53	0.00	10.96	0.85	5.29	12.92
Oct 01-31	22.87	0.00	10.71	1.05	4.96	12.59
Nov 01-30	27.22	-	11.54	1.39	5.29	12.92
Dec 01-31	27.66	-	11.72	1.32	5.53	13.47
Summed total	274.27	0.02	130.84	11.97	60.04	154.30

When 55.54MWh is added for the lifts, this results in a total of 686.98MWh.

Table 146: Simulation results for climate zone 2 NCC 2016 5A 40 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone2-Class5A-VAV-Base Case-DTS Update.aps	Zone2-Class5A-VAV-Base Case-DTS Update.aps	Zone2-Class5A-VAV-Base Case-DTS Update.aps	Zone2-Class5A-VAV-Base Case-DTS Update.aps	Zone2-Class5A-VAV-Base Case-DTS Update.aps	Zone2-Class5A-VAV-Base Case-DTS Update.aps
Jan 01-31	22.02	0.00	10.79	0.87	5.98	12.59
Feb 01-28	21.44	0.00	10.22	0.87	5.66	11.83
Mar 01-31	19.72	0.01	10.82	0.55	6.27	13.47
Apr 01-30	15.41	0.45	9.63	0.33	4.63	12.92
May 01-31	10.88	1.20	8.15	0.19	3.28	12.59
Jun 01-30	6.44	3.46	7.11	0.18	1.56	12.92
Jul 01-31	5.09	5.08	6.81	0.22	1.19	13.03
Aug 01-31	8.32	3.15	8.26	0.19	2.10	13.03
Sep 01-30	11.97	0.92	9.31	0.17	3.21	12.92
Oct 01-31	13.31	0.41	9.42	0.27	3.62	12.59
Nov 01-30	17.89	0.07	10.76	0.49	5.16	12.92
Dec 01-31	20.82	0.07	11.43	0.69	6.14	13.47
Summed total	173.31	14.83	112.69	5.01	48.81	154.30

When 55.54MWh is added for the lifts, this results in a total of 564.49MWh.

Table 147: Simulation results for climate zone 3 NCC 2016 5A 40 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Lights electricity (MWh)
Model	Zone3-Class5A-VAV-Base Case-DTS Update.aps	Zone3-Class5A-VAV-Base Case-DTS Update.aps	Zone3-Class5A-VAV-Base Case-DTS Update.aps	Zone3-Class5A-VAV-Base Case-DTS Update.aps	Zone3-Class5A-VAV-Base Case-DTS Update.aps	Zone3-Class5A-VAV-Base Case-DTS Update.aps
Jan 01-31	22.66	0.09	10.61	1.03	4.98	12.59
Feb 01-28	21.11	0.13	10.00	0.92	4.47	11.83
Mar 01-31	19.47	0.57	10.86	0.65	3.81	13.47
Apr 01-30	15.65	1.41	9.69	0.45	3.41	12.92
May 01-31	7.21	3.53	7.29	0.22	1.56	12.59
Jun 01-30	3.96	6.51	6.35	0.24	0.89	12.92
Jul 01-31	4.93	7.09	6.81	0.23	1.10	13.03
Aug 01-31	6.32	4.69	7.10	0.22	1.31	13.03
Sep 01-30	13.94	1.40	9.62	0.38	2.65	12.92
Oct 01-31	13.13	1.02	8.87	0.37	2.62	12.59
Nov 01-30	20.75	0.16	10.64	0.80	4.49	12.92
Dec 01-31	22.07	0.18	11.28	0.90	4.32	13.47
Summed total	171.20	26.77	109.13	6.41	35.59	154.30

When 55.54MWh is added for the lifts, this results in a total of 558.94MWh.

Table 148: Simulation results for climate zone 4 NCC 2016 5A 40 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone4-Class5A-VAV-Base Case-DTS Update.aps	Zone4-Class5A-VAV-Base Case-DTS Update.aps	Zone4-Class5A-VAV-Base Case-DTS Update.aps	Zone4-Class5A-VAV-Base Case-DTS Update.aps	Zone4-Class5A-VAV-Base Case-DTS Update.aps	Zone4-Class5A-VAV-Base Case-DTS Update.aps
Jan 01-31	13.65	0.25	10.67	0.46	3.40	12.59
Feb 01-28	14.12	0.40	9.87	0.64	3.58	11.83
Mar 01-31	11.69	0.60	10.41	0.27	2.89	13.47
Apr 01-30	6.74	1.78	7.99	0.20	1.63	12.92
May 01-31	2.09	5.62	5.53	0.17	0.55	12.59
Jun 01-30	0.37	13.26	5.42	0.24	0.10	12.92
Jul 01-31	0.03	15.68	5.44	0.25	0.01	13.03
Aug 01-31	0.77	11.50	5.68	0.21	0.20	13.03
Sep 01-30	1.00	6.45	5.48	0.14	0.26	12.92
Oct 01-31	5.49	1.94	7.32	0.16	1.41	12.59
Nov 01-30	8.39	0.92	9.30	0.17	2.07	12.92
Dec 01-31	13.41	0.43	11.12	0.37	3.16	13.47
Summed total	77.74	58.84	94.22	3.28	19.27	154.30

When 55.54MWh is added for the lifts, this results in a total of 463.19MWh.

Table 149: Simulation results for climate zone 5 NCC 2016 5A 40 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone5-Class5A-VAV-Base Case-DTS Update.aps	Zone5-Class5A-VAV-Base Case-DTS Update.aps	Zone5-Class5A-VAV-Base Case-DTS Update.aps	Zone5-Class5A-VAV-Base Case-DTS Update.aps	Zone5-Class5A-VAV-Base Case-DTS Update.aps	Zone5-Class5A-VAV-Base Case-DTS Update.aps
Jan 01-31	16.29	0.08	10.48	0.55	4.72	12.59
Feb 01-28	16.28	0.09	10.12	0.59	4.56	11.83
Mar 01-31	17.03	0.09	10.65	0.59	5.03	13.47
Apr 01-30	11.66	0.75	9.12	0.47	3.31	12.92
May 01-31	5.36	2.63	5.79	0.40	1.44	12.59
Jun 01-30	1.86	7.49	4.72	0.37	0.45	12.92
Jul 01-31	1.20	10.74	5.12	0.32	0.29	13.03
Aug 01-31	4.19	5.67	6.42	0.32	1.01	13.03
Sep 01-30	5.81	2.11	6.76	0.43	1.45	12.92
Oct 01-31	8.70	1.27	8.08	0.45	2.20	12.59
Nov 01-30	12.10	0.45	9.73	0.46	3.30	12.92
Dec 01-31	16.03	0.20	10.27	0.57	4.53	13.47
Summed total	116.49	31.57	97.27	5.52	32.29	154.30

When 55.54MWh is added for the lifts, this results in a total of 492.97MWh.

Table 150: Simulation results for climate zone 6 NCC 2016 5A 40 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone6-Class5A-VAV-Base Case-DTS.aps	Zone6-Class5A-VAV-Base Case-DTS.aps	Zone6-Class5A-VAV-Base Case-DTS.aps	Zone6-Class5A-VAV-Base Case-DTS.aps	Zone6-Class5A-VAV-Base Case-DTS.aps	Zone6-Class5A-VAV-Base Case-DTS.aps
Jan 01-31	10.30	0.30	9.75	0.22	2.76	12.59
Feb 01-28	11.04	0.29	9.34	0.32	2.89	11.83
Mar 01-31	9.86	0.72	9.79	0.23	2.56	13.47
Apr 01-30	3.50	1.84	6.87	0.15	0.88	12.92
May 01-31	0.88	5.65	5.27	0.13	0.23	12.59
Jun 01-30	-	12.00	5.51	0.20	-	12.92
Jul 01-31	-	14.20	5.76	0.23	-	13.03
Aug 01-31	-	9.36	5.40	0.15	-	13.03
Sep 01-30	1.02	4.34	5.80	0.12	0.26	12.92
Oct 01-31	2.93	2.15	6.65	0.11	0.72	12.59
Nov 01-30	6.15	0.96	8.76	0.17	1.49	12.92
Dec 01-31	8.33	0.55	9.91	0.20	2.11	13.47
Summed total	54.01	52.38	88.82	2.22	13.90	154.30

When 55.54MWh is added for the lifts, this results in a total of 421.16MWh.

Table 151: Simulation results for climate zone 7 NCC 2016 5A 40 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone7-Class5A-VAV-Base Case-DTS Update.aps	Zone7-Class5A-VAV-Base Case-DTS Update.aps	Zone7-Class5A-VAV-Base Case-DTS Update.aps	Zone7-Class5A-VAV-Base Case-DTS Update.aps	Zone7-Class5A-VAV-Base Case-DTS Update.aps	Zone7-Class5A-VAV-Base Case-DTS Update.aps
Jan 01-31	9.24	0.68	9.10	0.37	2.24	12.59
Feb 01-28	11.01	0.63	8.36	0.55	2.82	11.83
Mar 01-31	6.26	1.51	8.22	0.21	1.62	13.47
Apr 01-30	3.52	3.25	6.54	0.15	0.94	12.92
May 01-31	0.08	9.67	4.95	0.16	0.02	12.59
Jun 01-30	0.05	19.25	5.82	0.31	0.01	12.92
Jul 01-31	-	24.08	6.21	0.38	-	13.03
Aug 01-31	-	17.49	5.75	0.27	-	13.03
Sep 01-30	0.53	7.93	5.30	0.15	0.14	12.92
Oct 01-31	2.29	3.31	5.89	0.13	0.61	12.59
Nov 01-30	5.21	1.15	7.70	0.20	1.36	12.92
Dec 01-31	8.26	0.76	9.06	0.31	2.13	13.47
Summed total	46.44	89.70	82.89	3.20	11.89	154.30

When 55.54MWh is added for the lifts, this results in a total of 443.97MWh.

A.I.IV Model 6B 30 WWR

Table 152: Simulation results for climate zone 1 NCC2016 6B 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone1-Class6B-NCC2016-DTS Update.aps	Zone1-Class6B-NCC2016-DTS Update.aps	Zone1-Class6B-NCC2016-DTS Update.aps	Zone1-Class6B-NCC2016-DTS Update.aps	Zone1-Class6B-NCC2016-DTS Update.aps	Zone1-Class6B-NCC2016-DTS Update.aps
Jan 01-31	16.15	-	8.28	0.43	2.67	13.12
Feb 01-28	14.37	-	7.48	0.37	2.41	11.85
Mar 01-31	16.29	-	8.28	0.43	2.67	13.12
Apr 01-30	12.90	-	8.02	0.28	2.51	12.70
May 01-31	11.65	0.00	8.28	0.21	2.52	13.12
Jun 01-30	8.96	0.00	8.02	0.11	1.79	12.70
Jul 01-31	9.56	0.00	8.28	0.12	2.05	13.12
Aug 01-31	10.05	0.00	8.28	0.14	2.39	13.12
Sep 01-30	11.46	-	8.02	0.21	2.59	12.70
Oct 01-31	13.58	-	8.28	0.29	2.63	13.12
Nov 01-30	15.17	-	8.02	0.40	2.59	12.70
Dec 01-31	15.68	-	8.28	0.40	2.67	13.12
Summed total	155.81	0.01	97.54	3.39	29.49	154.47

The combined total is 440.71MWh.

Table 153: Simulation results for climate zone 2 NCC2016 6B 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone2-Class6B-NCC2016-DTS Update.aps	Zone2-Class6B-NCC2016-DTS Update.aps	Zone2-Class6B-NCC2016-DTS Update.aps	Zone2-Class6B-NCC2016-DTS Update.aps	Zone2-Class6B-NCC2016-DTS Update.aps	Zone2-Class6B-NCC2016-DTS Update.aps
Jan 01-31	10.49	-	5.09	0.16	2.08	13.12
Feb 01-28	9.60	0.00	4.60	0.16	1.85	11.85
Mar 01-31	8.09	0.00	5.09	0.07	1.90	13.12
Apr 01-30	6.72	0.18	4.93	0.05	1.21	12.70
May 01-31	5.68	0.75	5.09	0.03	0.91	13.12
Jun 01-30	4.31	2.14	4.93	0.04	0.42	12.70
Jul 01-31	3.94	3.44	5.09	0.05	0.38	13.12
Aug 01-31	4.61	2.34	5.09	0.04	0.48	13.12
Sep 01-30	5.54	0.42	4.93	0.03	0.63	12.70
Oct 01-31	6.40	0.15	5.09	0.04	0.91	13.12
Nov 01-30	7.51	0.00	4.93	0.07	1.41	12.70
Dec 01-31	8.48	0.00	5.09	0.10	1.77	13.12
Summed total	81.38	9.43	59.98	0.85	13.94	154.47

The combined total is 320.05MWh.

Table 154: Simulation results for climate zone 3 NCC2016 6B 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Lights electricity (MWh)
Model	Zone3-Class6B-NCC2016-DTS Update.aps	Zone3-Class6B-NCC2016-DTS Update.aps	Zone3-Class6B-NCC2016-DTS Update.aps	Zone3-Class6B-NCC2016-DTS Update.aps	Zone3-Class6B-NCC2016-DTS Update.aps	Zone3-Class6B-NCC2016-DTS Update.aps
Jan 01-31	12.11	0.01	8.29	0.24	1.79	13.12
Feb 01-28	10.78	0.01	7.48	0.21	1.51	11.85
Mar 01-31	9.92	0.09	8.29	0.11	1.17	13.12
Apr 01-30	8.25	0.60	8.02	0.08	1.07	12.70
May 01-31	5.83	3.07	8.29	0.07	0.62	13.12
Jun 01-30	4.37	5.16	8.02	0.07	0.46	12.70
Jul 01-31	4.88	5.71	8.29	0.08	0.51	13.12
Aug 01-31	5.47	3.62	8.29	0.08	0.56	13.12
Sep 01-30	7.87	0.71	8.02	0.07	0.78	12.70
Oct 01-31	8.31	0.58	8.29	0.09	0.90	13.12
Nov 01-30	10.16	0.02	8.02	0.14	1.41	12.70
Dec 01-31	11.17	0.01	8.29	0.19	1.41	13.12
Summed total	99.11	19.59	97.55	1.41	12.19	154.47

The combined total is 446.32MWh.

Table 155: Simulation results for climate zone 4 NCC2016 6B 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone4-Class6B-NCC2016-DTS Update.aps	Zone4-Class6B-NCC2016-DTS Update.aps	Zone4-Class6B-NCC2016-DTS Update.aps	Zone4-Class6B-NCC2016-DTS Update.aps	Zone4-Class6B-NCC2016-DTS Update.aps	Zone4-Class6B-NCC2016-DTS Update.aps
Jan 01-31	8.10	0.09	8.28	0.08	1.10	13.12
Feb 01-28	7.48	0.53	7.48	0.11	1.14	11.85
Mar 01-31	6.94	0.65	8.28	0.06	0.88	13.12
Apr 01-30	5.03	2.28	8.02	0.07	0.58	12.70
May 01-31	2.98	6.95	8.28	0.10	0.35	13.12
Jun 01-30	1.23	14.30	8.02	0.10	0.15	12.70
Jul 01-31	0.45	18.29	8.28	0.10	0.05	13.12
Aug 01-31	1.31	13.43	8.28	0.09	0.15	13.12
Sep 01-30	2.23	8.19	8.02	0.10	0.26	12.70
Oct 01-31	4.86	3.21	8.28	0.07	0.59	13.12
Nov 01-30	5.63	1.40	8.02	0.06	0.66	12.70
Dec 01-31	7.45	0.22	8.28	0.07	0.91	13.12
Summed total	53.70	69.52	97.54	1.00	6.82	154.47

The combined total is 383.06MWh.

Table 156: Simulation results for climate zone 5 NCC2016 6B 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone5-Class6B-NCC2016-DTS Update.aps	Zone5-Class6B-NCC2016-DTS Update.aps	Zone5-Class6B-NCC2016-DTS Update.aps	Zone5-Class6B-NCC2016-DTS Update.aps	Zone5-Class6B-NCC2016-DTS Update.aps	Zone5-Class6B-NCC2016-DTS Update.aps
Jan 01-31	7.29	0.01	8.28	0.19	1.45	13.12
Feb 01-28	7.46	0.01	7.48	0.24	1.55	11.85
Mar 01-31	7.18	0.03	8.28	0.17	1.48	13.12
Apr 01-30	5.64	0.34	8.02	0.09	1.00	12.70
May 01-31	4.25	1.39	8.28	0.08	0.64	13.12
Jun 01-30	2.71	3.87	8.02	0.10	0.38	12.70
Jul 01-31	2.48	6.22	8.28	0.11	0.34	13.12
Aug 01-31	3.30	3.83	8.28	0.10	0.45	13.12
Sep 01-30	4.30	1.26	8.02	0.08	0.61	12.70
Oct 01-31	5.73	0.68	8.28	0.12	0.86	13.12
Nov 01-30	5.86	0.16	8.02	0.09	1.03	12.70
Dec 01-31	7.23	0.05	8.28	0.18	1.36	13.12
Summed total	63.42	17.86	97.54	1.56	11.16	154.47

The combined total is 401.02MWh.

Table 157: Simulation results for climate zone 6 NCC2016 6B 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone6-Class6B-NCC2016-DTS Update.aps	Zone6-Class6B-NCC2016-DTS Update.aps	Zone6-Class6B-NCC2016-DTS Update.aps	Zone6-Class6B-NCC2016-DTS Update.aps	Zone6-Class6B-NCC2016-DTS Update.aps	Zone6-Class6B-NCC2016-DTS Update.aps
Jan 01-31	6.15	0.44	8.29	0.08	0.87	13.12
Feb 01-28	6.54	0.46	7.48	0.11	0.97	11.85
Mar 01-31	5.91	0.97	8.29	0.08	0.81	13.12
Apr 01-30	4.12	2.21	8.02	0.08	0.51	12.70
May 01-31	1.52	7.23	8.29	0.09	0.19	13.12
Jun 01-30	0.27	12.98	8.02	0.09	0.03	12.70
Jul 01-31	0.10	16.77	8.29	0.08	0.01	13.12
Aug 01-31	0.72	11.25	8.29	0.12	0.09	13.12
Sep 01-30	2.19	6.24	8.02	0.10	0.27	12.70
Oct 01-31	3.92	3.34	8.29	0.10	0.48	13.12
Nov 01-30	4.81	1.66	8.02	0.08	0.59	12.70
Dec 01-31	5.56	0.75	8.29	0.09	0.74	13.12
Summed total	41.83	64.29	97.56	1.09	5.57	154.47

The combined total is 364.81MWh.

Table 158: Simulation results for climate zone 7 NCC2016 6B 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone7-Class6B-NCC2016-DTS Update.aps	Zone7-Class6B-NCC2016-DTS Update.aps	Zone7-Class6B-NCC2016-DTS Update.aps	Zone7-Class6B-NCC2016-DTS Update.aps	Zone7-Class6B-NCC2016-DTS Update.aps	Zone7-Class6B-NCC2016-DTS Update.aps
Jan 01-31	6.15	0.37	5.09	0.09	0.63	13.12
Feb 01-28	5.25	0.74	4.60	0.08	0.68	11.85
Mar 01-31	4.43	1.78	5.09	0.06	0.45	13.12
Apr 01-30	3.00	4.51	4.93	0.06	0.31	12.70
May 01-31	0.98	13.83	5.09	0.07	0.10	13.12
Jun 01-30	0.18	22.14	4.93	0.06	0.02	12.70
Jul 01-31	0.07	27.31	5.09	0.08	0.01	13.12
Aug 01-31	0.17	22.26	5.09	0.06	0.02	13.12
Sep 01-30	1.38	11.10	4.93	0.07	0.14	12.70
Oct 01-31	2.77	6.41	5.09	0.07	0.28	13.12
Nov 01-30	4.36	1.63	4.93	0.06	0.45	12.70
Dec 01-31	5.32	0.53	5.09	0.05	0.58	13.12
Summed total	34.06	112.61	59.97	0.82	3.67	154.47

The combined total is 365.59MWh.

A.I.V Model 9aC

Table 159: Simulation results for climate zone 1 NCC2016 9aC 30 WWRs.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone1-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone1-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone1-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone1-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone1-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone1-Class9aC-VAV-Base Case-DTS Update final RIS.aps
Jan 01-31	5.1794	0	1.862	0.144	0.5807	1.2592
Feb 01-28	4.8845	0	1.7673	0.1314	0.5533	1.1828
Mar 01-31	5.6916	0	2.0459	0.1559	0.6363	1.3472
Apr 01-30	4.5756	0	1.9098	0.1086	0.5965	1.2924
May 01-31	4.0696	0	1.8052	0.0914	0.5678	1.2592
Jun 01-30	3.1414	0	1.7408	0.0502	0.4869	1.2924
Jul 01-31	3.2341	0	1.7076	0.0505	0.5206	1.3032
Aug 01-31	3.5043	0	1.7803	0.0611	0.5604	1.3032
Sep 01-30	4.1935	0	1.866	0.0887	0.6071	1.2924
Oct 01-31	4.5456	0	1.8564	0.1141	0.5729	1.2592
Nov 01-30	5.4425	0	2.0062	0.1612	0.609	1.2924
Dec 01-31	5.503	0	2.0238	0.1472	0.6365	1.3472
Summed total	53.9652	0	22.3713	1.3044	6.9278	15.4308

The combined total is 100.00MWh.

Table 160: Simulation results for climate zone 1 NCC2016 9aC 30 WWRs.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone2-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone2-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone2-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone2-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone2-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone2-Class9aC-VAV-Base Case-DTS Update final RIS.aps
Jan 01-31	3.4498	0	1.0237	0.0751	0.6312	1.2592
Feb 01-28	3.3821	0	0.9747	0.0819	0.5951	1.1828
Mar 01-31	2.9181	0.0021	0.9964	0.0401	0.648	1.3472
Apr 01-30	2.2353	0.1239	0.858	0.0227	0.4476	1.2924
May 01-31	1.6038	0.3475	0.7066	0.0154	0.3018	1.2592
Jun 01-30	1.1761	0.9143	0.6212	0.0196	0.1506	1.2924
Jul 01-31	1.092	1.2203	0.623	0.0241	0.1341	1.3032
Aug 01-31	1.3388	0.8291	0.7012	0.0199	0.1876	1.3032
Sep 01-30	1.6823	0.2894	0.7746	0.0141	0.2638	1.2924
Oct 01-31	1.9286	0.1273	0.8125	0.0171	0.3283	1.2592
Nov 01-30	2.6023	0.0067	0.9586	0.0321	0.5035	1.2924
Dec 01-31	3.153	0.0009	1.0624	0.0528	0.6304	1.3472
Summed total	26.5622	3.8614	10.1127	0.4148	4.822	15.4308

The combined total is 61.20MWh.

Table 161: Simulation results for climate zone 3 NCC2016 9aC 30 WWRs.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone3-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone3-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone3-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone3-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone3-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone3-Class9aC-VAV-Base Case-DTS Update final RIS.aps
Jan 01-31	4.01	0.00	1.86	0.10	0.63	1.26
Feb 01-28	3.75	0.00	1.75	0.09	0.54	1.18
Mar 01-31	3.54	0.07	1.92	0.06	0.42	1.35
Apr 01-30	2.84	0.25	1.71	0.04	0.38	1.29
May 01-31	1.76	0.88	1.30	0.03	0.21	1.26
Jun 01-30	1.46	1.62	1.22	0.04	0.18	1.29
Jul 01-31	1.55	1.69	1.27	0.04	0.19	1.30
Aug 01-31	1.65	1.30	1.31	0.04	0.19	1.30
Sep 01-30	2.58	0.32	1.63	0.04	0.28	1.29
Oct 01-31	2.53	0.23	1.54	0.04	0.30	1.26
Nov 01-30	3.62	0.01	1.85	0.06	0.52	1.29
Dec 01-31	3.90	0.00	1.98	0.08	0.49	1.35
Summed total	33.20	6.37	19.34	0.65	4.33	15.43

The combined total is 79.32MWh.

Table 162: Simulation results for climate zone 4 NCC2016 9aC 30 WWRs.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone4-Class9aC-VAV-Base Case_DTS Update final RIS.aps	Zone4-Class9aC-VAV-Base Case_DTS Update final RIS.aps	Zone4-Class9aC-VAV-Base Case_DTS Update final RIS.aps	Zone4-Class9aC-VAV-Base Case_DTS Update final RIS.aps	Zone4-Class9aC-VAV-Base Case_DTS Update final RIS.aps	Zone4-Class9aC-VAV-Base Case_DTS Update final RIS.aps
Jan 01-31	2.57	0.07	1.49	0.03	0.31	1.26
Feb 01-28	2.66	0.19	1.41	0.04	0.37	1.18
Mar 01-31	2.29	0.39	1.46	0.03	0.25	1.35
Apr 01-30	1.58	0.86	1.14	0.03	0.16	1.29
May 01-31	0.82	1.83	0.87	0.04	0.08	1.26
Jun 01-30	0.36	3.47	0.92	0.06	0.04	1.29
Jul 01-31	0.16	4.21	0.90	0.06	0.02	1.30
Aug 01-31	0.39	3.45	0.89	0.05	0.04	1.30
Sep 01-30	0.54	2.57	0.83	0.05	0.06	1.29
Oct 01-31	1.32	1.18	1.01	0.03	0.14	1.26
Nov 01-30	1.75	0.66	1.20	0.02	0.17	1.29
Dec 01-31	2.44	0.21	1.49	0.03	0.26	1.35
Summed total	16.87	19.09	13.61	0.46	1.90	15.43

The combined total is 67.36MWh.

Table 163: Simulation results for climate zone 5 NCC2016 9aC 30 WWRs.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone5-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone5-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone5-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone5-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone5-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone5-Class9aC-VAV-Base Case-DTS Update final RIS.aps
Jan 01-31	2.36	0.03	0.85	0.03	0.45	1.26
Feb 01-28	2.39	0.01	0.81	0.04	0.44	1.18
Mar 01-31	2.46	0.07	0.87	0.03	0.48	1.35
Apr 01-30	1.79	0.25	0.72	0.02	0.30	1.29
May 01-31	0.96	0.78	0.52	0.02	0.14	1.26
Jun 01-30	0.60	1.66	0.49	0.04	0.07	1.29
Jul 01-31	0.57	2.23	0.54	0.04	0.07	1.30
Aug 01-31	0.93	1.47	0.59	0.03	0.11	1.30
Sep 01-30	1.20	0.76	0.58	0.02	0.15	1.29
Oct 01-31	1.52	0.44	0.66	0.02	0.21	1.26
Nov 01-30	1.79	0.19	0.75	0.02	0.29	1.29
Dec 01-31	2.33	0.07	0.82	0.03	0.42	1.35
Summed total	18.90	7.95	8.19	0.33	3.12	15.43

The combined total is 53.92MWh.

Table 164: Simulation results for climate zone 6 NCC2016 9aC 30 WWRs.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone6-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone6-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone6-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone6-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone6-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone6-Class9aC-VAV-Base Case-DTS Update final RIS.aps
Jan 01-31	1.84	0.20	0.68	0.02	0.25	1.26
Feb 01-28	2.04	0.18	0.66	0.03	0.30	1.18
Mar 01-31	1.83	0.42	0.70	0.03	0.24	1.35
Apr 01-30	1.12	0.87	0.55	0.03	0.12	1.29
May 01-31	0.34	1.94	0.49	0.04	0.04	1.26
Jun 01-30	0.06	3.37	0.56	0.05	0.01	1.29
Jul 01-31	0.02	3.65	0.59	0.05	0.00	1.30
Aug 01-31	0.18	2.68	0.55	0.05	0.02	1.30
Sep 01-30	0.68	1.74	0.54	0.04	0.08	1.29
Oct 01-31	1.06	1.04	0.54	0.03	0.12	1.26
Nov 01-30	1.53	0.63	0.64	0.02	0.17	1.29
Dec 01-31	1.73	0.36	0.69	0.02	0.21	1.35
Summed total	12.44	17.07	7.20	0.42	1.55	15.43

The combined total is 54.11MWh.

Table 165: Simulation results for climate zone 7 NCC2016 9aC 30 WWRs.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone7-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone7-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone7-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone7-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone7-Class9aC-VAV-Base Case-DTS Update final RIS.aps	Zone7-Class9aC-VAV-Base Case-DTS Update final RIS.aps
Jan 01-31	1.93	0.14	1.26	0.06	0.22	1.26
Feb 01-28	2.08	0.17	1.21	0.08	0.29	1.18
Mar 01-31	1.54	0.39	1.20	0.03	0.18	1.35
Apr 01-30	1.14	0.83	1.01	0.03	0.14	1.29
May 01-31	0.41	2.22	0.89	0.04	0.05	1.26
Jun 01-30	0.13	3.79	1.01	0.05	0.02	1.29
Jul 01-31	0.10	4.51	1.07	0.06	0.01	1.30
Aug 01-31	0.17	3.48	0.99	0.05	0.02	1.30
Sep 01-30	0.55	2.02	0.94	0.04	0.07	1.29
Oct 01-31	1.04	1.11	0.97	0.03	0.13	1.26
Nov 01-30	1.50	0.37	1.12	0.03	0.18	1.29
Dec 01-31	1.91	0.16	1.28	0.05	0.24	1.35
Summed total	12.50	19.20	12.96	0.56	1.54	15.43

The combined total is 62.18MWh.

A.II NCC2019 Modelling Scenarios – Impact of Increased Stringency

A.II.I Model 3A 30 WWR

Table 166: Simulation results for climate zone 1 NCC2019 3A with 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone1-Class3A-NCC2019-DTS Update final RIS 1.aps	Zone1-Class3A-NCC2019-DTS Update final RIS 1.aps	Zone1-Class3A-NCC2019-DTS Update final RIS 1.aps	Zone1-Class3A-NCC2019-DTS Update final RIS 1.aps	Zone1-Class3A-NCC2019-DTS Update final RIS 1.aps	Zone1-Class3A-NCC2019-DTS Update final RIS 1.aps
Jan 01-31	37.8219	0	32.8611	0.2132	7.7082	5.6106
Feb 01-28	33.713	0	29.6178	0.18	6.9475	5.0677
Mar 01-31	38.1666	0	32.7387	0.2113	7.6795	5.6106
Apr 01-30	32.9719	0	31.6984	0.1718	7.131	5.4297
May 01-31	30.4548	0	32.8611	0.1648	7.2486	5.6106
Jun 01-30	22.9726	0	31.6984	0.1309	5.513	5.4297
Jul 01-31	23.6669	0	32.7999	0.1406	5.9528	5.6106
Aug 01-31	25.781	0	32.7999	0.1488	7.0674	5.6106
Sep 01-30	29.9598	0	31.6984	0.1532	7.4357	5.4297
Oct 01-31	34.6485	0	32.8611	0.1777	7.573	5.6106
Nov 01-30	36.4422	0	31.6984	0.2012	7.4355	5.4297
Dec 01-31	37.805	0	32.7387	0.2002	7.6796	5.6106
Summed total	384.4043	0	386.0719	2.0939	85.3717	66.0609

When 9.54MWh is added for the lifts, this results in a total of 933.55MWh.

Table 167: Simulation results for climate zone 2 NCC2019 3A with 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone2-Class3A-NCC2019-DTS Update final RIS 1.aps	Zone2-Class3A-NCC2019-DTS Update final RIS 1.aps	Zone2-Class3A-NCC2019-DTS Update final RIS 1.aps	Zone2-Class3A-NCC2019-DTS Update final RIS 1.aps	Zone2-Class3A-NCC2019-DTS Update final RIS 1.aps	Zone2-Class3A-NCC2019-DTS Update final RIS 1.aps
Jan 01-31	26.4234	0	32.87	0.161	7.0423	5.6106
Feb 01-28	23.5338	0	29.6258	0.1483	6.1777	5.0677
Mar 01-31	21.6478	0	32.7476	0.1385	5.7828	5.6106
Apr 01-30	17.4877	0.0271	31.707	0.1288	3.9388	5.4297
May 01-31	15.1357	0.1241	32.87	0.1453	3.1029	5.6106
Jun 01-30	10.6667	0.5241	31.707	0.2746	2.0545	5.4297
Jul 01-31	8.966	1.5543	32.8088	0.3245	1.7458	5.6106
Aug 01-31	10.9147	1.3411	32.8088	0.2748	2.1109	5.6106
Sep 01-30	14.5054	0.0057	31.707	0.1312	2.7613	5.4297
Oct 01-31	17.1779	0	32.87	0.1182	3.4872	5.6106
Nov 01-30	19.7227	0	31.707	0.1295	4.5302	5.4297
Dec 01-31	22.6104	0	32.7476	0.1417	5.4464	5.6106
Summed total	208.7923	3.5764	386.1767	2.1163	48.1808	66.0609

When 9.54MWh is added for the lifts, this results in a total of 724.45MWh.

Table 168: Simulation results for climate zone 3 NCC2019 3A with 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone3-Class3A-NCC2019-DTS Update final RIS.aps	Zone3-Class3A-NCC2019-DTS Update final RIS.aps	Zone3-Class3A-NCC2019-DTS Update final RIS.aps	Zone3-Class3A-NCC2019-DTS Update final RIS.aps	Zone3-Class3A-NCC2019-DTS Update final RIS.aps	Zone3-Class3A-NCC2019-DTS Update final RIS.aps
Jan 01-31	23.5124	0	32.8638	0.171	4.5992	5.6106
Feb 01-28	21.6399	0	29.6202	0.152	3.8405	5.0677
Mar 01-31	20.6074	0	32.7414	0.1518	3.5401	5.6106
Apr 01-30	16.8283	0	31.701	0.1463	3.1267	5.4297
May 01-31	11.1728	0.8	32.8638	0.2122	2.2253	5.6106
Jun 01-30	7.9604	1.7805	31.701	0.2223	1.6942	5.4297
Jul 01-31	7.7919	3.063	32.8026	0.2193	1.6227	5.6106
Aug 01-31	10.9805	1.5231	32.8026	0.2018	2.146	5.6106
Sep 01-30	15.8662	0.0864	31.701	0.1662	2.6256	5.4297
Oct 01-31	17.2667	0.0163	32.8638	0.1588	2.8745	5.6106
Nov 01-30	20.0401	0	31.701	0.1522	3.7359	5.4297
Dec 01-31	22.5746	0	32.7414	0.1598	3.8671	5.6106
Summed total	196.2412	7.2694	386.1033	2.1136	35.8977	66.0609

When 9.54MWh is added for the lifts, this results in a total of 703.23MWh.

Table 169: Simulation results for climate zone 4 NCC2019 3A with 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone4-Class3A-FCU-Base Case-DTS Update final RIS.aps	Zone4-Class3A-FCU-Base Case-DTS Update final RIS.aps	Zone4-Class3A-FCU-Base Case-DTS Update final RIS.aps	Zone4-Class3A-FCU-Base Case-DTS Update final RIS.aps	Zone4-Class3A-FCU-Base Case-DTS Update final RIS.aps	Zone4-Class3A-FCU-Base Case-DTS Update final RIS.aps
Jan 01-31	17.3453	0	32.8596	0.1521	3.2954	5.6106
Feb 01-28	15.393	0.0171	29.6164	0.1582	3.2296	5.0677
Mar 01-31	14.3793	0	32.7372	0.1455	2.9575	5.6106
Apr 01-30	10.3379	0.0622	31.6969	0.1953	2.3971	5.4297
May 01-31	7.615	0.5063	32.8596	0.3405	1.9023	5.6106
Jun 01-30	5.6195	1.1608	31.6969	0.4934	1.4294	5.4297
Jul 01-31	4.8938	1.7554	32.7984	0.6173	1.25	5.6106
Aug 01-31	6.0167	1.1172	32.7984	0.4775	1.5183	5.6106
Sep 01-30	6.6553	0.7764	31.6969	0.4071	1.6516	5.4297
Oct 01-31	9.9166	0.172	32.8596	0.2692	2.2803	5.6106
Nov 01-30	12.1892	0.0162	31.6969	0.1623	2.6197	5.4297
Dec 01-31	15.0991	0	32.7372	0.1385	2.9118	5.6106
Summed total	125.4607	5.5837	386.054	3.5567	27.4431	66.0609

When 9.54MWh is added for the lifts, this results in a total of 623.70MWh.

Table 170: Simulation results for climate zone 5 NCC2019 3A with 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone5-Class3A-NCC2019-DTS Update final RIS1.aps	Zone5-Class3A-NCC2019-DTS Update final RIS1.aps	Zone5-Class3A-NCC2019-DTS Update final RIS1.aps	Zone5-Class3A-NCC2019-DTS Update final RIS1.aps	Zone5-Class3A-NCC2019-DTS Update final RIS1.aps	Zone5-Class3A-NCC2019-DTS Update final RIS1.aps
Jan 01-31	19.628	0	32.8516	0.1272	4.1328	5.6106
Feb 01-28	19.0774	0	29.6093	0.1204	4.6676	5.0677
Mar 01-31	19.0787	0	32.7293	0.1262	4.2795	5.6106
Apr 01-30	15.1342	0.0058	31.6893	0.1175	2.9621	5.4297
May 01-31	12.4493	0.0384	32.8516	0.2239	2.4125	5.6106
Jun 01-30	8.8666	0.1916	31.6893	0.3384	1.7794	5.4297
Jul 01-31	8.3547	0.8957	32.7905	0.4542	1.6688	5.6106
Aug 01-31	9.9476	0.2527	32.7905	0.3626	1.9366	5.6106
Sep 01-30	11.5093	0.0487	31.6893	0.2502	2.2437	5.4297
Oct 01-31	15.213	0.0072	32.8516	0.1652	2.8432	5.6106
Nov 01-30	16.483	0	31.6893	0.1121	3.2243	5.4297
Dec 01-31	19.0171	0	32.7293	0.122	4.4312	5.6106
Summed total	174.7591	1.4401	385.9609	2.5199	36.5815	66.0609

When 9.54MWh is added for the lifts, this results in a total of 676.87MWh.

Table 171: Simulation results for climate zone 6 NCC2019 3A with 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone6-Class3A-NCC2019-DTS Update final RIS.aps	Zone6-Class3A-NCC2019-DTS Update final RIS.aps	Zone6-Class3A-NCC2019-DTS Update final RIS.aps	Zone6-Class3A-NCC2019-DTS Update final RIS.aps	Zone6-Class3A-NCC2019-DTS Update final RIS.aps	Zone6-Class3A-NCC2019-DTS Update final RIS.aps
Jan 01-31	13.5951	0	32.8505	0.1265	3.0181	5.6106
Feb 01-28	13.5189	0.0045	29.6083	0.1284	3.1348	5.0677
Mar 01-31	12.8418	0.0122	32.7282	0.1447	2.8529	5.6106
Apr 01-30	9.5865	0.0969	31.6882	0.2304	2.2746	5.4297
May 01-31	7.2909	0.4086	32.8505	0.3849	1.8139	5.6106
Jun 01-30	5.5958	0.9205	31.6882	0.4866	1.4038	5.4297
Jul 01-31	5.1636	1.6451	32.7894	0.59	1.2962	5.6106
Aug 01-31	6.1596	1.0504	32.7894	0.494	1.5436	5.6106
Sep 01-30	7.2084	0.5913	31.6882	0.3844	1.783	5.4297
Oct 01-31	9.4707	0.2371	32.8505	0.2977	2.209	5.6106
Nov 01-30	10.814	0.0871	31.6882	0.2212	2.4165	5.4297
Dec 01-31	12.5336	0.0054	32.7282	0.148	2.8277	5.6106
Summed total	113.7789	5.0591	385.9481	3.6367	26.574	66.0609

When 9.54MWh is added for the lifts, this results in a total of 610.60MWh.

Table 172: Simulation results for climate zone 7 NCC2019 3A with 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone7-Class3A-NCC2019-DTS Update final RIS.aps	Zone7-Class3A-NCC2019-DTS Update final RIS.aps	Zone7-Class3A-NCC2019-DTS Update final RIS.aps	Zone7-Class3A-NCC2019-DTS Update final RIS.aps	Zone7-Class3A-NCC2019-DTS Update final RIS.aps	Zone7-Class3A-NCC2019-DTS Update final RIS.aps
Jan 01-31	13.9249	0	32.8533	0.1405	2.9609	5.6106
Feb 01-28	12.3988	0	29.6108	0.1481	2.8949	5.0677
Mar 01-31	11.3624	0.0148	32.7309	0.1605	2.7359	5.6106
Apr 01-30	8.3963	0.2804	31.6909	0.2282	2.254	5.4297
May 01-31	6.1012	1.2995	32.8533	0.4191	1.7088	5.6106
Jun 01-30	4.8489	3.1398	31.6909	0.4673	1.3527	5.4297
Jul 01-31	4.21	4.4462	32.7921	0.5097	1.187	5.6106
Aug 01-31	5.5828	2.3111	32.7921	0.4674	1.5721	5.6106
Sep 01-30	6.1407	1.3321	31.6909	0.3631	1.7111	5.4297
Oct 01-31	8.2931	0.4613	32.8533	0.223	2.2185	5.6106
Nov 01-30	10.6733	0.0119	31.6909	0.1439	2.6201	5.4297
Dec 01-31	12.0551	0	32.7309	0.1282	2.8689	5.6106
Summed total	103.9877	13.2971	385.9801	3.399	26.0848	66.0609

When 9.54MWh is added for the lifts, this results in a total of 608.35MWh.

A.II.II Model 5A Sensitivity 56 WWR for CZ 1-6 and 50 WWR for CZ 7

Table 173: Simulation results for climate zone 1 NCC 2019 5A Sensitivity 56 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone1-Class5A-NCC2019-DTS UpdateRIS final.aps	Zone1-Class5A-NCC2019-DTS UpdateRIS final.aps	Zone1-Class5A-NCC2019-DTS UpdateRIS final.aps	Zone1-Class5A-NCC2019-DTS UpdateRIS final.aps	Zone1-Class5A-NCC2019-DTS UpdateRIS final.aps	Zone1-Class5A-NCC2019-DTS UpdateRIS final.aps
Jan 01-31	24.25	-	9.47	0.67	3.53	12.59
Feb 01-28	23.02	-	8.97	0.63	3.37	11.83
Mar 01-31	26.65	-	10.39	0.74	3.87	13.47
Apr 01-30	22.38	0.00	9.75	0.61	3.64	12.92
May 01-31	20.13	0.00	9.22	0.55	3.47	12.59
Jun 01-30	16.18	0.01	8.89	0.38	2.95	12.92
Jul 01-31	16.64	0.00	8.76	0.40	3.20	13.03
Aug 01-31	18.05	-	9.17	0.46	3.46	13.03
Sep 01-30	21.12	-	9.55	0.58	3.70	12.92
Oct 01-31	22.21	-	9.47	0.64	3.48	12.59
Nov 01-30	25.61	-	10.08	0.73	3.70	12.92
Dec 01-31	26.04	-	10.35	0.71	3.87	13.47
Summed total	262.28	0.01	114.06	7.10	42.25	154.30

When 55.54MWh is added for the lifts, this results in a total of 635.54MWh.

Table 174: Simulation results for climate zone 2 NCC 2019 5A Sensitivity 56 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone2-Class5A-NCC2019-DTS Update RIS final with HVAC.aps	Zone2-Class5A-NCC2019-DTS Update RIS final with HVAC.aps	Zone2-Class5A-NCC2019-DTS Update RIS final with HVAC.aps	Zone2-Class5A-NCC2019-DTS Update RIS final with HVAC.aps	Zone2-Class5A-NCC2019-DTS Update RIS final with HVAC.aps	Zone2-Class5A-NCC2019-DTS Update RIS final with HVAC.aps
Jan 01-31	18.99	-	8.74	0.38	3.48	12.59
Feb 01-28	18.36	0.01	8.40	0.39	3.29	11.83
Mar 01-31	16.95	0.00	9.09	0.28	3.63	13.47
Apr 01-30	13.46	0.10	7.94	0.17	2.62	12.92
May 01-31	9.79	0.35	6.79	0.11	1.95	12.59
Jun 01-30	7.51	1.20	6.24	0.09	1.18	12.92
Jul 01-31	6.71	1.97	6.10	0.09	1.05	13.03
Aug 01-31	8.35	1.18	6.74	0.10	1.36	13.03
Sep 01-30	10.14	0.21	7.42	0.12	1.79	12.92
Oct 01-31	11.79	0.05	7.60	0.14	2.02	12.59
Nov 01-30	15.37	-	8.70	0.25	2.90	12.92
Dec 01-31	17.98	-	9.33	0.31	3.53	13.47
Summed total	155.40	5.08	93.07	2.43	28.80	154.30

When 55.54MWh is added for the lifts, this results in a total of 494.62MWh.

Table 175: Simulation results for climate zone 3 NCC 2019 5A Sensitivity 56 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone3-Class5A-HVAC-DTS Update.aps	Zone3-Class5A-HVAC-DTS Update.aps	Zone3-Class5A-HVAC-DTS Update.aps	Zone3-Class5A-HVAC-DTS Update.aps	Zone3-Class5A-HVAC-DTS Update.aps	Zone3-Class5A-HVAC-DTS Update.aps
Jan 01-31	21.15	0.00	7.87	0.76	2.80	12.59
Feb 01-28	19.79	0.00	7.42	0.70	2.48	11.83
Mar 01-31	19.37	0.01	8.16	0.60	2.01	13.47
Apr 01-30	15.90	0.05	7.25	0.40	1.86	12.92
May 01-31	9.61	0.50	5.85	0.17	1.18	12.59
Jun 01-30	7.75	1.26	5.56	0.14	1.10	12.92
Jul 01-31	8.19	1.40	5.71	0.15	1.10	13.03
Aug 01-31	9.69	0.76	6.09	0.18	1.18	13.03
Sep 01-30	14.76	0.06	7.21	0.36	1.44	12.92
Oct 01-31	14.05	0.06	6.81	0.35	1.52	12.59
Nov 01-30	19.93	-	7.97	0.66	2.47	12.92
Dec 01-31	20.91	-	8.37	0.73	2.31	13.47
Summed total	181.11	4.10	84.27	5.20	21.44	154.30

When 55.54MWh is added for the lifts, this results in a total of 505.96MWh.

Table 176: Simulation results for climate zone 4 NCC 2019 5A Sensitivity 56 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone4-Class5A-VAV-HVAC-DTS Update.aps	Zone4-Class5A-VAV-HVAC-DTS Update.aps	Zone4-Class5A-VAV-HVAC-DTS Update.aps	Zone4-Class5A-VAV-HVAC-DTS Update.aps	Zone4-Class5A-VAV-HVAC-DTS Update.aps	Zone4-Class5A-VAV-HVAC-DTS Update.aps
Jan 01-31	12.72	0.19	8.73	0.24	1.78	12.59
Feb 01-28	13.02	0.26	7.98	0.32	1.97	11.83
Mar 01-31	10.66	0.38	8.54	0.15	1.39	13.47
Apr 01-30	5.82	1.17	6.51	0.09	0.71	12.92
May 01-31	1.51	4.22	4.46	0.12	0.22	12.59
Jun 01-30	0.21	10.83	4.39	0.25	0.03	12.92
Jul 01-31	0.02	13.14	4.50	0.31	0.00	13.03
Aug 01-31	0.54	9.50	4.55	0.24	0.08	13.03
Sep 01-30	0.80	4.93	4.29	0.12	0.11	12.92
Oct 01-31	4.44	1.29	5.90	0.08	0.62	12.59
Nov 01-30	6.94	0.54	7.46	0.08	0.90	12.92
Dec 01-31	12.19	0.24	9.03	0.20	1.50	13.47
Summed total	68.85	46.70	76.34	2.21	9.32	154.30

When 55.54MWh is added for the lifts, this results in a total of 413.26MWh.

Table 177: Simulation results for climate zone 5 NCC 2019 5A Sensitivity 56 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone5-Class5A-VAV-HVAC-DTS Update.aps	Zone5-Class5A-VAV-HVAC-DTS Update.aps	Zone5-Class5A-VAV-HVAC-DTS Update.aps	Zone5-Class5A-VAV-HVAC-DTS Update.aps	Zone5-Class5A-VAV-HVAC-DTS Update.aps	Zone5-Class5A-VAV-HVAC-DTS Update.aps
Jan 01-31	13.30	0.01	8.89	0.25	2.57	12.59
Feb 01-28	13.52	0.03	8.65	0.28	2.49	11.83
Mar 01-31	13.79	0.05	9.28	0.26	2.75	13.47
Apr 01-30	9.00	0.18	8.09	0.12	1.68	12.92
May 01-31	3.82	0.77	5.52	0.08	0.72	12.59
Jun 01-30	1.30	2.82	4.50	0.09	0.23	12.92
Jul 01-31	0.72	4.35	4.54	0.11	0.12	13.03
Aug 01-31	3.02	2.18	5.78	0.07	0.45	13.03
Sep 01-30	4.19	0.66	6.51	0.07	0.68	12.92
Oct 01-31	6.74	0.37	7.54	0.10	1.09	12.59
Nov 01-30	9.37	0.12	8.73	0.12	1.67	12.92
Dec 01-31	12.99	0.03	9.10	0.23	2.42	13.47
Summed total	91.76	11.56	87.13	1.79	16.88	154.30

When 55.54MWh is added for the lifts, this results in a total of 418.96MWh.

Table 178: Simulation results for climate zone 6 NCC 2019 5A Sensitivity 56 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone6-Class5A-HVAC- DTS Update.aps	Zone6-Class5A-HVAC- DTS Update.aps	Zone6-Class5A-HVAC- DTS Update.aps	Zone6-Class5A-HVAC- DTS Update.aps	Zone6-Class5A-HVAC- DTS Update.aps	Zone6-Class5A-HVAC- DTS Update.aps
Jan 01-31	8.66	0.32	7.19	0.12	1.28	12.59
Feb 01-28	9.52	0.26	6.92	0.17	1.46	11.83
Mar 01-31	8.30	0.68	7.30	0.12	1.16	13.47
Apr 01-30	2.47	2.22	4.93	0.07	0.30	12.92
May 01-31	0.63	6.84	3.89	0.16	0.08	12.59
Jun 01-30	-	14.57	4.67	0.30	-	12.92
Jul 01-31	-	16.37	5.01	0.32	-	13.03
Aug 01-31	-	10.75	4.36	0.21	-	13.03
Sep 01-30	0.60	5.41	4.21	0.12	0.08	12.92
Oct 01-31	2.22	2.59	4.73	0.08	0.27	12.59
Nov 01-30	4.93	1.06	6.22	0.08	0.59	12.92
Dec 01-31	6.69	0.49	7.12	0.10	0.89	13.47
Summed total	44.03	61.55	66.54	1.84	6.11	154.30

When 55.54MWh is added for the lifts, this results in a total of 389.91MWh.

Table 179: Simulation results for climate zone 7 NCC 2019 5A Sensitivity 50 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone7-Class5A-HVAC- DTS Update.aps	Zone7-Class5A-HVAC- DTS Update.aps	Zone7-Class5A-HVAC- DTS Update.aps	Zone7-Class5A-HVAC- DTS Update.aps	Zone7-Class5A-HVAC- DTS Update.aps	Zone7-Class5A-HVAC- DTS Update.aps
Jan 01-31	7.64	0.44	6.92	0.23	1.01	12.59
Feb 01-28	9.43	0.36	6.34	0.38	1.46	11.83
Mar 01-31	4.67	0.80	6.28	0.13	0.66	13.47
Apr 01-30	2.55	2.39	5.05	0.11	0.39	12.92
May 01-31	0.06	7.95	3.79	0.20	0.01	12.59
Jun 01-30	0.02	16.92	4.67	0.38	0.00	12.92
Jul 01-31	-	21.38	5.00	0.46	-	13.03
Aug 01-31	-	14.14	4.43	0.35	-	13.03
Sep 01-30	0.34	6.23	3.96	0.16	0.05	12.92
Oct 01-31	1.61	2.64	4.43	0.09	0.23	12.59
Nov 01-30	4.09	0.66	5.83	0.10	0.58	12.92
Dec 01-31	6.61	0.47	6.83	0.18	0.97	13.47
Summed total	37.02	74.38	63.52	2.75	5.37	154.30

When 55.54MWh is added for the lifts, this results in a total of 392.89MWh.

A.II.III Model 5A 40 WWR

Table 180: Simulation results for climate zone 1 NCC 2019 5A 40 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone1-Class5A-NCC2019-DTS Update.aps	Zone1-Class5A-NCC2019-DTS Update.aps	Zone1-Class5A-NCC2019-DTS Update.aps	Zone1-Class5A-NCC2019-DTS Update.aps	Zone1-Class5A-NCC2019-DTS Update.aps	Zone1-Class5A-NCC2019-DTS Update.aps
Jan 01-31	24.06	-	8.72	0.66	3.47	12.59
Feb 01-28	22.86	-	8.26	0.62	3.31	11.83
Mar 01-31	26.55	-	9.59	0.74	3.81	13.47
Apr 01-30	22.06	0.00	8.77	0.57	3.57	12.92
May 01-31	19.80	0.00	8.25	0.53	3.39	12.59
Jun 01-30	15.67	0.01	8.14	0.31	2.84	12.92
Jul 01-31	16.17	0.00	8.06	0.33	3.11	13.03
Aug 01-31	17.59	-	8.35	0.40	3.35	13.03
Sep 01-30	20.60	-	8.56	0.51	3.64	12.92
Oct 01-31	21.81	-	8.52	0.60	3.42	12.59
Nov 01-30	25.48	-	9.38	0.73	3.64	12.92
Dec 01-31	25.79	-	9.49	0.69	3.81	13.47
Summed total	258.43	0.01	104.09	6.68	41.35	154.30

When 55.54MWh is added for the lifts, this results in a total of 620.40MWh.

Table 181: Simulation results for climate zone 2 NCC 2019 5A 40 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone2-Class5A-NCC2019-DTS Update.aps	Zone2-Class5A-NCC2019-DTS Update.aps	Zone2-Class5A-NCC2019-DTS Update.aps	Zone2-Class5A-NCC2019-DTS Update.aps	Zone2-Class5A-NCC2019-DTS Update.aps	Zone2-Class5A-NCC2019-DTS Update.aps
Jan 01-31	17.94	-	9.02	0.43	3.28	12.59
Feb 01-28	17.34	-	8.68	0.43	3.10	11.83
Mar 01-31	16.01	-	9.40	0.31	3.43	13.47
Apr 01-30	12.60	0.10	8.24	0.19	2.53	12.92
May 01-31	9.16	0.35	7.07	0.12	1.91	12.59
Jun 01-30	7.09	1.10	6.55	0.09	1.21	12.92
Jul 01-31	6.35	1.79	6.38	0.10	1.08	13.03
Aug 01-31	7.81	1.14	6.98	0.11	1.36	13.03
Sep 01-30	9.40	0.19	7.71	0.13	1.76	12.92
Oct 01-31	10.97	0.05	7.86	0.15	1.97	12.59
Nov 01-30	14.42	-	8.97	0.28	2.77	12.92
Dec 01-31	16.90	-	9.60	0.34	3.34	13.47
Summed total	145.99	4.72	96.45	2.67	27.74	154.30

When 55.54MWh is added for the lifts, this results in a total of 487.41MWh.

Table 182: Simulation results for climate zone 3 NCC 2019 5A 40 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Lights electricity (MWh)
Model	Zone3-Class5A-NCC2019-DTS Update.aps	Zone3-Class5A-NCC2019-DTS Update.aps	Zone3-Class5A-NCC2019-DTS Update.aps	Zone3-Class5A-NCC2019-DTS Update.aps	Zone3-Class5A-NCC2019-DTS Update.aps	Zone3-Class5A-NCC2019-DTS Update.aps
Jan 01-31	22.12	0.02	7.64	0.49	2.95	12.59
Feb 01-28	20.67	0.03	7.21	0.46	2.60	11.83
Mar 01-31	19.75	0.08	7.88	0.32	2.03	13.47
Apr 01-30	16.14	0.47	6.98	0.22	1.85	12.92
May 01-31	9.35	2.43	5.28	0.13	1.09	12.59
Jun 01-30	7.15	4.95	4.97	0.16	0.95	12.92
Jul 01-31	7.65	5.42	5.15	0.16	0.97	13.03
Aug 01-31	9.06	3.40	5.39	0.14	1.06	13.03
Sep 01-30	15.01	0.50	6.84	0.20	1.42	12.92
Oct 01-31	14.29	0.41	6.43	0.19	1.50	12.59
Nov 01-30	20.64	0.03	7.70	0.39	2.53	12.92
Dec 01-31	21.67	0.04	8.17	0.42	2.37	13.47
Summed total	183.49	17.78	79.65	3.28	21.31	154.30

When 55.54MWh is added for the lifts, this results in a total of 515.36MWh.

Table 183: Simulation results for climate zone 4 NCC 2019 5A 40 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone4-Class5A-NCC2019-DTS Update.aps	Zone4-Class5A-NCC2019-DTS Update.aps	Zone4-Class5A-NCC2019-DTS Update.aps	Zone4-Class5A-NCC2019-DTS Update.aps	Zone4-Class5A-NCC2019-DTS Update.aps	Zone4-Class5A-NCC2019-DTS Update.aps
Jan 01-31	12.05	0.15	8.99	0.23	1.71	12.59
Feb 01-28	12.39	0.21	8.22	0.31	1.89	11.83
Mar 01-31	10.10	0.31	8.80	0.13	1.36	13.47
Apr 01-30	5.60	0.95	6.82	0.09	0.72	12.92
May 01-31	1.50	3.57	4.78	0.11	0.23	12.59
Jun 01-30	0.23	9.14	4.56	0.22	0.04	12.92
Jul 01-31	0.02	11.12	4.54	0.27	0.00	13.03
Aug 01-31	0.56	8.00	4.72	0.21	0.09	13.03
Sep 01-30	0.79	4.17	4.58	0.11	0.11	12.92
Oct 01-31	4.30	1.09	6.16	0.08	0.62	12.59
Nov 01-30	6.70	0.43	7.73	0.08	0.90	12.92
Dec 01-31	11.56	0.19	9.31	0.18	1.48	13.47
Summed total	65.78	39.32	79.21	1.99	9.15	154.30

When 55.54MWh is added for the lifts, this results in a total of 405.29MWh.

Table 184: Simulation results for climate zone 5 NCC 2019 5A 40 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone5-Class5A-NCC2019-DTS Update.aps	Zone5-Class5A-NCC2019-DTS Update.aps	Zone5-Class5A-NCC2019-DTS Update.aps	Zone5-Class5A-NCC2019-DTS Update.aps	Zone5-Class5A-NCC2019-DTS Update.aps	Zone5-Class5A-NCC2019-DTS Update.aps
Jan 01-31	12.44	0.02	9.08	0.25	2.51	12.59
Feb 01-28	12.78	0.02	8.87	0.30	2.41	11.83
Mar 01-31	12.99	0.04	9.57	0.27	2.68	13.47
Apr 01-30	8.47	0.12	8.39	0.12	1.68	12.92
May 01-31	3.74	0.68	5.85	0.08	0.75	12.59
Jun 01-30	1.41	2.37	4.82	0.08	0.27	12.92
Jul 01-31	0.71	3.77	4.74	0.09	0.13	13.03
Aug 01-31	2.84	1.94	6.04	0.07	0.46	13.03
Sep 01-30	4.07	0.65	6.89	0.07	0.72	12.92
Oct 01-31	6.47	0.33	7.92	0.10	1.12	12.59
Nov 01-30	8.84	0.09	9.04	0.12	1.66	12.92
Dec 01-31	12.36	0.01	9.49	0.25	2.37	13.47
Summed total	87.13	10.04	90.70	1.80	16.76	154.30

When 55.54MWh is added for the lifts, this results in a total of 416.26MWh.

Table 185: Simulation results for climate zone 6 NCC 2019 5A 40 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone6-Class5A-NCC2019-DTS Update.aps	Zone6-Class5A-NCC2019-DTS Update.aps	Zone6-Class5A-NCC2019-DTS Update.aps	Zone6-Class5A-NCC2019-DTS Update.aps	Zone6-Class5A-NCC2019-DTS Update.aps	Zone6-Class5A-NCC2019-DTS Update.aps
Jan 01-31	7.83	0.19	7.53	0.12	1.27	12.59
Feb 01-28	8.53	0.18	7.30	0.17	1.40	11.83
Mar 01-31	7.54	0.40	7.71	0.12	1.17	13.47
Apr 01-30	2.36	1.42	5.40	0.06	0.33	12.92
May 01-31	0.64	4.33	4.26	0.10	0.09	12.59
Jun 01-30	-	9.76	4.51	0.19	-	12.92
Jul 01-31	-	11.57	4.73	0.22	-	13.03
Aug 01-31	-	7.55	4.41	0.15	-	13.03
Sep 01-30	0.64	3.77	4.57	0.09	0.09	12.92
Oct 01-31	2.03	1.76	5.10	0.06	0.29	12.59
Nov 01-30	4.43	0.73	6.58	0.07	0.61	12.92
Dec 01-31	6.05	0.32	7.50	0.09	0.91	13.47
Summed total	40.06	41.99	69.59	1.44	6.16	154.30

When 55.54MWh is added for the lifts, this results in a total of 369.07MWh.

Table 186: Simulation results for climate zone 7 NCC 2019 5A 40 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone7-Class5A-NCC2019-DTS Update.aps	Zone7-Class5A-NCC2019-DTS Update.aps	Zone7-Class5A-NCC2019-DTS Update.aps	Zone7-Class5A-NCC2019-DTS Update.aps	Zone7-Class5A-NCC2019-DTS Update.aps	Zone7-Class5A-NCC2019-DTS Update.aps
Jan 01-31	7.35	0.45	6.97	0.25	1.02	12.59
Feb 01-28	9.16	0.34	6.30	0.43	1.44	11.83
Mar 01-31	4.43	0.74	6.32	0.13	0.67	13.47
Apr 01-30	2.39	2.29	4.96	0.10	0.39	12.92
May 01-31	0.04	7.47	3.70	0.18	0.01	12.59
Jun 01-30	0.01	15.93	4.53	0.37	0.00	12.92
Jul 01-31	-	20.22	4.81	0.45	-	13.03
Aug 01-31	-	13.27	4.32	0.33	-	13.03
Sep 01-30	0.32	5.83	3.97	0.14	0.05	12.92
Oct 01-31	1.51	2.52	4.43	0.09	0.23	12.59
Nov 01-30	3.86	0.62	5.78	0.10	0.59	12.92
Dec 01-31	6.37	0.44	6.84	0.19	0.97	13.47
Summed total	35.45	70.12	62.93	2.77	5.37	154.30

When 55.54MWh is added for the lifts, this results in a total of 386.49MWh.

A.II.IV Model 6B 30 WWR

Table 187: Simulation results for climate zone 1 NCC2019 6B 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone1-Class6B-DTS Update.aps	Zone1-Class6B-DTS Update.aps	Zone1-Class6B-DTS Update.aps	Zone1-Class6B-DTS Update.aps	Zone1-Class6B-DTS Update.aps	Zone1-Class6B-DTS Update.aps
Jan 01-31	14.77	-	6.32	0.23	1.76	13.12
Feb 01-28	13.17	-	5.71	0.21	1.59	11.85
Mar 01-31	15.00	-	6.32	0.24	1.76	13.12
Apr 01-30	11.88	0.00	6.12	0.16	1.66	12.70
May 01-31	10.61	0.00	6.32	0.12	1.67	13.12
Jun 01-30	7.72	0.03	6.12	0.06	1.20	12.70
Jul 01-31	8.28	0.01	6.32	0.06	1.36	13.12
Aug 01-31	8.96	0.00	6.32	0.08	1.59	13.12
Sep 01-30	10.47	-	6.12	0.12	1.70	12.70
Oct 01-31	12.60	-	6.32	0.17	1.73	13.12
Nov 01-30	14.06	-	6.12	0.23	1.70	12.70
Dec 01-31	14.40	-	6.32	0.22	1.76	13.12
Summed total	141.91	0.04	74.43	1.90	19.47	154.47

The combined total is 392.22MWh.

Table 188: Simulation results for climate zone 2 NCC2019 6B 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone2-Class6B-DTS Update.aps	Zone2-Class6B-DTS Update.aps	Zone2-Class6B-DTS Update.aps	Zone2-Class6B-DTS Update.aps	Zone2-Class6B-DTS Update.aps	Zone2-Class6B-DTS Update.aps
Jan 01-31	8.38	0.00	4.17	0.10	1.41	13.12
Feb 01-28	7.57	0.01	3.77	0.09	1.26	11.85
Mar 01-31	6.49	0.01	4.17	0.05	1.31	13.12
Apr 01-30	5.16	0.26	4.04	0.03	0.83	12.70
May 01-31	3.85	0.99	4.17	0.02	0.60	13.12
Jun 01-30	2.59	2.62	4.04	0.02	0.25	12.70
Jul 01-31	2.25	4.12	4.17	0.03	0.22	13.12
Aug 01-31	2.89	2.82	4.17	0.02	0.30	13.12
Sep 01-30	3.68	0.55	4.04	0.01	0.42	12.70
Oct 01-31	4.72	0.26	4.17	0.02	0.62	13.12
Nov 01-30	5.91	0.00	4.04	0.04	0.99	12.70
Dec 01-31	6.82	-	4.17	0.06	1.23	13.12
Summed total	60.31	11.64	49.13	0.50	9.45	154.47

The combined total is 285.50MWh.

Table 189: Simulation results for climate zone 3 NCC2019 6B 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone3-Class6B-DTS Update.aps	Zone3-Class6B-DTS Update.aps	Zone3-Class6B-DTS Update.aps	Zone3-Class6B-DTS Update.aps	Zone3-Class6B-DTS Update.aps	Zone3-Class6B-DTS Update.aps
Jan 01-31	10.01	0.02	6.32	0.10	1.17	13.12
Feb 01-28	8.90	0.01	5.71	0.09	0.97	11.85
Mar 01-31	8.19	0.17	6.32	0.05	0.69	13.12
Apr 01-30	6.67	0.79	6.12	0.04	0.63	12.70
May 01-31	3.88	3.70	6.32	0.03	0.30	13.12
Jun 01-30	2.60	6.15	6.12	0.04	0.21	12.70
Jul 01-31	3.05	6.59	6.32	0.04	0.24	13.12
Aug 01-31	3.66	4.35	6.32	0.04	0.26	13.12
Sep 01-30	6.18	0.91	6.12	0.03	0.41	12.70
Oct 01-31	6.55	0.76	6.32	0.04	0.50	13.12
Nov 01-30	8.39	0.05	6.12	0.06	0.87	12.70
Dec 01-31	9.25	0.02	6.32	0.09	0.88	13.12
Summed total	77.31	23.52	74.45	0.64	7.13	154.47

The combined total is 337.52MWh.

Table 190: Simulation results for climate zone 4 NCC2019 6B 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone4-Class6B-DTS Update.aps	Zone4-Class6B-DTS Update.aps	Zone4-Class6B-DTS Update.aps	Zone4-Class6B-DTS Update.aps	Zone4-Class6B-DTS Update.aps	Zone4-Class6B-DTS Update.aps
Jan 01-31	6.47	0.22	6.32	0.05	0.62	13.12
Feb 01-28	5.84	0.81	5.71	0.06	0.68	11.85
Mar 01-31	5.38	1.14	6.32	0.04	0.46	13.12
Apr 01-30	3.57	3.28	6.12	0.03	0.27	12.70
May 01-31	1.64	8.77	6.32	0.04	0.14	13.12
Jun 01-30	0.50	16.45	6.12	0.05	0.05	12.70
Jul 01-31	0.16	20.65	6.32	0.05	0.02	13.12
Aug 01-31	0.67	15.68	6.32	0.05	0.06	13.12
Sep 01-30	1.08	10.30	6.12	0.05	0.10	12.70
Oct 01-31	3.11	4.30	6.32	0.04	0.26	13.12
Nov 01-30	3.92	2.12	6.12	0.03	0.31	12.70
Dec 01-31	5.87	0.47	6.32	0.04	0.48	13.12
Summed total	38.19	84.19	74.42	0.52	3.44	154.47

The combined total is 355.23MWh.

Table 191: Simulation results for climate zone 5 NCC2019 6B 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone5-Class6B-DTS Update.aps	Zone5-Class6B-DTS Update.aps	Zone5-Class6B-DTS Update.aps	Zone5-Class6B-DTS Update.aps	Zone5-Class6B-DTS Update.aps	Zone5-Class6B-DTS Update.aps
Jan 01-31	5.27	0.05	6.32	0.10	0.85	13.12
Feb 01-28	5.43	0.02	5.71	0.12	0.95	11.85
Mar 01-31	5.13	0.09	6.32	0.09	0.87	13.12
Apr 01-30	3.79	0.54	6.12	0.05	0.54	12.70
May 01-31	2.34	2.27	6.32	0.03	0.29	13.12
Jun 01-30	1.12	5.65	6.12	0.04	0.13	12.70
Jul 01-31	1.17	8.30	6.32	0.04	0.14	13.12
Aug 01-31	1.78	5.45	6.32	0.04	0.19	13.12
Sep 01-30	2.30	2.01	6.12	0.04	0.26	12.70
Oct 01-31	3.70	1.06	6.32	0.06	0.44	13.12
Nov 01-30	3.98	0.30	6.12	0.05	0.56	12.70
Dec 01-31	5.06	0.12	6.32	0.09	0.79	13.12
Summed total	41.07	25.85	74.43	0.76	6.02	154.47

The combined total is 302.60MWh.

Table 192: Simulation results for climate zone 6 NCC2019 6B 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone6-Class6B-DTS Update.aps	Zone6-Class6B-DTS Update.aps	Zone6-Class6B-DTS Update.aps	Zone6-Class6B-DTS Update.aps	Zone6-Class6B-DTS Update.aps	Zone6-Class6B-DTS Update.aps
Jan 01-31	3.97	1.15	6.31	0.04	0.43	13.12
Feb 01-28	4.45	1.07	5.70	0.06	0.54	11.85
Mar 01-31	3.95	1.86	6.31	0.04	0.40	13.12
Apr 01-30	2.15	3.98	6.11	0.04	0.19	12.70
May 01-31	0.58	11.45	6.31	0.04	0.06	13.12
Jun 01-30	0.02	17.85	6.11	0.05	0.00	12.70
Jul 01-31	0.01	22.10	6.31	0.06	0.00	13.12
Aug 01-31	0.11	16.34	6.31	0.06	0.01	13.12
Sep 01-30	0.79	9.79	6.11	0.05	0.08	12.70
Oct 01-31	2.01	5.80	6.31	0.05	0.18	13.12
Nov 01-30	2.78	3.19	6.11	0.05	0.25	12.70
Dec 01-31	3.37	1.86	6.31	0.04	0.34	13.12
Summed total	24.18	96.45	74.35	0.56	2.49	154.47

The combined total is 352.51MWh.

Table 193: Simulation results for climate zone 7 NCC2019 6B 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone7-Class6B-DTS Update.aps	Zone7-Class6B-DTS Update.aps	Zone7-Class6B-DTS Update.aps	Zone7-Class6B-DTS Update.aps	Zone7-Class6B-DTS Update.aps	Zone7-Class6B-DTS Update.aps
Jan 01-31	4.66	0.50	6.32	0.09	0.43	13.12
Feb 01-28	3.94	0.82	5.70	0.08	0.47	11.85
Mar 01-31	3.16	1.80	6.32	0.04	0.30	13.12
Apr 01-30	2.20	4.03	6.11	0.04	0.23	12.70
May 01-31	1.02	11.74	6.32	0.04	0.12	13.12
Jun 01-30	0.42	18.45	6.11	0.05	0.05	12.70
Jul 01-31	0.30	23.17	6.32	0.06	0.04	13.12
Aug 01-31	0.46	18.32	6.32	0.05	0.06	13.12
Sep 01-30	1.11	9.48	6.11	0.04	0.13	12.70
Oct 01-31	1.99	5.68	6.32	0.04	0.21	13.12
Nov 01-30	3.08	1.64	6.11	0.04	0.31	12.70
Dec 01-31	3.73	0.70	6.32	0.04	0.38	13.12
Summed total	26.05	96.32	74.37	0.62	2.71	154.47

The combined total is 354.54MWh.

A.II.V Model 9aC 30 WWR

Table 194: Simulation results for climate zone 1 NCC2019 9aC 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone1-Class9aC-NCC2019-DTS Update final RIS.aps	Zone1-Class9aC-NCC2019-DTS Update final RIS.aps	Zone1-Class9aC-NCC2019-DTS Update final RIS.aps	Zone1-Class9aC-NCC2019-DTS Update final RIS.aps	Zone1-Class9aC-NCC2019-DTS Update final RIS.aps	Zone1-Class9aC-NCC2019-DTS Update final RIS.aps
Jan 01-31	3.9092	0	1.3198	0.0616	0.5153	1.2592
Feb 01-28	3.6973	0	1.2568	0.0565	0.491	1.1828
Mar 01-31	4.29	0	1.4529	0.0667	0.5645	1.3472
Apr 01-30	3.544	0	1.3551	0.0465	0.5262	1.2924
May 01-31	3.1648	0	1.2818	0.0399	0.4997	1.2592
Jun 01-30	2.4661	0.005	1.221	0.0207	0.3957	1.2924
Jul 01-31	2.5339	0.0025	1.2062	0.021	0.4345	1.3032
Aug 01-31	2.7513	0	1.2593	0.0253	0.4834	1.3032
Sep 01-30	3.2743	0	1.3198	0.037	0.5393	1.2924
Oct 01-31	3.5127	0	1.3173	0.0491	0.5059	1.2592
Nov 01-30	4.1079	0	1.4237	0.0681	0.5403	1.2924
Dec 01-31	4.1698	0	1.4323	0.0618	0.5649	1.3472
Summed total	41.4212	0.0075	15.8458	0.5541	6.0607	15.4308

The combined total is 79.32MWh.

Table 195: Simulation results for climate zone 2 NCC2019 9aC 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone2-Class9aC-NCC2019-DTS Update final RIS.aps	Zone2-Class9aC-NCC2019-DTS Update final RIS.aps	Zone2-Class9aC-NCC2019-DTS Update final RIS.aps	Zone2-Class9aC-NCC2019-DTS Update final RIS.aps	Zone2-Class9aC-NCC2019-DTS Update final RIS.aps	Zone2-Class9aC-NCC2019-DTS Update final RIS.aps
Jan 01-31	2.5523	0	0.7661	0.0344	0.4218	1.2592
Feb 01-28	2.498	0	0.7293	0.0399	0.3966	1.1828
Mar 01-31	2.1636	0.0055	0.7389	0.0182	0.4292	1.3472
Apr 01-30	1.6625	0.133	0.6346	0.0115	0.2952	1.2924
May 01-31	1.1193	0.3728	0.5175	0.0096	0.1989	1.2592
Jun 01-30	0.8413	0.9436	0.4612	0.0165	0.1059	1.2924
Jul 01-31	0.7483	1.272	0.4692	0.0206	0.0954	1.3032
Aug 01-31	0.9424	0.8645	0.5182	0.0158	0.1279	1.3032
Sep 01-30	1.1548	0.3156	0.5587	0.0087	0.1702	1.2924
Oct 01-31	1.433	0.1461	0.5968	0.0089	0.2175	1.2592
Nov 01-30	1.9075	0.011	0.7045	0.0141	0.3302	1.2924
Dec 01-31	2.3363	0.0017	0.7886	0.0224	0.4182	1.3472
Summed total	19.3592	4.0657	7.4835	0.2207	3.207	15.4308

The combined total is 49.77MWh.

Table 196: Simulation results for climate zone 3 NCC2019 9aC 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone3-Class9aC-NCC2019-DTS Update final RIS.aps	Zone3-Class9aC-NCC2019-DTS Update final RIS.aps	Zone3-Class9aC-NCC2019-DTS Update final RIS.aps	Zone3-Class9aC-NCC2019-DTS Update final RIS.aps	Zone3-Class9aC-NCC2019-DTS Update final RIS.aps	Zone3-Class9aC-NCC2019-DTS Update final RIS.aps
Jan 01-31	3.1517	0	1.2673	0.0402	0.3966	1.2592
Feb 01-28	2.9573	0	1.1951	0.0357	0.3401	1.1828
Mar 01-31	2.8425	0.0443	1.3005	0.0246	0.2435	1.3472
Apr 01-30	2.3226	0.2088	1.1572	0.0207	0.2181	1.2924
May 01-31	1.3734	0.7857	0.872	0.0191	0.1161	1.2592
Jun 01-30	1.0612	1.4596	0.8258	0.027	0.1004	1.2924
Jul 01-31	1.1473	1.51	0.863	0.0267	0.1043	1.3032
Aug 01-31	1.2936	1.1675	0.8844	0.0238	0.1081	1.3032
Sep 01-30	2.1009	0.2635	1.1031	0.0172	0.151	1.2924
Oct 01-31	2.0491	0.1921	1.0377	0.0167	0.1674	1.2592
Nov 01-30	2.8807	0.0042	1.2601	0.0246	0.3136	1.2924
Dec 01-31	3.0692	0.0004	1.3426	0.0304	0.2936	1.3472
Summed total	26.2495	5.6362	13.1087	0.3067	2.5527	15.4308

The combined total is 63.28MWh.

Table 197: Simulation results for climate zone 4 NCC2019 9aC 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone4-Class9aC-NCC2019-DTS Update final RIS.aps	Zone4-Class9aC-NCC2019-DTS Update final RIS.aps	Zone4-Class9aC-NCC2019-DTS Update final RIS.aps	Zone4-Class9aC-NCC2019-DTS Update final RIS.aps	Zone4-Class9aC-NCC2019-DTS Update final RIS.aps	Zone4-Class9aC-NCC2019-DTS Update final RIS.aps
Jan 01-31	1.9196	0.0646	0.9889	0.0143	0.2062	1.2592
Feb 01-28	1.9542	0.19	0.9447	0.0201	0.2506	1.1828
Mar 01-31	1.7462	0.4036	1.0079	0.0186	0.1659	1.3472
Apr 01-30	1.1749	0.8727	0.8182	0.0223	0.1058	1.2924
May 01-31	0.616	1.8193	0.6924	0.038	0.0663	1.2592
Jun 01-30	0.2844	3.523	0.7601	0.0685	0.033	1.2924
Jul 01-31	0.1139	4.2606	0.7866	0.0795	0.0135	1.3032
Aug 01-31	0.2565	3.5461	0.7751	0.0672	0.0282	1.3032
Sep 01-30	0.3725	2.7019	0.7228	0.0556	0.0408	1.2924
Oct 01-31	0.936	1.1854	0.745	0.0274	0.0941	1.2592
Nov 01-30	1.2368	0.7165	0.8363	0.0189	0.1117	1.2924
Dec 01-31	1.814	0.2299	0.9915	0.0144	0.1666	1.3472
Summed total	12.4252	19.5134	10.0694	0.4447	1.2825	15.4308

The combined total is 59.17MWh.

Table 198: Simulation results for climate zone 5 NCC2019 9aC 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone5-Class9aC-NCC2019-DTS Update final RIS.aps	Zone5-Class9aC-NCC2019-DTS Update final RIS.aps	Zone5-Class9aC-NCC2019-DTS Update final RIS.aps	Zone5-Class9aC-NCC2019-DTS Update final RIS.aps	Zone5-Class9aC-NCC2019-DTS Update final RIS.aps	Zone5-Class9aC-NCC2019-DTS Update final RIS.aps
Jan 01-31	1.6815	0.0368	0.6271	0.0178	0.2965	1.2592
Feb 01-28	1.733	0.009	0.6048	0.0201	0.2982	1.1828
Mar 01-31	1.774	0.0731	0.6444	0.0216	0.3219	1.3472
Apr 01-30	1.3002	0.256	0.5335	0.0137	0.1995	1.2924
May 01-31	0.783	0.7877	0.4022	0.0166	0.1094	1.2592
Jun 01-30	0.534	1.6628	0.3925	0.028	0.0717	1.2924
Jul 01-31	0.4732	2.2158	0.4251	0.0357	0.0639	1.3032
Aug 01-31	0.6999	1.5005	0.4506	0.0256	0.084	1.3032
Sep 01-30	0.8604	0.7829	0.4424	0.017	0.1071	1.2924
Oct 01-31	1.0789	0.4657	0.4814	0.0135	0.1372	1.2592
Nov 01-30	1.2702	0.2084	0.5344	0.0114	0.1867	1.2924
Dec 01-31	1.6569	0.0832	0.5951	0.0163	0.2781	1.3472
Summed total	13.8453	8.0818	6.1337	0.2372	2.1541	15.4308

The combined total is 45.88MWh.

Table 199: Simulation results for climate zone 6 NCC2019 9aC 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone6-Class9aC-NCC2019-DTS Update final RIS.aps	Zone6-Class9aC-NCC2019-DTS Update final RIS.aps	Zone6-Class9aC-NCC2019-DTS Update final RIS.aps	Zone6-Class9aC-NCC2019-DTS Update final RIS.aps	Zone6-Class9aC-NCC2019-DTS Update final RIS.aps	Zone6-Class9aC-NCC2019-DTS Update final RIS.aps
Jan 01-31	1.264	0.4062	0.7534	0.0169	0.1498	1.2592
Feb 01-28	1.4612	0.3385	0.7261	0.023	0.1919	1.1828
Mar 01-31	1.3027	0.7057	0.7839	0.0221	0.1439	1.3472
Apr 01-30	0.5896	1.2771	0.5573	0.0297	0.0569	1.2924
May 01-31	0.1652	2.8583	0.5355	0.0489	0.017	1.2592
Jun 01-30	0.0156	4.7719	0.6731	0.0735	0.0018	1.2924
Jul 01-31	0.0015	5.2122	0.732	0.0774	0.0002	1.3032
Aug 01-31	0.0326	4.0411	0.6423	0.0662	0.0038	1.3032
Sep 01-30	0.2867	2.6319	0.5435	0.0478	0.0309	1.2924
Oct 01-31	0.5252	1.5933	0.5264	0.0314	0.0514	1.2592
Nov 01-30	0.9828	0.9921	0.6647	0.0248	0.093	1.2924
Dec 01-31	1.1331	0.6452	0.7221	0.0186	0.1192	1.3472
Summed total	7.7604	25.4735	7.8601	0.4803	0.8598	15.4308

The combined total is 57.86MWh.

Table 200: Simulation results for climate zone 7 NCC2019 9aC 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone7-Class9aC-NCC2019-DTS Update final RIS.aps	Zone7-Class9aC-NCC2019-DTS Update final RIS.aps	Zone7-Class9aC-NCC2019-DTS Update final RIS.aps	Zone7-Class9aC-NCC2019-DTS Update final RIS.aps	Zone7-Class9aC-NCC2019-DTS Update final RIS.aps	Zone7-Class9aC-NCC2019-DTS Update final RIS.aps
Jan 01-31	1.3933	0.2814	0.7917	0.0459	0.1414	1.2592
Feb 01-28	1.4306	0.3698	0.803	0.0559	0.1893	1.1828
Mar 01-31	1.0728	0.8333	0.705	0.0358	0.1163	1.3472
Apr 01-30	0.7638	1.3566	0.6285	0.0346	0.0903	1.2924
May 01-31	0.2393	3.3629	0.5914	0.0532	0.0322	1.2592
Jun 01-30	0.1014	5.5856	0.6874	0.0791	0.0137	1.2924
Jul 01-31	0.0698	6.6654	0.7394	0.0888	0.0096	1.3032
Aug 01-31	0.0575	5.5358	0.6894	0.0819	0.0079	1.3032
Sep 01-30	0.2678	3.3466	0.6083	0.0533	0.0341	1.2924
Oct 01-31	0.6393	1.7204	0.6026	0.0318	0.0767	1.2592
Nov 01-30	1.0162	0.7837	0.6727	0.0328	0.1139	1.2924
Dec 01-31	1.3064	0.3703	0.7617	0.0369	0.1507	1.3472
Summed total	8.3581	30.2117	8.281	0.63	0.9762	15.4308

The combined total is 63.89MWh.

A.II.VI Model 9bHC 30 WWR

Table 201: Simulation results for climate zone 1 NCC2019 9bH 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone1-Class9bH-NCC2019-DTS Update.aps	Zone1-Class9bH-NCC2019-DTS Update.aps	Zone1-Class9bH-NCC2019-DTS Update.aps	Zone1-Class9bH-NCC2019-DTS Update.aps	Zone1-Class9bH-NCC2019-DTS Update.aps	Zone1-Class9bH-NCC2019-DTS Update.aps
Jan 01-31	24.27	-	8.09	0.28	-	2.62
Feb 01-28	23.01	0.00	7.70	0.27	-	2.47
Mar 01-31	27.18	0.00	8.86	0.32	-	2.82
Apr 01-30	22.34	0.00	8.47	0.24	-	2.70
May 01-31	19.43	0.01	8.09	0.20	-	2.62
Jun 01-30	14.70	0.03	8.47	0.13	-	2.70
Jul 01-31	14.61	0.02	8.47	0.14	-	2.72
Aug 01-31	16.64	0.01	8.47	0.16	-	2.72
Sep 01-30	19.98	0.00	8.47	0.21	-	2.70
Oct 01-31	22.30	0.00	8.09	0.23	-	2.62
Nov 01-30	26.64	-	8.47	0.30	-	2.70
Dec 01-31	26.92	-	8.86	0.30	-	2.82
Summed total	258.03	0.08	100.49	2.77	-	32.21

The combined total is 393.57MWh.

Table 202: Simulation results for climate zone 2 NCC2019 9bH 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone2-Class9bH-NCC2019-DTS Update.aps	Zone2-Class9bH-NCC2019-DTS Update.aps	Zone2-Class9bH-NCC2019-DTS Update.aps	Zone2-Class9bH-NCC2019-DTS Update.aps	Zone2-Class9bH-NCC2019-DTS Update.aps	Zone2-Class9bH-NCC2019-DTS Update.aps
Jan 01-31	11.87	0.00	6.03	0.14	-	2.62
Feb 01-28	11.74	0.01	5.75	0.13	-	2.47
Mar 01-31	9.12	0.04	6.61	0.10	-	2.82
Apr 01-30	7.09	0.85	6.32	0.07	-	2.70
May 01-31	3.52	2.42	6.03	0.04	-	2.62
Jun 01-30	2.07	5.48	6.32	0.04	-	2.70
Jul 01-31	1.59	7.42	6.32	0.05	-	2.72
Aug 01-31	2.57	5.00	6.32	0.04	-	2.72
Sep 01-30	3.52	1.89	6.32	0.04	-	2.70
Oct 01-31	5.77	0.90	6.03	0.05	-	2.62
Nov 01-30	7.85	0.05	6.32	0.08	-	2.70
Dec 01-31	10.54	0.01	6.61	0.11	-	2.82
Summed total	77.25	24.08	75.00	0.90	-	32.21

The combined total is 209.43MWh.

Table 203: Simulation results for climate zone 3 NCC2019 9bH 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone3-Class9bH-NCC2019 DTS Update.aps	Zone3-Class9bH-NCC2019 DTS Update.aps	Zone3-Class9bH-NCC2019 DTS Update.aps	Zone3-Class9bH-NCC2019 DTS Update.aps	Zone3-Class9bH-NCC2019 DTS Update.aps	Zone3-Class9bH-NCC2019 DTS Update.aps
Jan 01-31	23.91	0.10	8.09	0.40	-	2.62
Feb 01-28	21.51	0.12	7.70	0.35	-	2.47
Mar 01-31	18.04	0.36	8.86	0.27	-	2.82
Apr 01-30	13.32	1.11	8.47	0.18	-	2.70
May 01-31	5.12	3.44	8.09	0.07	-	2.62
Jun 01-30	2.92	6.55	8.47	0.06	-	2.70
Jul 01-31	3.37	6.49	8.47	0.07	-	2.72
Aug 01-31	4.81	4.99	8.47	0.07	-	2.72
Sep 01-30	11.90	1.20	8.47	0.15	-	2.70
Oct 01-31	12.10	0.93	8.09	0.16	-	2.62
Nov 01-30	21.04	0.17	8.47	0.31	-	2.70
Dec 01-31	21.44	0.17	8.86	0.33	-	2.82
Summed total	159.47	25.63	100.49	2.44	-	32.21

The combined total is 320.24MWh.

Table 204: Simulation results for climate zone 4 NCC2019 9bH 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone4-Class9bH-NCC2019-DTS Update.aps	Zone4-Class9bH-NCC2019-DTS Update.aps	Zone4-Class9bH-NCC2019-DTS Update.aps	Zone4-Class9bH-NCC2019-DTS Update.aps	Zone4-Class9bH-NCC2019-DTS Update.aps	Zone4-Class9bH-NCC2019-DTS Update.aps
Jan 01-31	10.75	0.37	8.09	0.16	-	2.62
Feb 01-28	11.33	1.08	7.70	0.18	-	2.47
Mar 01-31	8.43	1.30	8.86	0.11	-	2.82
Apr 01-30	4.65	3.63	8.47	0.07	-	2.70
May 01-31	1.44	7.97	8.09	0.07	-	2.62
Jun 01-30	0.52	15.67	8.47	0.10	-	2.70
Jul 01-31	0.16	19.58	8.47	0.10	-	2.72
Aug 01-31	0.64	15.12	8.47	0.09	-	2.72
Sep 01-30	1.10	11.34	8.47	0.08	-	2.70
Oct 01-31	3.57	4.04	8.09	0.06	-	2.62
Nov 01-30	4.75	2.61	8.47	0.05	-	2.70
Dec 01-31	9.34	0.80	8.86	0.12	-	2.82
Summed total	56.68	83.51	100.49	1.20	-	32.21

The combined total is 274.08MWh.

Table 205: Simulation results for climate zone 5 NCC2019 9bH 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone5-Class9bH-NCC2019-DTS Update.aps	Zone5-Class9bH-NCC2019-DTS Update.aps	Zone5-Class9bH-NCC2019-DTS Update.aps	Zone5-Class9bH-NCC2019-DTS Update.aps	Zone5-Class9bH-NCC2019-DTS Update.aps	Zone5-Class9bH-NCC2019-DTS Update.aps
Jan 01-31	6.91	0.14	6.03	0.12	-	2.62
Feb 01-28	7.05	0.02	5.75	0.13	-	2.47
Mar 01-31	6.95	0.16	6.61	0.13	-	2.82
Apr 01-30	5.00	0.90	6.32	0.09	-	2.70
May 01-31	2.23	2.60	6.03	0.06	-	2.62
Jun 01-30	1.12	5.51	6.32	0.07	-	2.70
Jul 01-31	0.73	8.80	6.32	0.09	-	2.72
Aug 01-31	1.89	6.18	6.32	0.08	-	2.72
Sep 01-30	2.59	3.08	6.32	0.06	-	2.70
Oct 01-31	4.06	1.77	6.03	0.07	-	2.62
Nov 01-30	4.58	0.94	6.32	0.07	-	2.70
Dec 01-31	6.79	0.30	6.61	0.12	-	2.82
Summed total	49.90	30.39	75.00	1.08	-	32.21

The combined total is 188.58MWh.

Table 206: Simulation results for climate zone 6 NCC2019 9bH 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone6-Class9bH-NCC2019-DTS Update.aps	Zone6-Class9bH-NCC2019-DTS Update.aps	Zone6-Class9bH-NCC2019-DTS Update.aps	Zone6-Class9bH-NCC2019-DTS Update.aps	Zone6-Class9bH-NCC2019-DTS Update.aps	Zone6-Class9bH-NCC2019-DTS Update.aps
Jan 01-31	5.55	1.13	8.09	0.08	-	2.62
Feb 01-28	8.32	0.96	7.70	0.14	-	2.47
Mar 01-31	6.12	1.96	8.86	0.10	-	2.82
Apr 01-30	2.57	3.92	8.47	0.07	-	2.70
May 01-31	0.70	9.49	8.09	0.08	-	2.62
Jun 01-30	0.12	17.03	8.47	0.12	-	2.70
Jul 01-31	0.07	18.62	8.47	0.13	-	2.72
Aug 01-31	0.34	13.58	8.47	0.11	-	2.72
Sep 01-30	0.97	9.69	8.47	0.09	-	2.70
Oct 01-31	2.38	5.59	8.09	0.08	-	2.62
Nov 01-30	4.24	3.31	8.47	0.09	-	2.70
Dec 01-31	4.81	1.85	8.86	0.08	-	2.82
Summed total	36.19	87.14	100.49	1.17	-	32.21

The combined total is 257.19MWh.

Table 207: Simulation results for climate zone 7 NCC2019 9bH 30 WWR.

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVAC distr fans energy (MWh)	ApHVAC distr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone7-Class9bH-NCC2019-DTS Update.aps	Zone7-Class9bH-NCC2019-DTS Update.aps	Zone7-Class9bH-NCC2019-DTS Update.aps	Zone7-Class9bH-NCC2019-DTS Update.aps	Zone7-Class9bH-NCC2019-DTS Update.aps	Zone7-Class9bH-NCC2019-DTS Update.aps
Jan 01-31	7.48	1.34	12.19	0.06	-	2.62
Feb 01-28	8.35	1.41	11.61	0.09	-	2.47
Mar 01-31	4.94	3.02	13.35	0.05	-	2.82
Apr 01-30	3.36	4.98	12.77	0.07	-	2.70
May 01-31	0.89	12.21	12.19	0.10	-	2.62
Jun 01-30	0.38	21.37	12.77	0.14	-	2.70
Jul 01-31	0.20	25.24	12.77	0.15	-	2.72
Aug 01-31	0.32	19.08	12.77	0.12	-	2.72
Sep 01-30	1.42	10.99	12.77	0.10	-	2.70
Oct 01-31	2.63	7.19	12.19	0.08	-	2.62
Nov 01-30	4.85	3.22	12.77	0.06	-	2.70
Dec 01-31	6.48	1.87	13.35	0.06	-	2.82
Summed total	41.30	111.91	151.46	1.08	-	32.21

The combined total is 337.96MWh.

A.III Mixed Model Scenarios – NCC 2016 Façade and NCC 2019 Services

A.III.I Mixed Model 3A 30 WWR

Table 208: Simulation results for climate zone 2 Mixed Model 3A 30 WWR

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVACdistr fans energy (MWh)	ApHVACdistr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone2-Class3A-NCC2019-DTS Update final RIS Service.aps	Zone2-Class3A-NCC2019-DTS Update final RIS Service.aps	Zone2-Class3A-NCC2019-DTS Update final RIS Service.aps	Zone2-Class3A-NCC2019-DTS Update final RIS Service.aps	Zone2-Class3A-NCC2019-DTS Update final RIS Service.aps	Zone2-Class3A-NCC2019-DTS Update final RIS Service.aps
Jan 01-31	32.4159	0	32.8743	0.1549	8.0031	5.6106
Feb 01-28	28.8424	0	29.6297	0.1416	6.9803	5.0677
Mar 01-31	26.7243	0	32.7518	0.1331	6.3016	5.6106
Apr 01-30	21.4927	0.1055	31.7111	0.1423	4.1015	5.4297
May 01-31	18.1384	0.5629	32.8743	0.1842	2.9753	5.6106
Jun 01-30	11.1442	2.4039	31.7111	0.3303	1.6976	5.4297
Jul 01-31	9.0715	5.2882	32.813	0.344	1.3988	5.6106
Aug 01-31	12.107	3.796	32.813	0.2652	1.8646	5.6106
Sep 01-30	17.1829	0.1167	31.7111	0.1673	2.6196	5.4297
Oct 01-31	21.0114	0.0018	32.8743	0.1287	3.5161	5.6106
Nov 01-30	24.5161	0	31.7111	0.1251	4.886	5.4297
Dec 01-31	27.9758	0	32.7518	0.1357	5.9716	5.6106
Summed total	250.6224	12.275	386.2266	2.2525	50.3161	66.0609

When 9.54MWh is added for the lifts, this results in a total of 777.30MWh.

Table 209: Simulation results for climate zone 5 Mixed Model 3A 30 WWR

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVACdistr fans energy (MWh)	ApHVACdistr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone5-Class3A-NCC2019-DTS Update final RIS Service.aps	Zone5-Class3A-NCC2019-DTS Update final RIS Service.aps	Zone5-Class3A-NCC2019-DTS Update final RIS Service.aps	Zone5-Class3A-NCC2019-DTS Update final RIS Service.aps	Zone5-Class3A-NCC2019-DTS Update final RIS Service.aps	Zone5-Class3A-NCC2019-DTS Update final RIS Service.aps
Jan 01-31	23.9072	0	32.8525	0.1205	4.2654	5.6106
Feb 01-28	23.2054	0	29.61	0.1134	4.9977	5.0677
Mar 01-31	23.2937	0	32.7301	0.1227	4.4884	5.6106
Apr 01-30	18.0581	0.0159	31.6901	0.1484	2.8873	5.4297
May 01-31	13.6613	0.2583	32.8525	0.3349	2.1276	5.6106
Jun 01-30	7.7488	1.6553	31.6901	0.6204	1.2503	5.4297
Jul 01-31	7.181	4.456	32.7913	0.5871	1.1503	5.6106
Aug 01-31	10.2791	1.7075	32.7913	0.516	1.6035	5.6106
Sep 01-30	12.5292	0.3004	31.6901	0.353	1.9649	5.4297
Oct 01-31	17.5176	0.1763	32.8525	0.2225	2.6547	5.6106
Nov 01-30	19.8736	0.0041	31.6901	0.1228	3.2086	5.4297
Dec 01-31	22.9263	0	32.7301	0.1175	4.6773	5.6106
Summed total	200.1814	8.5737	385.9706	3.3792	35.276	66.0609

When 9.54MWh is added for the lifts, this results in a total of 708.98MWh.

Table 210: Simulation results for climate zone 6 Mixed Model 3A 30 WWR

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVACdistr fans energy (MWh)	ApHVACdistr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone6-Class3A-NCC2019-DTS Update final RIS Service.aps	Zone6-Class3A-NCC2019-DTS Update final RIS Service.aps	Zone6-Class3A-NCC2019-DTS Update final RIS Service.aps	Zone6-Class3A-NCC2019-DTS Update final RIS Service.aps	Zone6-Class3A-NCC2019-DTS Update final RIS Service.aps	Zone6-Class3A-NCC2019-DTS Update final RIS Service.aps
Jan 01-31	14.658	0.0108	32.8589	0.1266	3.0407	5.6106
Feb 01-28	14.4684	0.0019	29.6159	0.1252	3.1777	5.0677
Mar 01-31	13.7118	0.029	32.7366	0.1454	2.8528	5.6106
Apr 01-30	10.2148	0.2756	31.6963	0.2382	2.2577	5.4297
May 01-31	7.4924	0.8818	32.8589	0.4229	1.7344	5.6106
Jun 01-30	5.6896	1.6484	31.6963	0.5068	1.3274	5.4297
Jul 01-31	5.1802	2.9955	32.7977	0.6282	1.2093	5.6106
Aug 01-31	6.344	1.9777	32.7977	0.5246	1.4789	5.6106
Sep 01-30	7.5868	1.201	31.6963	0.3976	1.7464	5.4297
Oct 01-31	10.1675	0.5378	32.8589	0.3004	2.2079	5.6106
Nov 01-30	11.7094	0.2202	31.6963	0.2247	2.4376	5.4297
Dec 01-31	13.5589	0.0174	32.7366	0.143	2.8532	5.6106
Summed total	120.7818	9.7971	386.0467	3.7836	26.3239	66.0609

When 9.54MWh is added for the lifts, this results in a total of 622.34MWh.

A.III.II Mixed Model 5A 40 WWR

Table 211: Simulation results for climate zone 2 Mixed Model 5A 40 WWR

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVACdistr fans energy (MWh)	ApHVACdistr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone2-Class5A-NCC2019-DTS Update RIS final service R1.aps	Zone2-Class5A-NCC2019-DTS Update RIS final service R1.aps	Zone2-Class5A-NCC2019-DTS Update RIS final service R1.aps	Zone2-Class5A-NCC2019-DTS Update RIS final service R1.aps	Zone2-Class5A-NCC2019-DTS Update RIS final service R1.aps	Zone2-Class5A-NCC2019-DTS Update RIS final service R1.aps
Jan 01-31	21.1655	0.0052	8.3097	0.4244	3.6579	12.591
Feb 01-28	20.4616	0.0087	7.8994	0.4316	3.4577	11.8271
Mar 01-31	18.5029	0.006	8.3171	0.2757	3.7853	13.4717
Apr 01-30	14.4993	0.3197	7.1492	0.1698	2.6996	12.9235
May 01-31	10.2625	0.8739	5.9932	0.1123	1.9455	12.591
Jun 01-30	7.5312	2.7332	5.4151	0.1008	1.0877	12.9235
Jul 01-31	6.6913	4.1047	5.3209	0.1194	0.9685	13.0314
Aug 01-31	8.6409	2.4175	5.9901	0.1186	1.3211	13.0314
Sep 01-30	10.8368	0.5776	6.6676	0.1223	1.7983	12.9235
Oct 01-31	12.7942	0.202	6.879	0.1411	2.0877	12.591
Nov 01-30	16.9587	0.0007	8.0185	0.2637	3.0428	12.9235
Dec 01-31	19.9916	0.0022	8.7449	0.3431	3.7001	13.4718
Summed total	168.3365	11.2514	84.7047	2.6228	29.5524	154.3004

When 55.54MWh is added for the lifts, this results in a total of 506.31MWh.

Table 212: Simulation results for climate zone 5 Mixed Model 5A 40 WWR

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVACdistr fans energy (MWh)	ApHVACdistr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone5-Class5A-NCC2019-DTS Update final RIS service R1.aps	Zone5-Class5A-NCC2019-DTS Update final RIS service R1.aps	Zone5-Class5A-NCC2019-DTS Update final RIS service R1.aps	Zone5-Class5A-NCC2019-DTS Update final RIS service R1.aps	Zone5-Class5A-NCC2019-DTS Update final RIS service R1.aps	Zone5-Class5A-NCC2019-DTS Update final RIS service R1.aps
Jan 01-31	14.7915	0.0577	8.1795	0.2232	2.712	12.591
Feb 01-28	14.9352	0.0581	7.9297	0.2427	2.6219	11.8271
Mar 01-31	15.1108	0.078	8.2945	0.215	2.8759	13.4717
Apr 01-30	9.7479	0.5003	7.1749	0.1054	1.6988	12.9235
May 01-31	3.8505	2.0839	4.5936	0.102	0.6608	12.591
Jun 01-30	1.0218	6.1509	3.7521	0.158	0.1614	12.9235
Jul 01-31	0.7354	8.7239	4.0702	0.1756	0.1093	13.0314
Aug 01-31	3.2227	4.7441	5.1322	0.1118	0.4256	13.0314
Sep 01-30	4.2245	1.6505	5.4187	0.0851	0.613	12.9235
Oct 01-31	7.0232	0.9867	6.4427	0.1117	1.0352	12.591
Nov 01-30	10.1863	0.2864	7.7406	0.1147	1.6817	12.9235
Dec 01-31	14.1219	0.1038	8.0305	0.1908	2.5144	13.4718
Summed total	98.9718	25.4242	76.7593	1.8359	17.1099	154.3004

When 55.54MWh is added for the lifts, this results in a total of 429.94MWh.

Table 213: Simulation results for climate zone 6 Mixed Model 5A 40 WWR

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVACdistr fans energy (MWh)	ApHVACdistr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone6-Class5A-NCC2019-DTS Update final RIS service R1.aps	Zone6-Class5A-NCC2019-DTS Update final RIS service R1.aps	Zone6-Class5A-NCC2019-DTS Update final RIS service R1.aps	Zone6-Class5A-NCC2019-DTS Update final RIS service R1.aps	Zone6-Class5A-NCC2019-DTS Update final RIS service R1.aps	Zone6-Class5A-NCC2019-DTS Update final RIS service R1.aps
Jan 01-31	9.3823	0.3162	7.3591	0.1323	1.3449	12.591
Feb 01-28	10.0123	0.3139	7.059	0.1783	1.5133	11.8271
Mar 01-31	8.791	0.684	7.3491	0.1183	1.1984	13.4717
Apr 01-30	2.7035	2.1258	5.0563	0.0719	0.3126	12.9235
May 01-31	0.669	6.3734	4.0157	0.1465	0.0804	12.591
Jun 01-30	0	13.7017	4.5482	0.2738	0	12.9235
Jul 01-31	0	15.7761	4.7899	0.2996	0	13.0314
Aug 01-31	0	10.3364	4.2622	0.2007	0	13.0314
Sep 01-30	0.693	5.0757	4.2599	0.1115	0.0831	12.9235
Oct 01-31	2.4356	2.4418	4.8529	0.0757	0.2877	12.591
Nov 01-30	5.3286	1.0144	6.4429	0.0793	0.6269	12.9235
Dec 01-31	7.3187	0.5439	7.4129	0.11	0.9474	13.4718
Summed total	47.3339	58.7035	67.4079	1.7979	6.3948	154.3004

When 55.54MWh is added for the lifts, this results in a total of 391.48MWh.

A.III.III Mixed Model 6B 30 WWR

Table 214: Simulation results for climate zone 2 Mixed Model 6B 30 WWR

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVACdistr fans energy (MWh)	ApHVACdistr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone2-Class6B-DTS Update final RIS Service.aps	Zone2-Class6B-DTS Update final RIS Service.aps	Zone2-Class6B-DTS Update final RIS Service.aps	Zone2-Class6B-DTS Update final RIS Service.aps	Zone2-Class6B-DTS Update final RIS Service.aps	Zone2-Class6B-DTS Update final RIS Service.aps
Jan 01-31	8.193	0.0018	4.1744	0.1018	1.3745	13.1195
Feb 01-28	7.4132	0.004	3.7705	0.0934	1.2225	11.8499
Mar 01-31	6.3219	0.0027	4.1744	0.0434	1.2666	13.1195
Apr 01-30	5.0673	0.1611	4.0398	0.0257	0.802	12.6963
May 01-31	3.8428	0.6724	4.1744	0.0161	0.5921	13.1195
Jun 01-30	2.649	1.9167	4.0398	0.0174	0.2589	12.6963
Jul 01-31	2.3167	3.1076	4.1744	0.0235	0.2331	13.1195
Aug 01-31	2.9032	2.1157	4.1744	0.0202	0.3022	13.1195
Sep 01-30	3.6698	0.3543	4.0398	0.014	0.4091	12.6963
Oct 01-31	4.6676	0.1278	4.1744	0.0222	0.5996	13.1195
Nov 01-30	5.7938	0	4.0398	0.0399	0.9468	12.6963
Dec 01-31	6.6805	0	4.1744	0.0574	1.1852	13.1195
Summed total	59.5189	8.4641	49.1507	0.4752	9.1926	154.4721

The combined total is 281.27MWh.

Table 215: Simulation results for climate zone 5 Mixed Model 6B 30 WWR

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVACdistr fans energy (MWh)	ApHVACdistr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone5-Class6B-DTS Update final RIS Service.aps	Zone5-Class6B-DTS Update final RIS Service.aps	Zone5-Class6B-DTS Update final RIS Service.aps	Zone5-Class6B-DTS Update final RIS Service.aps	Zone5-Class6B-DTS Update final RIS Service.aps	Zone5-Class6B-DTS Update final RIS Service.aps
Jan 01-31	5.2085	0.0165	6.3224	0.1132	0.8555	13.1195
Feb 01-28	5.3696	0.0046	5.7105	0.1318	0.9293	11.8499
Mar 01-31	5.0217	0.0223	6.3224	0.1016	0.8687	13.1195
Apr 01-30	3.7052	0.321	6.1184	0.0502	0.5528	12.6963
May 01-31	2.355	1.421	6.3224	0.0348	0.3061	13.1195
Jun 01-30	1.2262	3.9615	6.1184	0.0399	0.1548	12.6963
Jul 01-31	1.1991	6.2503	6.3224	0.0428	0.1471	13.1195
Aug 01-31	1.7817	3.9143	6.3224	0.0393	0.2052	13.1195
Sep 01-30	2.3608	1.2691	6.1184	0.0368	0.289	12.6963
Oct 01-31	3.6731	0.6623	6.3224	0.0637	0.4558	13.1195
Nov 01-30	3.9069	0.1495	6.1184	0.0558	0.568	12.6963
Dec 01-31	5.0129	0.0426	6.3224	0.0994	0.7905	13.1195
Summed total	40.8205	18.0348	74.4407	0.8093	6.1227	154.4721

The combined total is 294.70MWh.

Table 216: Simulation results for climate zone 6 Mixed Model 6B 30 WWR

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVACdistr fans energy (MWh)	ApHVACdistr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone6-Class6B-DTS Update final RIS service.aps	Zone6-Class6B-DTS Update final RIS service.aps	Zone6-Class6B-DTS Update final RIS service.aps	Zone6-Class6B-DTS Update final RIS service.aps	Zone6-Class6B-DTS Update final RIS service.aps	Zone6-Class6B-DTS Update final RIS service.aps
Jan 01-31	4.0004	0.422	6.3147	0.0315	0.4538	13.1195
Feb 01-28	4.4283	0.4531	5.7036	0.0494	0.5478	11.8499
Mar 01-31	3.94	0.9241	6.3147	0.0315	0.4206	13.1195
Apr 01-30	2.3313	2.1587	6.111	0.0297	0.2281	12.6963
May 01-31	0.6719	7.1534	6.3147	0.0304	0.0708	13.1195
Jun 01-30	0.0374	12.4542	6.111	0.0335	0.0043	12.6963
Jul 01-31	0.0084	16.0262	6.3147	0.0398	0.001	13.1195
Aug 01-31	0.1765	10.9943	6.3147	0.048	0.0203	13.1195
Sep 01-30	0.9866	6.1923	6.111	0.0405	0.1058	12.6963
Oct 01-31	2.1928	3.3272	6.3147	0.0423	0.2142	13.1195
Nov 01-30	2.9267	1.6552	6.111	0.0347	0.2844	12.6963
Dec 01-31	3.4627	0.7362	6.3147	0.0376	0.3717	13.1195
Summed total	25.163	62.4969	74.3505	0.4488	2.723	154.4721

The combined total is 319.65MWh.

A.III.IV Mixed Model 9aC 30 WWR

Table 217: Simulation results for climate zone 2 Mixed Model 9aC 30 WWR

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVACdistr fans energy (MWh)	ApHVACdistr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone2-Class9aC-NCC2019-DTS Update final RIS Service.aps	Zone2-Class9aC-NCC2019-DTS Update final RIS Service.aps	Zone2-Class9aC-NCC2019-DTS Update final RIS Service.aps	Zone2-Class9aC-NCC2019-DTS Update final RIS Service.aps	Zone2-Class9aC-NCC2019-DTS Update final RIS Service.aps	Zone2-Class9aC-NCC2019-DTS Update final RIS Service.aps
Jan 01-31	2.6523	0	0.7897	0.0388	0.429	1.2592
Feb 01-28	2.5737	0	0.7536	0.0422	0.4042	1.1828
Mar 01-31	2.2552	0.0037	0.7644	0.0208	0.44	1.3472
Apr 01-30	1.7275	0.1155	0.661	0.0124	0.3036	1.2924
May 01-31	1.1732	0.3238	0.5462	0.0097	0.2051	1.2592
Jun 01-30	0.8798	0.8493	0.4863	0.0155	0.1091	1.2924
Jul 01-31	0.7833	1.149	0.4882	0.0191	0.0979	1.3032
Aug 01-31	0.9814	0.7784	0.5435	0.0145	0.1316	1.3032
Sep 01-30	1.2119	0.2697	0.5955	0.0084	0.178	1.2924
Oct 01-31	1.4921	0.1166	0.624	0.0091	0.224	1.2592
Nov 01-30	2.0016	0.0055	0.7342	0.0165	0.342	1.2924
Dec 01-31	2.44	0.0009	0.817	0.0265	0.4286	1.3472
Summed total	20.1718	3.6124	7.8037	0.2335	3.2932	15.4308

The combined total is 50.55MWh.

Table 218: Simulation results for climate zone 5 Mixed Model 9aC 30 WWR

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVACdistr fans energy (MWh)	ApHVACdistr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone5-Class9aC-NCC2019-DTS Update final RIS service.aps	Zone5-Class9aC-NCC2019-DTS Update final RIS service.aps	Zone5-Class9aC-NCC2019-DTS Update final RIS service.aps	Zone5-Class9aC-NCC2019-DTS Update final RIS service.aps	Zone5-Class9aC-NCC2019-DTS Update final RIS service.aps	Zone5-Class9aC-NCC2019-DTS Update final RIS service.aps
Jan 01-31	1.7555	0.0253	0.6315	0.0163	0.3034	1.2592
Feb 01-28	1.8033	0.0053	0.6024	0.0198	0.2982	1.1828
Mar 01-31	1.8252	0.0555	0.6509	0.0191	0.3222	1.3472
Apr 01-30	1.3026	0.2261	0.5486	0.0115	0.204	1.2924
May 01-31	0.7876	0.7004	0.4139	0.0151	0.1156	1.2592
Jun 01-30	0.5581	1.5114	0.4007	0.0262	0.0788	1.2924
Jul 01-31	0.4913	2.0545	0.4362	0.0329	0.0697	1.3032
Aug 01-31	0.712	1.3661	0.464	0.0242	0.0899	1.3032
Sep 01-30	0.8637	0.691	0.4596	0.0149	0.1129	1.2924
Oct 01-31	1.0891	0.4076	0.5039	0.0118	0.1422	1.2592
Nov 01-30	1.2995	0.1671	0.5612	0.0101	0.193	1.2924
Dec 01-31	1.7138	0.0626	0.6148	0.0155	0.2827	1.3472
Summed total	14.2017	7.273	6.2875	0.2176	2.2125	15.4308

The combined total is 45.62MWh.

Table 219: Simulation results for climate zone 6 Mixed Model 9aC 30 WWR

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVACdistr fans energy (MWh)	ApHVACdistr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone6-Class9aC-NCC2019-DTS Update final RIS service.aps	Zone6-Class9aC-NCC2019-DTS Update final RIS service.aps	Zone6-Class9aC-NCC2019-DTS Update final RIS service.aps	Zone6-Class9aC-NCC2019-DTS Update final RIS service.aps	Zone6-Class9aC-NCC2019-DTS Update final RIS service.aps	Zone6-Class9aC-NCC2019-DTS Update final RIS service.aps
Jan 01-31	1.2475	0.1779	0.4936	0.0133	0.1616	1.2592
Feb 01-28	1.4428	0.1609	0.4836	0.018	0.1964	1.1828
Mar 01-31	1.2794	0.3838	0.5095	0.0158	0.1526	1.3472
Apr 01-30	0.6875	0.813	0.4053	0.0194	0.0765	1.2924
May 01-31	0.1918	1.8169	0.366	0.0338	0.0225	1.2592
Jun 01-30	0.026	3.2291	0.4148	0.052	0.0034	1.2924
Jul 01-31	0.0054	3.5479	0.43	0.0533	0.0007	1.3032
Aug 01-31	0.0778	2.6144	0.4029	0.047	0.0101	1.3032
Sep 01-30	0.3641	1.7018	0.3983	0.034	0.0446	1.2924
Oct 01-31	0.6336	1.0067	0.3995	0.023	0.0721	1.2592
Nov 01-30	1.0095	0.6112	0.4668	0.017	0.1082	1.2924
Dec 01-31	1.1422	0.3296	0.503	0.0145	0.1332	1.3472
Summed total	8.1076	16.3932	5.2733	0.341	0.9819	15.4308

The combined total is 46.53MWh.

A.III.V Mixed Model 9bH 30 WWR

Table 220: Simulation results for climate zone 2 Mixed Model 9bH 30 WWR

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVACdistr fans energy (MWh)	ApHVACdistr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone2-Class9bH-NCC2019-DTS Update final RIS service.aps	Zone2-Class9bH-NCC2019-DTS Update final RIS service.aps	Zone2-Class9bH-NCC2019-DTS Update final RIS service.aps	Zone2-Class9bH-NCC2019-DTS Update final RIS service.aps	Zone2-Class9bH-NCC2019-DTS Update final RIS service.aps	Zone2-Class9bH-NCC2019-DTS Update final RIS service.aps
Jan 01-31	13.6014	0.0035	6.0347	0.1447	0	2.6158
Feb 01-28	13.6399	0.0137	5.7473	0.1395	0	2.4683
Mar 01-31	10.125	0.0398	6.6094	0.0951	0	2.8205
Apr 01-30	7.6815	0.3291	6.3221	0.0562	0	2.7031
May 01-31	3.8836	1.4032	6.0347	0.0318	0	2.6158
Jun 01-30	2.3612	3.6139	6.3221	0.0299	0	2.7031
Jul 01-31	1.8575	5.0343	6.3221	0.0377	0	2.7182
Aug 01-31	2.8058	3.2477	6.3221	0.0313	0	2.7182
Sep 01-30	3.7556	0.9393	6.3221	0.0247	0	2.7031
Oct 01-31	6.081	0.3073	6.0347	0.0428	0	2.6158
Nov 01-30	8.624	0.0328	6.3221	0.0692	0	2.7031
Dec 01-31	11.7187	0.0157	6.6094	0.1047	0	2.8205
Summed total	86.1351	14.9805	75.0028	0.8076	0	32.2055

The combined total is 209.13MWh.

Table 221: Simulation results for climate zone 5 Mixed Model 9bH 30 WWR

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVACdistr fans energy (MWh)	ApHVACdistr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone5-Class9bH-NCC2019-DTS Update final RIS Service.aps	Zone5-Class9bH-NCC2019-DTS Update final RIS Service.aps	Zone5-Class9bH-NCC2019-DTS Update final RIS Service.aps	Zone5-Class9bH-NCC2019-DTS Update final RIS Service.aps	Zone5-Class9bH-NCC2019-DTS Update final RIS Service.aps	Zone5-Class9bH-NCC2019-DTS Update final RIS Service.aps
Jan 01-31	6.8296	0.0705	6.0348	0.15	0	2.6158
Feb 01-28	7.0132	0	5.7474	0.1575	0	2.4683
Mar 01-31	6.9172	0.0593	6.6096	0.1602	0	2.8205
Apr 01-30	5.0477	0.5526	6.3222	0.1067	0	2.7031
May 01-31	2.322	1.8814	6.0348	0.061	0	2.6158
Jun 01-30	1.2572	4.3213	6.3222	0.0699	0	2.7031
Jul 01-31	0.9121	6.7272	6.3222	0.0844	0	2.7182
Aug 01-31	2.0289	4.6573	6.3222	0.0804	0	2.7182
Sep 01-30	2.6547	2.1936	6.3222	0.065	0	2.7031
Oct 01-31	4.0216	1.2439	6.0348	0.079	0	2.6158
Nov 01-30	4.565	0.5456	6.3222	0.0868	0	2.7031
Dec 01-31	6.6888	0.1452	6.6096	0.1346	0	2.8205
Summed total	50.2581	22.3979	75.004	1.2357	0	32.2055

The combined total is 181.10MWh.

Table 222: Simulation results for climate zone 6 Mixed Model 9bH 30 WWR

Date	ApHVAC chillers energy (MWh)	ApHVAC boilers energy (MWh)	ApHVACdistr fans energy (MWh)	ApHVACdistr pumps energy (MWh)	ApHVAC heat rej fans/pumps energy (MWh)	Total lights energy (MWh)
Model	Zone6-Class9bH-NCC2019-DTS Update final RIS service.aps	Zone6-Class9bH-NCC2019-DTS Update final RIS service.aps	Zone6-Class9bH-NCC2019-DTS Update final RIS service.aps	Zone6-Class9bH-NCC2019-DTS Update final RIS service.aps	Zone6-Class9bH-NCC2019-DTS Update final RIS service.aps	Zone6-Class9bH-NCC2019-DTS Update final RIS service.aps
Jan 01-31	5.4079	0.522	8.0854	0.091	0	2.6158
Feb 01-28	7.8654	0.4445	7.7004	0.149	0	2.4683
Mar 01-31	6.0209	1.0898	8.8554	0.1038	0	2.8205
Apr 01-30	2.7339	2.4445	8.4704	0.0599	0	2.7031
May 01-31	0.9433	6.4703	8.0854	0.0772	0	2.6158
Jun 01-30	0.2715	12.1904	8.4704	0.1098	0	2.7031
Jul 01-31	0.1591	13.7524	8.4704	0.118	0	2.7182
Aug 01-31	0.495	10.1807	8.4704	0.1072	0	2.7182
Sep 01-30	1.1677	6.8646	8.4704	0.0831	0	2.7031
Oct 01-31	2.447	3.7984	8.0854	0.0736	0	2.6158
Nov 01-30	4.2051	2.0732	8.4704	0.0866	0	2.7031
Dec 01-31	4.7766	0.9415	8.8554	0.0805	0	2.8205
Summed total	36.4933	60.7723	100.4898	1.1396	0	32.2055

The combined total is 231.10MWh.

B. Appendix – Breakdown of Energy Results

B.I Impact of Increased Stringency Modelling

Table 223: Breakdown of sub-system energy results for model 3A (30% WWR) – lighting and lift energy not displayed.

Climate zone	NCC	Chiller	Boiler	Fans	Pumps	Heat Rejection	Total
Climate zone 1	NCC2016	365.91	0.00	471.24	4.46	117.88	1,035.10
Climate zone 1	NCC2019	384.40	0.00	386.07	2.09	85.37	933.55
Climate zone 1	Variance	5%	-	-18%	-53%	-28%	-10%
Climate zone 2	NCC2016	305.83	9.74	471.33	4.36	75.90	942.75
Climate zone 2	NCC2019	208.79	3.58	386.18	2.12	48.18	724.45
Climate zone 2	Variance	-32%	-63%	-18%	-51%	-37%	-23%
Climate zone 3	NCC2016	254.67	8.16	471.16	4.12	55.65	869.37
Climate zone 3	NCC2019	196.24	7.27	386.10	2.11	35.90	703.23
Climate zone 3	Variance	-23%	-11%	-18%	-49%	-35%	-19%
Climate zone 4	NCC2016	197.03	34.67	471.25	4.88	40.14	823.58
Climate zone 4	NCC2019	125.46	5.58	386.05	3.56	27.44	623.70
Climate zone 4	Variance	-36%	-84%	-18%	-27%	-32%	-24%
Climate zone 5	NCC2016	243.38	2.30	471.18	3.73	58.80	854.99
Climate zone 5	NCC2019	174.76	1.44	385.96	2.52	36.58	676.87
Climate zone 5	Variance	-28%	-37%	-18%	-32%	-38%	-21%
Climate zone 6	NCC2016	193.47	25.68	471.33	5.27	39.58	810.93
Climate zone 6	NCC2019	113.78	5.06	385.95	3.64	26.57	610.60
Climate zone 6	Variance	-41%	-80%	-18%	-31%	-33%	-25%
Climate zone 7	NCC2016	172.65	34.67	471.31	4.26	39.30	797.79
Climate zone 7	NCC2019	103.99	13.30	385.98	3.40	26.08	608.35
Climate zone 7	Variance	-40%	-62%	-18%	-20%	-34%	-24%

Table 224: Breakdown of sub-system energy results for model 9aC (30% WWR) – lighting and lift energy not displayed.

Climate zone	NCC	Chiller	Boiler	Fans	Pumps	Heat Rejection	Total
Climate zone 1	NCC2016	53.97	0.00	22.37	1.30	6.93	100.00
Climate zone 1	NCC2019	41.42	0.01	15.85	0.55	6.06	79.32
Climate zone 1	Variance	-23%	-	-29%	-58%	-13%	-21%
Climate zone 2	NCC2016	26.56	3.86	10.11	0.41	4.82	61.20
Climate zone 2	NCC2019	19.36	4.07	7.48	0.22	3.21	49.77
Climate zone 2	Variance	-27%	5%	-26%	-47%	-33%	-19%
Climate zone 3	NCC2016	33.20	6.37	19.34	0.65	4.33	79.32
Climate zone 3	NCC2019	26.25	5.64	13.11	0.31	2.55	63.28
Climate zone 3	Variance	-21%	-12%	-32%	-52%	-41%	-20%
Climate zone 4	NCC2016	16.87	19.09	13.61	0.46	1.90	67.36
Climate zone 4	NCC2019	12.43	19.51	10.07	0.44	1.28	59.17
Climate zone 4	Variance	-26%	2%	-26%	-3%	-32%	-12%
Climate zone 5	NCC2016	18.90	7.95	8.19	0.33	3.12	53.92
Climate zone 5	NCC2019	13.85	8.08	6.13	0.24	2.15	45.88
Climate zone 5	Variance	-27%	2%	-25%	-29%	-31%	-15%
Climate zone 6	NCC2016	12.44	17.07	7.20	0.42	1.55	54.11
Climate zone 6	NCC2019	7.76	25.47	7.86	0.48	0.86	57.86
Climate zone 6	Variance	-38%	49%	9%	14%	-44%	7%
Climate zone 7	NCC2016	12.50	19.20	12.96	0.56	1.54	62.18
Climate zone 7	NCC2019	8.36	30.21	8.28	0.63	0.98	63.89
Climate zone 7	Variance	-33%	57%	-36%	13%	-37%	3%

Table 225: Breakdown of sub-system energy results for model 5A (56% WWR) – lighting and lift energy not displayed.

Climate zone	NCC	Chiller	Boiler	Fans	Pumps	Heat Rejection	Total
Climate zone 1	NCC2016	262.79	0.00	138.33	16.05	57.17	684.18
Climate zone 1	NCC2019	262.28	0.01	114.06	7.10	42.25	635.54
Climate zone 1	Variance	-0.2%	-	-18%	-56%	-26%	-7%
Climate zone 2	NCC2016	162.29	12.36	114.61	4.93	48.73	552.77
Climate zone 2	NCC2019	155.40	5.08	93.07	2.43	28.80	494.62
Climate zone 2	Variance	-4%	-59%	-19%	-51%	-41%	-11%
Climate zone 3	NCC2016	161.44	17.67	111.45	8.43	35.24	544.07
Climate zone 3	NCC2019	181.11	4.10	84.27	5.20	21.44	505.96
Climate zone 3	Variance	12%	-77%	-24%	-38%	-39%	-7%
Climate zone 4	NCC2016	80.52	33.04	98.84	3.51	19.68	445.43
Climate zone 4	NCC2019	68.85	46.70	76.34	2.21	9.32	413.26
Climate zone 4	Variance	-14%	41%	-23%	-37%	-53%	-7%
Climate zone 5	NCC2016	109.42	13.11	107.00	5.56	32.50	477.42
Climate zone 5	NCC2019	91.76	11.56	87.13	1.79	16.88	418.96
Climate zone 5	Variance	-16%	-12%	-19%	-68%	-48%	-12%
Climate zone 6	NCC2016	52.92	50.26	91.48	2.27	13.69	420.46
Climate zone 6	NCC2019	44.03	61.55	66.54	1.84	6.11	389.91
Climate zone 6	Variance	-17%	22%	-27%	-19%	-55%	-7%
Climate zone 7	NCC2016	53.18	33.30	97.65	2.73	13.95	410.65
Climate zone 7	NCC2019	37.02	74.38	63.52	2.75	5.37	392.89
Climate zone 7	Variance	-30%	123%	-35%	1%	-61%	-4%

Table 226: Breakdown of sub-system energy results for model 6B (30% WWR) – lighting and lift energy not displayed.

Climate zone	NCC	Chiller	Boiler	Fans	Pumps	Heat Rejection	Total
Climate zone 1	NCC2016	155.81	0.01	97.54	3.39	29.49	440.71
Climate zone 1	NCC2019	141.91	0.04	74.43	1.90	19.47	392.22
Climate zone 1	Variance	-9%	572%	-24%	-44%	-34%	-11%
Climate zone 2	NCC2016	81.38	9.43	59.98	0.85	13.94	320.05
Climate zone 2	NCC2019	60.31	11.64	49.13	0.50	9.45	285.50
Climate zone 2	Variance	-26%	23%	-18%	-41%	-32%	-11%
Climate zone 3	NCC2016	99.11	19.59	97.55	1.41	12.19	384.32
Climate zone 3	NCC2019	77.31	23.52	74.45	0.64	7.13	337.52
Climate zone 3	Variance	-22%	20%	-24%	-55%	-41%	-12%
Climate zone 4	NCC2016	53.70	69.52	97.54	1.00	6.82	383.06
Climate zone 4	NCC2019	38.19	84.19	74.42	0.52	3.44	355.23
Climate zone 4	Variance	-29%	21%	-24%	-48%	-50%	-7%
Climate zone 5	NCC2016	63.42	17.86	97.54	1.56	11.16	346.01
Climate zone 5	NCC2019	41.07	25.85	74.43	0.76	6.02	302.60
Climate zone 5	Variance	-35%	45%	-24%	-51%	-46%	-13%
Climate zone 6	NCC2016	41.83	64.29	97.56	1.09	5.57	364.81
Climate zone 6	NCC2019	24.18	96.45	74.35	0.56	2.49	352.51
Climate zone 6	Variance	-42%	50%	-24%	-48%	-55%	-3%
Climate zone 7	NCC2016	34.06	112.61	59.97	0.82	3.67	365.59
Climate zone 7	NCC2019	26.05	96.32	74.37	0.62	2.71	354.54
Climate zone 7	Variance	-24%	-14%	24%	-24%	-26%	-3%

Table 227: Breakdown of sub-system energy results for model 9bH (30% WWR) – lighting and lift energy not displayed.

Climate zone	NCC	Chiller	Boiler	Fans	Pumps	Heat Rejection	Total
Climate zone 1	NCC2016	359.67	0.28	133.26	5.08	0.00	530.50
Climate zone 1	NCC2019	258.03	0.08	100.49	2.77	0.00	393.57
Climate zone 1	Variance	-28%	-73%	-25%	-45%	-	-26%
Climate zone 2	NCC2016	146.44	15.62	98.31	2.01	0.00	294.59
Climate zone 2	NCC2019	77.25	24.08	75.00	0.90	0.00	209.43
Climate zone 2	Variance	-47%	54%	-24%	-55%	-	-29%
Climate zone 3	NCC2016	211.49	35.13	133.26	3.73	0.00	415.81
Climate zone 3	NCC2019	159.47	25.63	100.49	2.44	0.00	320.24
Climate zone 3	Variance	-25%	-27%	-25%	-35%	-	-23%
Climate zone 4	NCC2016	76.44	111.06	133.26	2.09	0.00	355.05
Climate zone 4	NCC2019	56.68	83.51	100.49	1.20	0.00	274.08
Climate zone 4	Variance	-26%	-25%	-25%	-43%	-	-23%
Climate zone 5	NCC2016	64.43	45.91	98.31	2.50	0.00	243.36
Climate zone 5	NCC2019	49.90	30.39	75.00	1.08	0.00	188.58
Climate zone 5	Variance	-23%	-34%	-24%	-57%	-	-23%
Climate zone 6	NCC2016	46.45	119.69	133.26	1.78	0.00	333.39
Climate zone 6	NCC2019	36.19	87.14	100.49	1.17	0.00	257.19
Climate zone 6	Variance	-22%	-27%	-25%	-34%	-	-23%
Climate zone 7	NCC2016	55.88	134.19	203.89	1.81	0.00	427.97
Climate zone 7	NCC2019	41.30	111.91	151.46	1.08	0.00	337.96
Climate zone 7	Variance	-26%	-17%	-26%	-40%	-	-21%

Table 228: Breakdown of sub-system energy results for model 5A (40% WWR) – lighting and lift energy not displayed.

Climate zone	NCC	Chiller	Boiler	Fans	Pumps	Heat Rejection	Total
Climate zone 1	NCC2016	274.27	0.02	130.84	11.97	60.04	686.98
Climate zone 1	NCC2019	258.43	0.01	104.09	6.68	41.35	620.40
Climate zone 1	Variance	-6%	-42%	-20%	-44%	-31%	-10%
Climate zone 2	NCC2016	173.31	14.83	112.69	5.01	48.81	564.49
Climate zone 2	NCC2019	145.99	4.72	96.45	2.67	27.74	487.41
Climate zone 2	Variance	-16%	-68%	-14%	-47%	-43%	-14%
Climate zone 3	NCC2016	171.20	26.77	109.13	6.41	35.59	558.94
Climate zone 3	NCC2019	183.49	17.78	79.65	3.28	21.31	515.36
Climate zone 3	Variance	7%	-34%	-27%	-49%	-40%	-8%
Climate zone 4	NCC2016	77.74	58.84	94.22	3.28	19.27	463.19
Climate zone 4	NCC2019	65.78	39.32	79.21	1.99	9.15	405.29
Climate zone 4	Variance	-15%	-33%	-16%	-39%	-53%	-12%
Climate zone 5	NCC2016	116.49	31.57	97.27	5.52	32.29	492.97
Climate zone 5	NCC2019	87.13	10.04	90.70	1.80	16.76	416.26
Climate zone 5	Variance	-25%	-68%	-7%	-67%	-48%	-16%
Climate zone 6	NCC2016	54.01	52.38	88.82	2.22	13.90	421.16
Climate zone 6	NCC2019	40.06	41.99	69.59	1.44	6.16	369.07
Climate zone 6	Variance	-26%	-20%	-22%	-35%	-56%	-12%
Climate zone 7	NCC2016	46.44	89.70	82.89	3.20	11.89	443.97
Climate zone 7	NCC2019	35.45	70.12	62.93	2.77	5.37	386.49
Climate zone 7	Variance	-24%	-22%	-24%	-13%	-55%	-13%

B.II Façade vs Services Contribution Modelling

Table 229: Breakdown of sub-system energy results for model 5A (40% WWR) – lighting and lift energy not displayed.

Climate zone	NCC	Chiller	Boiler	Fans	Pumps	Heat Rejection	Total
Climate zone 2	NCC2016	173.31	14.83	112.69	5.01	48.81	564.49
Climate zone 2	Mixed	168.34	11.25	84.70	2.62	29.55	506.31
Climate zone 2	NCC2019	145.99	4.72	96.45	2.67	27.74	487.41
Climate zone 2	Services (%)	-3%	-24%	-25%	-48%	-39%	-10%
Climate zone 2	Façade (%)	-13%	-58%	14%	2%	-6%	-4%
Climate zone 2	Total (%)	-16%	-68%	-14%	-47%	-43%	-14%
Climate zone 5	NCC2016	116.49	31.57	97.27	5.52	32.29	492.97
Climate zone 5	Mixed	98.97	25.42	76.76	1.84	17.11	429.94
Climate zone 5	NCC2019	87.13	10.04	90.70	1.80	16.76	416.26
Climate zone 5	Services (%)	-15%	-19%	-21%	-67%	-47%	-13%
Climate zone 5	Façade (%)	-12%	-61%	18%	-2%	-2%	-3%
Climate zone 5	Total (%)	-25%	-68%	-7%	-67%	-48%	-16%
Climate zone 6	NCC2016	54.01	52.38	88.82	2.22	13.90	421.16
Climate zone 6	Mixed	47.33	58.70	67.41	1.80	6.39	391.48
Climate zone 6	NCC2019	40.06	41.99	69.59	1.44	6.16	369.07
Climate zone 6	Services (%)	-12%	12%	-24%	-19%	-54%	-7%
Climate zone 6	Façade (%)	-15%	-28%	3%	-20%	-4%	-6%
Climate zone 6	Total (%)	-26%	-20%	-22%	-35%	-56%	-12%

Table 230: Breakdown of sub-system energy results for model 6B (30% WWR) – lighting and lift energy not displayed.

Climate zone	NCC	Chiller	Boiler	Fans	Pumps	Heat Rejection	Total
Climate zone 2	NCC2016	81.38	9.43	59.98	0.85	13.94	320.05
Climate zone 2	Mixed	59.52	8.46	49.15	0.48	9.19	281.27
Climate zone 2	NCC2019	60.31	11.64	49.13	0.50	9.45	285.50
Climate zone 2	Services (%)	-27%	-10%	-18%	-44%	-34%	-12%
Climate zone 2	Façade (%)	1%	38%	0%	5%	3%	2%
Climate zone 2	Total (%)	-26%	23%	-18%	-41%	-32%	-11%
Climate zone 5	NCC2016	63.42	17.86	97.54	1.56	11.16	346.01
Climate zone 5	Mixed	40.82	18.03	74.44	0.81	6.12	294.70
Climate zone 5	NCC2019	41.07	25.85	74.43	0.76	6.02	302.60
Climate zone 5	Services (%)	-36%	1%	-24%	-48%	-45%	-15%
Climate zone 5	Façade (%)	1%	43%	0%	-6%	-2%	3%
Climate zone 5	Total (%)	-35%	45%	-24%	-51%	-46%	-13%
Climate zone 6	NCC2016	41.83	64.29	97.56	1.09	5.57	364.81
Climate zone 6	Mixed	25.16	62.50	74.35	0.45	2.72	319.65
Climate zone 6	NCC2019	24.18	96.45	74.35	0.56	2.49	352.51
Climate zone 6	Services (%)	-40%	-3%	-24%	-59%	-51%	-12%
Climate zone 6	Façade (%)	-4%	54%	0%	25%	-8%	10%
Climate zone 6	Total (%)	-42%	50%	-24%	-48%	-55%	-3%

Table 231: Breakdown of sub-system energy results for model 9aC (30% WWR) – lighting and lift energy not displayed.

Climate zone	NCC	Chiller	Boiler	Fans	Pumps	Heat Rejection	Total
Climate zone 2	NCC2016	26.56	3.86	10.11	0.41	4.82	61.20
Climate zone 2	Mixed	20.17	3.61	7.80	0.23	3.29	50.55
Climate zone 2	NCC2019	19.36	4.07	7.48	0.22	3.21	49.77
Climate zone 2	Services (%)	-24%	-6%	-23%	-44%	-32%	-17%
Climate zone 2	Façade (%)	-4%	13%	-4%	-5%	-3%	-2%
Climate zone 2	Total (%)	-27%	5%	-26%	-47%	-33%	-19%
Climate zone 5	NCC2016	18.90	7.95	8.19	0.33	3.12	53.92
Climate zone 5	Mixed	14.20	7.27	6.29	0.22	2.21	45.62
Climate zone 5	NCC2019	13.85	8.08	6.13	0.24	2.15	45.88
Climate zone 5	Services (%)	-25%	-8%	-23%	-35%	-29%	-15%
Climate zone 5	Façade (%)	-3%	11%	-2%	9%	-3%	1%
Climate zone 5	Total (%)	-27%	2%	-25%	-29%	-31%	-15%
Climate zone 6	NCC2016	12.44	17.07	7.20	0.42	1.55	54.11
Climate zone 6	Mixed	8.11	16.39	5.27	0.34	0.98	46.53
Climate zone 6	NCC2019	7.76	25.47	7.86	0.48	0.86	57.86
Climate zone 6	Services (%)	-35%	-4%	-27%	-19%	-37%	-14%
Climate zone 6	Façade (%)	-4%	55%	49%	41%	-12%	24%
Climate zone 6	Total (%)	-38%	49%	9%	14%	-44%	7%

Table 232: Breakdown of sub-system energy results for model 9bH (30% WWR) – lighting and lift energy not displayed.

Climate zone	NCC	Chiller	Boiler	Fans	Pumps	Heat Rejection	Total
Climate zone 2	NCC2016	146.44	15.62	98.31	2.01	0.00	294.59
Climate zone 2	Mixed	86.14	14.98	75.00	0.81	0.00	209.13
Climate zone 2	NCC2019	77.25	24.08	75.00	0.90	0.00	209.43
Climate zone 2	Services (%)	-41%	-4%	-24%	-60%	-	-29%
Climate zone 2	Façade (%)	-10%	61%	0%	12%	-	0%
Climate zone 2	Total (%)	-47%	54%	-24%	-55%	-	-29%
Climate zone 5	NCC2016	64.43	45.91	98.31	2.50	0.00	243.36
Climate zone 5	Mixed	50.26	22.40	75.00	1.24	0.00	181.10
Climate zone 5	NCC2019	49.90	30.39	75.00	1.08	0.00	188.58
Climate zone 5	Services (%)	-22%	-51%	-24%	-51%	-	-26%
Climate zone 5	Façade (%)	-1%	36%	0%	-13%	-	4%
Climate zone 5	Total (%)	-23%	-34%	-24%	-57%	-	-23%
Climate zone 6	NCC2016	46.45	119.69	133.26	1.78	0.00	333.39
Climate zone 6	Mixed	36.49	60.77	100.49	1.14	0.00	231.10
Climate zone 6	NCC2019	36.19	87.14	100.49	1.17	0.00	257.19
Climate zone 6	Services (%)	-21%	-49%	-25%	-36%	-	-31%
Climate zone 6	Façade (%)	-1%	43%	0%	3%	-	11%
Climate zone 6	Total (%)	-22%	-27%	-25%	-34%	-	-23%

Table 233: Breakdown of sub-system energy results for model 3A (30% WWR) – lighting and lift energy not displayed.

Climate zone	NCC	Chiller	Boiler	Fans	Pumps	Heat Rejection	Total
Climate zone 2	NCC2016	305.83	9.74	471.33	4.36	75.90	942.75
Climate zone 2	Mixed	250.62	12.28	386.23	2.25	50.32	777.30
Climate zone 2	NCC2019	208.79	3.58	386.18	2.12	48.18	724.45
Climate zone 2	Services (%)	-18%	26%	-18%	-48%	-34%	-18%
Climate zone 2	Façade (%)	-17%	-71%	0%	-6%	-4%	-7%
Climate zone 2	Total (%)	-32%	-63%	-18%	-51%	-37%	-23%
Climate zone 5	NCC2016	243.38	2.30	471.18	3.73	58.80	854.99
Climate zone 5	Mixed	200.18	8.57	385.97	3.38	35.28	708.98
Climate zone 5	NCC2019	174.76	1.44	385.96	2.52	36.58	676.87
Climate zone 5	Services (%)	-18%	273%	-18%	-9%	-40%	-17%
Climate zone 5	Façade (%)	-13%	-83%	0%	-25%	4%	-5%
Climate zone 5	Total (%)	-28%	-37%	-18%	-32%	-38%	-21%
Climate zone 6	NCC2016	193.47	25.68	471.33	5.27	39.58	810.93
Climate zone 6	Mixed	120.78	9.80	386.05	3.78	26.32	622.34
Climate zone 6	NCC2019	113.78	5.06	385.95	3.64	26.57	610.60
Climate zone 6	Services (%)	-38%	-62%	-18%	-28%	-33%	-23%
Climate zone 6	Façade (%)	-6%	-48%	0%	-4%	1%	-2%
Climate zone 6	Total (%)	-41%	-80%	-18%	-31%	-33%	-25%

C. Appendix – HVAC Equipment Capacities

C.I Impact of Increased Stringency Equipment Capacities

Table 234: HVAC equipment capacities modelled in the scope 2.1 analysis – Model 3A, 30% WWR in NCC 2016.

Equipment	Climate zone 1	Climate zone 2	Climate zone 3	Climate zone 4	Climate zone 5	Climate zone 6	Climate zone 7
Total FCU (L/s)	23,656	33,491	32,739	31,259	27,987	29,352	24,593
Max FCU (L/s)	486	749	632	596	568	584	538
Min FCU (L/s)	211	237	297	261	209	231	195
Chiller (kW)	734	932	714	681	715	691	589
Boiler (kW)	0	202	190	197	118	148	192
Cooling Tower (kW)	858	1078	766	732	820	772	640

Table 235: HVAC equipment capacities modelled in the scope 2.1 analysis – Model 3A, 30% WWR in NCC 2019.

Equipment	Climate zone 1	Climate zone 2	Climate zone 3	Climate zone 4	Climate zone 5	Climate zone 6	Climate zone 7
Total FCU (L/s)	26,090	24,647	30,305	28,167	29,231	26,800	23,322
Max FCU (L/s)	576	526	604	523	632	556	507
Min FCU (L/s)	224	195	288	243	216	214	188
Chiller (kW)	750	728	643	568	718	579	515
Boiler (kW)	0	159	192	124	104	83	149
Cooling Tower (kW)	879	846	688	604	820	639	552

Table 236: HVAC equipment capacities modelled in the scope 2.1 analysis – Model 5A, 56% WWR in NCC 2016.

Equipment	Climate zone 1	Climate zone 2	Climate zone 3	Climate zone 4	Climate zone 5	Climate zone 6	Climate zone 7
Centre AHU (L/s)	25,020	22,066	29,072	21,729	15,426	18,523	21,766
West AHU (L/s)	5,815	9,808	7,094	8,789	6,036	5,820	6,183
North AHU (L/s)	6,342	5,453	6,414	6,078	5,740	5,370	6,010
East AHU (L/s)	6,706	7,730	8,904	6,240	6,574	5,383	6,532
South AHU (L/s)	6,477	5,985	8,123	5,783	6,961	8,459	6,873
Chiller (kW)	789	899	828	790	755	802	721
Boiler (kW)	13	175	209	135	124	138	120
Cooling Tower (kW)	929	1,046	900	858	869	889	778

Table 237: HVAC equipment capacities modelled in the scope 2.1 analysis – Model 5A, 56% WWR in NCC 2019.

Equipment	Climate zone 1	Climate zone 2	Climate zone 3	Climate zone 4	Climate zone 5	Climate zone 6	Climate zone 7
Centre AHU (L/s)	26,478	20,314	32,090	20,046	14,874	20,843	25,475
West AHU (L/s)	6,984	5,917	7,454	6,628	6,246	7,169	8,113
North AHU (L/s)	6,626	5,383	7,067	6,220	5,793	6,588	7,968
East AHU (L/s)	8,049	7,640	9,361	7,033	6,635	6,590	7,894
South AHU (L/s)	6,837	4,764	7,254	6,162	4,893	6,604	8,114
Chiller (kW)	742	797	819	788	748	833	735
Boiler (kW)	48	150	158	263	166	206	259
Cooling Tower (kW)	969	946	874	849	854	912	781

Table 238: HVAC equipment capacities modelled in the scope 2.1 analysis – Model 5A, 40% WWR in NCC 2016.

Equipment	Climate zone 1	Climate zone 2	Climate zone 3	Climate zone 4	Climate zone 5	Climate zone 6	Climate zone 7
Centre AHU (L/s)	25,109	22,078	30,262	19,971	15,752	17,488	22,624
West AHU (L/s)	5,930	7,940	9,686	7,889	8,438	8,420	8,891
North AHU (L/s)	5,825	7,367	7,730	5,276	7,750	5,217	7,082
East AHU (L/s)	6,867	10,073	8,011	6,014	9,024	5,212	6,573
South AHU (L/s)	7,976	5,508	7,136	6,866	5,977	7,066	8,888
Chiller (kW)	869	900	903	802	869	819	764
Boiler (kW)	51	298	343	349	325	256	331
Cooling Tower (kW)	1,022	1,055	981	870	997	908	811

Table 239: HVAC equipment capacities modelled in the scope 2.1 analysis – Model 5A, 40% WWR in NCC 2019.

Equipment	Climate zone 1	Climate zone 2	Climate zone 3	Climate zone 4	Climate zone 5	Climate zone 6	Climate zone 7
Centre AHU (L/s)	24,960	18,921	28,425	18,625	14,193	17,504	24,603
West AHU (L/s)	6,165	5,247	9,381	5,871	5,569	6,010	7,778
North AHU (L/s)	6,064	4,796	7,718	5,564	5,056	5,762	7,659
East AHU (L/s)	7,189	6,539	11,569	6,075	5,676	5,764	7,600
South AHU (L/s)	6,272	4,347	7,225	5,714	4,493	5,775	7,779
Chiller (kW)	807	743	903	752	691	711	682
Boiler (kW)	46	225	363	261	198	199	285
Cooling Tower (kW)	945	863	973	797	790	776	729

Table 240: HVAC equipment capacities modelled in the scope 2.1 analysis – Model 6B, 30% WWR in NCC 2016.

Equipment	Climate zone 1	Climate zone 2	Climate zone 3	Climate zone 4	Climate zone 5	Climate zone 6	Climate zone 7
Total FCU (L/s)	14,480	12,302	15,738	15,777	14,620	14,736	15,795
Max FCU (L/s)	1,096	1,025	1,187	1,241	1,171	1,223	1,387
Min FCU (L/s)	325	269	362	340	332	313	321
Chiller (kW)	355	279	265	291	250	279	251
Boiler (kW)	20	137	165	169	117	135	191
Cooling Tower (kW)	422	334	344	328	297	321	275

Table 241: HVAC equipment capacities modelled in the scope 2.1 analysis – Model 6B, 30% WWR in NCC 2019.

Equipment	Climate zone 1	Climate zone 2	Climate zone 3	Climate zone 4	Climate zone 5	Climate zone 6	Climate zone 7
Total FCU (L/s)	14,793	12,435	16,861	18,828	15,255	17,710	20,455
Max FCU (L/s)	1,105	990	1,384	1,598	1,338	1,507	1,766
Min FCU (L/s)	342	261	372	392	325	364	438
Chiller (kW)	334	256	310	304	240	281	239
Boiler (kW)	37	148	197	223	140	161	218
Cooling Tower (kW)	390	298	335	324	272	309	253

Table 242: HVAC equipment capacities modelled in the scope 2.1 analysis – Model 9aC, 30% WWR in NCC 2016.

Equipment	Climate zone 1	Climate zone 2	Climate zone 3	Climate zone 4	Climate zone 5	Climate zone 6	Climate zone 7
Centre AHU (L/s)	3,227	2,274	3,409	3,664	2,491	3,710	4,818
West AHU (L/s)	1,248	1,051	1,318	1,366	1,158	1,066	1,389
North AHU (L/s)	1,120	952	1,092	1,259	1,100	1,389	1,382
East AHU (L/s)	1,264	1,205	1,440	1,181	1,131	1,085	1,387
South AHU (L/s)	939	891	1,223	1,349	1,135	1,304	1,602
Chiller (kW)	139	114	145	134	112	122	111
Boiler (kW)	0	33	41	42	30	28	34
Cooling Tower (kW)	166	140	161	148	134	140	122

Table 243: HVAC equipment capacities modelled in the scope 2.1 analysis – Model 9aC, 30% WWR in NCC 2019.

Equipment	Climate zone 1	Climate zone 2	Climate zone 3	Climate zone 4	Climate zone 5	Climate zone 6	Climate zone 7
Centre AHU (L/s)	3,020	2,205	3,343	3,976	2,707	4,347	5,588
West AHU (L/s)	1,246	1,039	1,348	1,407	1,178	1,468	1,754
North AHU (L/s)	1,124	950	1,100	1,297	1,126	1,455	1,710
East AHU (L/s)	1,295	1,200	1,458	1,292	1,129	1,459	1,703
South AHU (L/s)	1,020	967	1,298	1,454	1,192	1,466	1,753
Chiller (kW)	136	106	142	127	109	132	111
Boiler (kW)	8	36	45	47	33	40	61
Cooling Tower (kW)	159	123	152	135	124	145	119

Table 244: HVAC equipment capacities modelled in the scope 2.1 analysis – Model 9bH, 30% WWR in NCC 2016.

Equipment	Climate zone 1	Climate zone 2	Climate zone 3	Climate zone 4	Climate zone 5	Climate zone 6	Climate zone 7
Total FCU (L/s)	31,125	24,180	34,954	42,185	34,665	41,592	54,679
Max FCU (L/s)	5,307	4,367	6,281	7,591	6,280	7,422	9,683
Min FCU (L/s)	5,052	3,580	5,307	6,504	5,094	6,359	8,417
Chiller (kW)	755	577	581	529	436	518	579
Boiler (kW)	35	244	344	365	234	271	349
Cooling Tower (kW)	0	0	0	0	0	0	0

Table 245: HVAC equipment capacities modelled in the scope 2.1 analysis – Model 9bH, 30% WWR in NCC 2019.

Equipment	Climate zone 1	Climate zone 2	Climate zone 3	Climate zone 4	Climate zone 5	Climate zone 6	Climate zone 7
Total FCU (L/s)	32,232	30,863	40,784	48,564	37,117	46,646	61,089
Max FCU (L/s)	5,438	5,550	7,345	8,847	6,800	8,226	10,893
Min FCU (L/s)	5,307	4,875	6,338	7,415	5,366	7,219	9,266
Chiller (kW)	655	597	525	521	470	510	635
Boiler (kW)	23	321	286	272	155	184	319
Cooling Tower (kW)	0	0	0	0	0	0	0

C.II Façade vs Services Contribution Equipment Capacities

Table 246: HVAC equipment capacities modelled in the Decomposition Results analysis for the NCC 2016 version of Model 3A, 30% WWR.

Equipment	Climate zone 2	Climate zone 5	Climate zone 6
Total FCU (L/s)	24,647	29,231	26,800
Max FCU (L/s)	526	632	556
Min FCU (L/s)	195	216	214
Chiller (kW)	932	715	691
Boiler (kW)	202	118	148
Cooling Tower (kW)	1078	820	772

Table 247: HVAC equipment capacities modelled in the Decomposition Results analysis for the Mixed version of Model 3A, 30% WWR.

Equipment	Climate zone 2	Climate zone 5	Climate zone 6
Total FCU (L/s)	33,328	37,527	29,157
Max FCU (L/s)	732	879	564
Min FCU (L/s)	237	244	231
Chiller (kW)	915	892	623
Boiler (kW)	220	163	91
Cooling Tower (kW)	1062	1019	687

Table 248: HVAC equipment capacities modelled in the Decomposition Results analysis for the NCC 2019 version of Model 3A, 30% WWR.

Equipment	Climate zone 2	Climate zone 5	Climate zone 6
Total FCU (L/s)	33,491	27,987	29,352
Max FCU (L/s)	749	568	584
Min FCU (L/s)	237	209	231
Chiller (kW)	728	718	579
Boiler (kW)	159	104	83
Cooling Tower (kW)	846	820	639

Table 249: HVAC equipment capacities modelled in the Decomposition Results analysis for the NCC 2016 version of Model 5A, 40% WWR.

Model 5A 40% WWR	Climate zone 2	Climate zone 5	Climate zone 6
Centre AHU (L/s)	22,078	15,752	17,488
West AHU (L/s)	7,940	8,438	8,420
North AHU (L/s)	7,367	7,750	5,217
East AHU (L/s)	10,073	9,024	5,212
South AHU (L/s)	5,508	5,977	7,066
Chiller (kW)	900	869	819
Boiler (kW)	298	325	256
Cooling Tower (kW)	1055	997	908

Table 250: HVAC equipment capacities modelled in the Decomposition Results analysis for the Mixed version of Model 5A, 40% WWR.

Model 5A 40% WWR	Climate zone 2	Climate zone 5	Climate zone 6
Centre AHU (L/s)	21,974	15,651	19,373
West AHU (L/s)	7,930	8,425	8,703
North AHU (L/s)	7,363	7,740	5,975
East AHU (L/s)	10,062	9,014	5,970
South AHU (L/s)	5,499	5,984	7,641
Chiller (kW)	879	844	866
Boiler (kW)	205	224	229
Cooling Tower (kW)	1023	964	944

Table 251: HVAC equipment capacities modelled in the Decomposition Results analysis for the NCC 2019 version of Model 5A, 40% WWR.

Model 5A 40% WWR	Climate zone 2	Climate zone 5	Climate zone 6
Centre AHU (L/s)	18,921	14,193	17,504
West AHU (L/s)	5,247	5,569	6,010
North AHU (L/s)	4,796	5,056	5,762
East AHU (L/s)	6,539	5,676	5,764
South AHU (L/s)	4,347	4,493	5,775
Chiller (kW)	743	691	711
Boiler (kW)	225	198	199
Cooling Tower (kW)	863	790	776

Table 252: HVAC equipment capacities modelled in the Decomposition Results analysis for the NCC 2016 version of Model 6B, 30% WWR.

Equipment	Climate zone 2	Climate zone 5	Climate zone 6
Total FCU (L/s)	12,302	14,620	14,736
Max FCU (L/s)	1,025	1,171	1,223
Min FCU (L/s)	269	332	313
Chiller (kW)	279	250	279
Boiler (kW)	137	117	135
Cooling Tower (kW)	334	297	321

Table 253: HVAC equipment capacities modelled in the Decomposition Results analysis for the Mixed version of Model 6B, 30% WWR.

Equipment	Climate zone 2	Climate zone 5	Climate zone 6
Total FCU (L/s)	11,567	14,195	14,947
Max FCU (L/s)	953	1,110	1,299
Min FCU (L/s)	249	313	308
Chiller (kW)	251	226	265
Boiler (kW)	141	123	141
Cooling Tower (kW)	288	257	291

Table 254: HVAC equipment capacities modelled in the Decomposition Results analysis for the NCC 2019 version of Model 6B, 30% WWR.

Equipment	Climate zone 2	Climate zone 5	Climate zone 6
Total FCU (L/s)	12,435	15,255	17,710
Max FCU (L/s)	990	1,338	1,507
Min FCU (L/s)	261	325	364
Chiller (kW)	256	240	281
Boiler (kW)	148	140	161
Cooling Tower (kW)	298	272	309

Table 255: HVAC equipment capacities modelled in the Decomposition Results analysis for the NCC 2016 version of Model 9aC, 30% WWR.

Equipment	Climate zone 2	Climate zone 5	Climate zone 6
Centre AHU (L/s)	2,274	2,491	3,710
West AHU (L/s)	1,051	1,158	1,066
North AHU (L/s)	952	1,100	1,389
East AHU (L/s)	1,205	1,131	1,085
South AHU (L/s)	891	1,135	1,304
Chiller (kW)	114	112	122
Boiler (kW)	33	30	28
Cooling Tower (kW)	140	134	140

Table 256: HVAC equipment capacities modelled in the Decomposition Results analysis for the Mixed version of Model 9aC, 30% WWR.

Equipment	Climate zone 2	Climate zone 5	Climate zone 6
Centre AHU (L/s)	2,192	2,528	3,752
West AHU (L/s)	1,035	1,148	1,073
North AHU (L/s)	942	1,104	1,392
East AHU (L/s)	1,198	1,122	1,091
South AHU (L/s)	899	1,140	1,307
Chiller (kW)	108	104	118
Boiler (kW)	34	32	32
Cooling Tower (kW)	126	118	130

Table 257: HVAC equipment capacities modelled in the Decomposition Results analysis for the NCC 2019 version of Model 9aC, 30% WWR.

Equipment	Climate zone 2	Climate zone 5	Climate zone 6
Centre AHU (L/s)	2,205	2,707	4,347
West AHU (L/s)	1,039	1,178	1,468
North AHU (L/s)	950	1,126	1,455
East AHU (L/s)	1,200	1,129	1,459
South AHU (L/s)	967	1,192	1,466
Chiller (kW)	106	109	132
Boiler (kW)	36	33	40
Cooling Tower (kW)	123	124	145

Table 258: HVAC equipment capacities modelled in the Decomposition Results analysis for the NCC 2016 version of Model 9bH, 30% WWR.

Equipment	Climate zone 2	Climate zone 5	Climate zone 6
Total FCU (L/s)	24,180	34,665	41,592
Max FCU (L/s)	4,367	6,280	7,422
Min FCU (L/s)	3,580	5,094	6,359
Chiller (kW)	577	436	518
Boiler (kW)	244	234	271
Cooling Tower (kW)	-	-	-

Table 259: HVAC equipment capacities modelled in the Decomposition Results analysis for the Mixed version of Model 9bH, 30% WWR.

Equipment	Climate zone 2	Climate zone 5	Climate zone 6
Total FCU (L/s)	30,863	37,117	46,646
Max FCU (L/s)	5,550	6,800	8,226
Min FCU (L/s)	4,875	5,366	7,219
Chiller (kW)	597	470	510
Boiler (kW)	321	155	184
Cooling Tower (kW)	-	-	-

Table 260: HVAC equipment capacities modelled in the Decomposition Results analysis for the NCC 2019 version of Model 9bH, 30% WWR.

Equipment	Climate zone 2	Climate zone 5	Climate zone 6
Total FCU (L/s)	24,311	34,739	41,668
Max FCU (L/s)	4,397	6,296	7,440
Min FCU (L/s)	3,592	5,103	6,366
Chiller (kW)	574	421	465
Boiler (kW)	261	135	157
Cooling Tower (kW)	-	-	-

D. Appendix – Glazing Assignment

D.I Impact of Increased Stringency Glazing Assignment

Table 261: Glazing selections for the 3A 30% WWR models.

Climate zone	Orientation	NCC2016	NCC2019
1	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
1	East	(G07) 6mm Supergrey+12mm arg+6mm LEC(3)	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
1	South	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
1	West	(G07) 6mm Supergrey+12mm arg+6mm LEC(3)	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
2	North	(G11) 6mm Supergrey	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
2	East	(G11) 6mm Supergrey	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
2	South	(SC01) 6mm clear	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
2	West	(G11) 6mm Supergrey	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
3	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
3	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
3	South	(G18) 6mm Azur Blue	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
3	West	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
4	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
4	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
4	South	(G06) 4mm Low-e coated (2)	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
4	West	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
5	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
5	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
5	South	(G18) 6mm Azur Blue	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
5	West	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
6	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
6	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
6	South	(SC04) 6mm Evantage Clear	(G01) Tinted 6mm super grey+12mm arg+6mm clear float

Climate zone	Orientation	NCC2016	NCC2019
6	West	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
7	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
7	East	(G07) 6mm Supergrey+12mm arg+6mm LEC(3)	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
7	South	(SC07) 6/12/6 Clear Argon	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
7	West	(G02) 10mm N Sunergy(2)+ 12mm arg+8mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float

Table 262: Glazing selections for the 9aC 30% WWR models.

Climate zone	Orientation	NCC2016	NCC2019
1	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
1	East	(G07) 6mm Supergrey+12mm arg+6mm LEC(3)	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
1	South	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
1	West	(G07) 6mm Supergrey+12mm arg+6mm LEC(3)	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
2	North	(G11) 6mm Supergrey	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
2	East	(G11) 6mm Supergrey	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
2	South	(SC01) 6mm clear	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
2	West	(G11) 6mm Supergrey	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
3	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
3	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
3	South	(G18) 6mm Azur Blue	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
3	West	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
4	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
4	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
4	South	(G06) 4mm Low-e coated (2)	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
4	West	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
5	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
5	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
5	South	(G18) 6mm Azur Blue	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
5	West	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
6	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
6	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
6	South	(SC04) 6mm Evantage Clear	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
6	West	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
7	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
7	East	(G07) 6mm Supergrey+12mm arg+6mm LEC(3)	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
7	South	(SC07) 6/12/6 Clear Argon	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
7	West	(G02) 10mm N Sunergy(2)+ 12mm arg+8mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float

Table 263: Glazing selections for the 9bH 30% WWR models.

Climate zone	Orientation	NCC2016	NCC2019
1	North	(G11) 6mm Supergrey	(G11) 6mm Supergrey
1	East	(G10) 6mm Superblue EV(2)	(G11) 6mm Supergrey
1	South	(SC01) 6mm clear	(G11) 6mm Supergrey
1	West	(G11) 6mm Supergrey	(G11) 6mm Supergrey
2	North	(G11) 6mm Supergrey	(G11) 6mm Supergrey
2	East	(G11) 6mm Supergrey	(G11) 6mm Supergrey
2	South	(SC01) 6mm clear	(G11) 6mm Supergrey
2	West	(G11) 6mm Supergrey	(G11) 6mm Supergrey
3	North	(G11) 6mm Supergrey	(G18) 6mm Azur Blue
3	East	(G11) 6mm Supergrey	(G18) 6mm Azur Blue
3	South	(SC01) 6mm clear	(G18) 6mm Azur Blue
3	West	(G11) 6mm Supergrey	(G18) 6mm Azur Blue
4	North	(G11) 6mm Supergrey	(G11) 6mm Supergrey
4	East	(G10) 6mm Superblue EV(2)	(G11) 6mm Supergrey
4	South	(SC01) 6mm clear	(G11) 6mm Supergrey
4	West	(G11) 6mm Supergrey	(G11) 6mm Supergrey
5	North	(G11) 6mm Supergrey	(G11) 6mm Supergrey
5	East	(G11) 6mm Supergrey	(G11) 6mm Supergrey
5	South	(SC01) 6mm clear	(G11) 6mm Supergrey
5	West	(G11) 6mm Supergrey	(G11) 6mm Supergrey
6	North	(G11) 6mm Supergrey	(G11) 6mm Supergrey
6	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G11) 6mm Supergrey
6	South	(SC04) 6mm Evantage Clear	(G11) 6mm Supergrey
6	West	(G03) 5mm Green +12mm arg +5mm clear	(G11) 6mm Supergrey
7	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G11) 6mm Supergrey
7	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G11) 6mm Supergrey
7	South	(G04) 6.38mm clear 82(2)	(G11) 6mm Supergrey
7	West	(SC07) 6/12/6 Clear Argon	(G11) 6mm Supergrey

Table 264: Glazing selections for the 6B 30% WWR models – ground floor glazing.

Climate zone	Orientation	NCC2016	NCC2019
1	North	(G11) 6mm Supergrey	(SC01) 6mm clear
1	East	(G11) 6mm Supergrey	(SC01) 6mm clear
1	South	(SC01) 6mm clear	(SC01) 6mm clear
1	West	(G11) 6mm Supergrey	(SC01) 6mm clear
2	North	(SC02) 6mm Green	(SC01) 6mm clear
2	East	(G11) 6mm Supergrey	(SC01) 6mm clear
2	South	(SC01) 6mm clear	(SC01) 6mm clear
2	West	(SC02) 6mm Green	(SC01) 6mm clear
3	North	(SC02) 6mm Green	(SC01) 6mm clear
3	East	(G11) 6mm Supergrey	(SC01) 6mm clear
3	South	(SC01) 6mm clear	(SC01) 6mm clear
3	West	(SC02) 6mm Green	(SC01) 6mm clear
4	North	(SC02) 6mm Green	(SC01) 6mm clear
4	East	(SC02) 6mm Green	(SC01) 6mm clear
4	South	(SC01) 6mm clear	(SC01) 6mm clear
4	West	(SC01) 6mm clear	(SC01) 6mm clear
5	North	(SC02) 6mm Green	(SC01) 6mm clear
5	East	(SC02) 6mm Green	(SC01) 6mm clear
5	South	(SC01) 6mm clear	(SC01) 6mm clear
5	West	(SC01) 6mm clear	(SC01) 6mm clear
6	North	(SC02) 6mm Green	(SC01) 6mm clear
6	East	(SC02) 6mm Green	(SC01) 6mm clear
6	South	(SC01) 6mm clear	(SC01) 6mm clear
6	West	(SC01) 6mm clear	(SC01) 6mm clear
7	North	(G11) 6mm Supergrey	(SC01) 6mm clear
7	East	(G11) 6mm Supergrey	(SC01) 6mm clear
7	South	(SC01) 6mm clear	(SC01) 6mm clear
7	West	(SC01) 6mm clear	(SC01) 6mm clear

Table 265: Glazing selections for the 6B 30% WWR models – upper floor glazing

Climate zone	Orientation	NCC2016	NCC2019
1	North	(G11) 6mm Supergrey	(G11) 6mm Supergrey
1	East	(G10) 6mm Superblue EV(2)	(G11) 6mm Supergrey
1	South	(SC02) 6mm Green	(G11) 6mm Supergrey
1	West	(G11) 6mm Supergrey	(G11) 6mm Supergrey
2	North	(G11) 6mm Supergrey	(G11) 6mm Supergrey
2	East	(G11) 6mm Supergrey	(G11) 6mm Supergrey
2	South	(SC01) 6mm clear	(G11) 6mm Supergrey
2	West	(G11) 6mm Supergrey	(G11) 6mm Supergrey
3	North	(G11) 6mm Supergrey	(G11) 6mm Supergrey
3	East	(G11) 6mm Supergrey	(G11) 6mm Supergrey
3	South	(SC01) 6mm clear	(G11) 6mm Supergrey
3	West	(G11) 6mm Supergrey	(G11) 6mm Supergrey
4	North	(G11) 6mm Supergrey	(G11) 6mm Supergrey
4	East	(G10) 6mm Superblue EV(2)	(G11) 6mm Supergrey
4	South	(SC01) 6mm clear	(G11) 6mm Supergrey
4	West	(G11) 6mm Supergrey	(G11) 6mm Supergrey
5	North	(G11) 6mm Supergrey	(G11) 6mm Supergrey
5	East	(G11) 6mm Supergrey	(G11) 6mm Supergrey
5	South	(SC01) 6mm clear	(G11) 6mm Supergrey
5	West	(G11) 6mm Supergrey	(G11) 6mm Supergrey
6	North	(G11) 6mm Supergrey	(G11) 6mm Supergrey
6	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G11) 6mm Supergrey
6	South	(SC04) 6mm Evantage Clear	(G11) 6mm Supergrey
6	West	(G03) 5mm Green +12mm arg +5mm clear	(G11) 6mm Supergrey
7	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G11) 6mm Supergrey
7	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G11) 6mm Supergrey
7	South	(G06) 4mm Low-e coated (2)	(G11) 6mm Supergrey
7	West	(SC07) 6/12/6 Clear Argon	(G11) 6mm Supergrey

Table 266: Glazing selections for the 5A 56% WWR models.

Climate zone	Orientation	NCC2016	NCC2019
1	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
1	East	(G07) 6mm Supergrey+12mm arg+6mm LEC(3)	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
1	South	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
1	West	(G07) 6mm Supergrey+12mm arg+6mm LEC(3)	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
2	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
2	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
2	South	(SC02) 6mm Green	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
2	West	(G11) 6mm Supergrey	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
3	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G12) 6mm Superblue EV(2)+ 12mm arg+6mm clear float
3	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G12) 6mm Superblue EV(2)+ 12mm arg+6mm clear float
3	South	(G18) 6mm Azur Blue	(G12) 6mm Superblue EV(2)+ 12mm arg+6mm clear float
3	West	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G12) 6mm Superblue EV(2)+ 12mm arg+6mm clear float
4	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
4	East	(G07) 6mm Supergrey+12mm arg+6mm LEC(3)	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
4	South	(SC07) 6/12/6 Clear Argon	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
4	West	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
5	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
5	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
5	South	(G18) 6mm Azur Blue	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
5	West	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
6	North	(G07) 6mm Supergrey+12mm arg+6mm LEC(3)	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
6	East	(G07) 6mm Supergrey+12mm arg+6mm LEC(3)	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
6	South	(G06) 4mm Low-e coated (2)	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
6	West	(G07) 6mm Supergrey+12mm arg+6mm LEC(3)	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
7	North	(G07) 6mm Supergrey+12mm arg+6mm LEC(3)	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
7	East	(G07) 6mm Supergrey+12mm arg+6mm LEC(3)	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
7	South	(SC07) 6/12/6 Clear Argon	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
7	West	(G02) 10mm N Sunergy(2)+ 12mm arg+8mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float

Table 267: Glazing selections for the 5A 40% WWR models.

Climate zone	Orientation	NCC2016	NCC2019
1	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
1	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
1	South	(G11) 6mm Supergrey	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
1	West	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
2	North	(G11) 6mm Supergrey	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
2	East	(G11) 6mm Supergrey	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
2	South	(SC01) 6mm clear	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
2	West	(G11) 6mm Supergrey	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
3	North	(G11) 6mm Supergrey	(G10) 6mm Superblue EV(2)
3	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G10) 6mm Superblue EV(2)
3	South	(SC01) 6mm clear	(G10) 6mm Superblue EV(2)
3	West	(G11) 6mm Supergrey	(G10) 6mm Superblue EV(2)
4	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
4	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
4	South	(G18) 6mm Azur Blue	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
4	West	(G15) 6mm gry+0.38mmPVB+6mmNSunergy (4)	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
5	North	(G11) 6mm Supergrey	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
5	East	(G11) 6mm Supergrey	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
5	South	(SC01) 6mm clear	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
5	West	(G11) 6mm Supergrey	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
6	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
6	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
6	South	(G06) 4mm Low-e coated (2)	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
6	West	(G15) 6mm gry+0.38mmPVB+6mmNSunergy (4)	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
7	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
7	East	(G07) 6mm Supergrey+12mm arg+6mm LEC(3)	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
7	South	(G15) 6mm gry+0.38mmPVB+6mmNSunergy (4)	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
7	West	(G15) 6mm gry+0.38mmPVB+6mmNSunergy (4)	(G01) Tinted 6mm super grey+12mm arg+6mm clear float

D.II Façade vs Services Contribution Glazing Assignment – Mixed Models Only

Table 268: Glazing selections for the 3A 30% WWR models.

Climate zone	Orientation	Mixed
1	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
1	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
1	South	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
1	West	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
2	North	(G11) 6mm Supergrey
2	East	(G11) 6mm Supergrey
2	South	(SC01) 6mm clear
2	West	(G11) 6mm Supergrey
3	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
3	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
3	South	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
3	West	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
4	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
4	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
4	South	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
4	West	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
5	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
5	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
5	South	(G18) 6mm Azur Blue
5	West	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
6	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
6	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
6	South	(SC04) 6mm Evantage Clear
6	West	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
7	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
7	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
7	South	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
7	West	(G01) Tinted 6mm super grey+12mm arg+6mm clear float

Table 269: Glazing selections for the 5A 40% WWR models.

Climate zone	Orientation	Mixed
1	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
1	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
1	South	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
1	West	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
2	North	(G11) 6mm Supergrey
2	East	(G11) 6mm Supergrey
2	South	(SC01) 6mm clear
2	West	(G11) 6mm Supergrey
3	North	(G10) 6mm Superblue EV(2)
3	East	(G10) 6mm Superblue EV(2)
3	South	(G10) 6mm Superblue EV(2)
3	West	(G10) 6mm Superblue EV(2)
4	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
4	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
4	South	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
4	West	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
5	North	(G11) 6mm Supergrey
5	East	(G11) 6mm Supergrey
5	South	(SC01) 6mm clear
5	West	(G11) 6mm Supergrey
6	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
6	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
6	South	(G06) 4mm Low-e coated (2)
6	West	(G15) 6mm gry+0.38mmPVB+6mmNSunergy (4)
7	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
7	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
7	South	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
7	West	(G01) Tinted 6mm super grey+12mm arg+6mm clear float

Table 270: Glazing selections for the 6B 30% WWR models.

Climate zone	Orientation	Mixed
1	North	(SC01) 6mm clear
1	East	(SC01) 6mm clear
1	South	(SC01) 6mm clear
1	West	(SC01) 6mm clear
2	North	(SC02) 6mm Green
2	East	(G11) 6mm Supergrey
2	South	(SC01) 6mm clear
2	West	(SC02) 6mm Green
3	North	(SC01) 6mm clear
3	East	(SC01) 6mm clear
3	South	(SC01) 6mm clear
3	West	(SC01) 6mm clear
4	North	(SC01) 6mm clear
4	East	(SC01) 6mm clear
4	South	(SC01) 6mm clear
4	West	(SC01) 6mm clear
5	North	(SC02) 6mm Green
5	East	(SC02) 6mm Green
5	South	(SC01) 6mm clear
5	West	(SC01) 6mm clear
6	North	(SC02) 6mm Green
6	East	(SC02) 6mm Green
6	South	(SC01) 6mm clear
6	West	(SC01) 6mm clear
7	North	(SC01) 6mm clear
7	East	(SC01) 6mm clear
7	South	(SC01) 6mm clear
7	West	(SC01) 6mm clear

Table 271: Glazing selections for the 9aC 30% WWR models.

Climate zone	Orientation	Mixed
1	North	(G11) 6mm Supergrey
1	East	(G11) 6mm Supergrey
1	South	(G11) 6mm Supergrey
1	West	(G11) 6mm Supergrey
2	North	(G11) 6mm Supergrey
2	East	(G11) 6mm Supergrey
2	South	(SC01) 6mm clear
2	West	(G11) 6mm Supergrey
3	North	(G18) 6mm Azur Blue
3	East	(G18) 6mm Azur Blue
3	South	(G18) 6mm Azur Blue
3	West	(G18) 6mm Azur Blue
4	North	(G11) 6mm Supergrey
4	East	(G11) 6mm Supergrey
4	South	(G11) 6mm Supergrey
4	West	(G11) 6mm Supergrey
5	North	(G11) 6mm Supergrey
5	East	(G11) 6mm Supergrey
5	South	(SC01) 6mm clear
5	West	(G11) 6mm Supergrey
6	North	(G11) 6mm Supergrey
6	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
6	South	(SC04) 6mm Evantage Clear
6	West	(G03) 5mm Green +12mm arg +5mm clear
7	North	(G11) 6mm Supergrey
7	East	(G11) 6mm Supergrey
7	South	(G11) 6mm Supergrey
7	West	(G11) 6mm Supergrey

Table 272: Glazing selections for the 9bH 30% WWR models.

Climate zone	Orientation	Mixed
1	North	(G11) 6mm Supergrey
1	East	(G10) 6mm Superblue EV(2)
1	South	(SC01) 6mm clear
1	West	(G11) 6mm Supergrey
2	North	(G11) 6mm Supergrey
2	East	(G11) 6mm Supergrey
2	South	(SC01) 6mm clear
2	West	(G11) 6mm Supergrey
3	North	(G11) 6mm Supergrey
3	East	(G11) 6mm Supergrey
3	South	(SC01) 6mm clear
3	West	(G11) 6mm Supergrey
4	North	(G11) 6mm Supergrey
4	East	(G10) 6mm Superblue EV(2)
4	South	(SC01) 6mm clear
4	West	(G11) 6mm Supergrey
5	North	(G11) 6mm Supergrey
5	East	(G11) 6mm Supergrey
5	South	(SC01) 6mm clear
5	West	(G11) 6mm Supergrey
6	North	(G11) 6mm Supergrey
6	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
6	South	(SC04) 6mm Evantage Clear
6	West	(G03) 5mm Green +12mm arg +5mm clear
7	North	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
7	East	(G01) Tinted 6mm super grey+12mm arg+6mm clear float
7	South	(G04) 6.38mm clear 82(2)
7	West	(SC07) 6/12/6 Clear Argon

E. Appendix – Construction Cost Breakdown

E.I Impact of Increased Stringency Models

The HVAC equipment cost could increase or decrease from 2016 models to 2019 models. This is because peak thermal load is impacted by the building façade. The proposed NCC2019 window-wall system DtS provision uses a complete different methodology from NCC2016 DtS provisions for wall and glazing. NCC2016 glazing stringencies are different across the climate zones and orientations. NCC2019 glazing stringencies are different across the climate zones but the same across the orientations except climate zone 8 based on the draft provisions we used to develop the models. In addition, we have selected the cheapest compliant glazing in our glazing database rather than the glazing that on the boundary of the stringency as requested by the CIE. All above reasons result in inconsistency in the HVAC equipment cost variation pattern from NCC2016 to NCC2019.

E.I.I Scenario 1

Table 273: Breakdown of construction cost for model 3A (30% WWR).

Climate zone	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
NCC	NCC2016	NCC2016	NCC2016	NCC2016	NCC2019	NCC2019	NCC2019	NCC2019
North Wall	$1,167	$1,167	$1,167	$954	$627	$487	$627	$627
East Wall	$1,167	$1,167	$1,167	$954	$627	$487	$627	$627
South Wall	$1,167	$1,167	$1,167	$954	$627	$487	$627	$627
West Wall	$1,167	$1,167	$1,167	$954	$627	$487	$627	$627
Total (10 Storey)	$46,665	$46,665	$46,665	$38,146	$25,066	$19,498	$25,066	$25,066
North Glazing	$14,413	$11,820	$14,413	$14,413	$14,413	$14,413	$14,413	$14,413
East Glazing	$20,374	$11,820	$14,413	$14,413	$14,413	$14,413	$14,413	$14,413
South Glazing	$14,413	$10,307	$11,820	$13,446	$14,413	$14,413	$14,413	$14,413
West Glazing	$20,374	$11,820	$14,413	$14,413	$14,413	$14,413	$14,413	$14,413
Total (10 Storey)	$695,756	$457,656	$550,598	$566,866	$576,536	$576,536	$576,536	$576,536
FCU	$324,406	$393,629	$390,454	$380,439	$342,355	$332,190	$374,104	$358,749
Chiller	$113,935	$124,421	$112,697	$105,730	$118,969	$117,525	$111,675	$105,934

Climate zone	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
Boiler	$-	$11,398	$10,863	$11,189	$-	$14,250	$16,255	$11,991
Cooling Tower	$31,743	$36,180	$29,745	$28,964	$34,090	$33,411	$29,965	$27,962
Economy Cycle	$-	$-	$-	$-	$-	$-	$-	$-
CO2 Sensor	$-	$-	$-	$-	$18,350	$-	$-	$-
Heat Exchanger	$-	$-	$-	$-	$-	$-	$-	$15,866
Lighting	$91,392	$91,392	$91,392	$91,392	$91,392	$91,392	$91,392	$91,392
Grand Total	$1,303,897	$1,161,342	$1,232,413	$1,222,727	$1,206,758	$1,184,802	$1,224,993	$1,213,497

Table 274: Breakdown of construction cost for model 3A (30% WWR).

Climate zone	Zone 5	Zone 6	Zone 7	Zone 8	Zone 5	Zone 6	Zone 7	Zone 8
NCC	NCC2016	NCC2016	NCC2016	NCC2016	NCC2019	NCC2019	NCC2019	NCC2019
North Wall	$954	$954	$954	-	$487	$627	$627	-
East Wall	$954	$954	$954	-	$487	$627	$627	-
South Wall	$954	$954	$954	-	$487	$627	$627	-
West Wall	$954	$954	$954	-	$487	$627	$627	-
Total (10 Storey)	$38,146	$38,146	$38,146	-	$19,498	$25,066	$25,066	-
North Glazing	$14,413	$14,413	$14,413	-	$14,413	$14,413	$14,413	-
East Glazing	$14,413	$14,413	$20,374	-	$14,413	$14,413	$14,413	-
South Glazing	$11,820	$13,446	$14,027	-	$14,413	$14,413	$14,413	-
West Glazing	$14,413	$14,413	$19,999	-	$14,413	$14,413	$14,413	-
Total (10 Storey)	$550,598	$566,866	$688,134	-	$576,536	$576,536	$576,536	-
FCU	$356,413	$366,396	$331,234	-	$365,322	$347,949	$321,215	-
Chiller	$112,795	$106,328	$100,138	-	$116,914	$106,801	$101,483	-
Boiler	$7,644	$9,049	$10,959	-	$10,612	$9,100	$13,618	-
Cooling Tower	$30,924	$29,878	$26,817	-	$32,867	$28,807	$26,681	-
Economy Cycle	$-	$-	$-	-	$-	$-	$-	-
CO2 Sensor	$-	$-	$-	-	$-	$-	$-	-
Heat Exchanger	$-	$-	$-	-	$15,866	$15,866	$15,866	-
Lighting	$91,392	$91,392	$91,392	-	$91,392	$91,392	$91,392	-
Grand Total	$1,187,913	$1,208,056	$1,286,821	-	$1,229,007	$1,201,517	$1,171,857	-

Table 275: Breakdown of construction cost for model 9aC (30% WWR).

Climate zone	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
NCC	NCC2016	NCC2016	NCC2016	NCC2016	NCC2019	NCC2019	NCC2019	NCC2019
North Wall	$7,949	$7,949	$7,949	$6,983	$6,017	$6,017	$3,601	$6,017
East Wall	$7,949	$7,949	$7,949	$6,983	$6,017	$6,017	$3,601	$6,017
South Wall	$7,949	$7,949	$7,949	$6,983	$6,017	$6,017	$3,601	$6,017
West Wall	$7,949	$7,949	$7,949	$6,983	$6,017	$6,017	$3,601	$6,017
Total (1 Storey)	$31,797	$31,797	$31,797	$27,932	$24,066	$24,066	$14,403	$24,066
North Glazing	$19,699	$19,699	$19,699	$19,699	$19,699	$19,699	$19,699	$19,699
East Glazing	$22,771	$19,699	$19,699	$22,771	$19,699	$19,699	$19,699	$19,699
South Glazing	$17,633	$17,178	$17,178	$17,178	$19,699	$19,699	$19,699	$19,699
West Glazing	$19,699	$19,699	$19,699	$19,699	$19,699	$19,699	$19,699	$19,699
Total (1 Storey)	$79,803	$76,276	$76,276	$79,348	$78,798	$78,798	$78,798	$78,798
AHU	$45,893	$37,512	$49,922	$51,899	$55,210	$45,585	$61,247	$67,548
Chiller	$49,757	$45,301	$50,625	$48,785	$53,437	$46,870	$54,655	$51,602
Boiler	$0	$2,972	$3,540	$3,568	$1,780	$5,082	$5,988	$6,148
Cooling Tower	$12,371	$11,198	$12,135	$11,577	$13,827	$12,067	$13,479	$12,696
Economy Cycle	$0	$3,836	$4,927	$5,172	$0	$0	$0	$0
CO2 Sensor	$0	$0	$0	$0	$0	$0	$0	$0
Heat Exchanger	$0	$0	$0	$0	$0	$0	$0	$0
Lighting	$18,088	$18,088	$18,088	$18,088	$18,088	$18,088	$18,088	$18,088
Grand Total	$237,708	$226,979	$247,310	$246,369	$245,207	$230,556	$246,658	$258,946

Table 276: Breakdown of construction cost for model 9aC (30% WWR).

Climate zone	Zone 5	Zone 6	Zone 7	Zone 8	Zone 5	Zone 6	Zone 7	Zone 8
NCC	NCC2016	NCC2016	NCC2016	NCC2016	NCC2019	NCC2019	NCC2019	NCC2019
North Wall	$6,983	$6,983	$6,983	-	$6,017	$6,017	$6,017	-
East Wall	$6,983	$6,983	$6,983	-	$6,017	$6,017	$6,017	-
South Wall	$6,983	$6,983	$6,983	-	$6,017	$6,017	$6,017	-
West Wall	$6,983	$6,983	$6,983	-	$6,017	$6,017	$6,017	-
Total (1 Storey)	$27,932	$27,932	$27,932	-	$24,066	$24,066	$24,066	-
North Glazing	$19,699	$19,699	$24,022	-	$19,699	$19,699	$19,699	-
East Glazing	$19,699	$24,022	$24,022	-	$19,699	$19,699	$19,699	-
South Glazing	$17,178	$22,411	$22,411	-	$19,699	$19,699	$19,699	-
West Glazing	$19,699	$23,378	$23,378	-	$19,699	$19,699	$19,699	-
Total (1 Storey)	$76,276	$89,510	$93,833	-	$78,798	$78,798	$78,798	-
AHU	$41,282	$50,336	$62,243	-	$52,539	$73,061	$89,636	-
Chiller	$44,910	$46,779	$44,555	-	$47,647	$52,558	$48,074	-
Boiler	$2,823	$2,648	$3,048	-	$4,818	$5,444	$7,377	-
Cooling Tower	$10,911	$11,221	$10,361	-	$12,117	$13,155	$11,865	-
Economy Cycle	$4,044	$5,216	$6,281	-	$0	$5,828	$7,022	-
CO2 Sensor	$0	$0	$0	-	$0	$0	$1,835	-
Heat Exchanger	$0	$0	$0	-	$0	$0	$0	-
Lighting	$18,088	$18,088	$18,088	-	$18,088	$18,088	$18,088	-
Grand Total	$226,266	$251,730	$266,341	-	$238,073	$270,998	$286,761	-

Table 277: Breakdown of construction cost for model 9bH (30% WWR).

Climate zone	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
NCC	NCC2016	NCC2016	NCC2016	NCC2016	NCC2019	NCC2019	NCC2019	NCC2019
North Wall	$2,608	$2,608	$2,608	$2,199	$1,625	$1,625	$572	$1,625
East Wall	$863	$863	$863	$728	$538	$538	$189	$538
South Wall	$2,608	$2,608	$2,608	$2,199	$1,625	$1,625	$572	$1,625
West Wall	$863	$863	$863	$728	$538	$538	$189	$538
Total (3 Storey)	$20,830	$20,830	$20,830	$17,564	$12,975	$12,975	$4,571	$12,975
North Glazing	$22,598	$22,598	$22,598	$22,598	$22,598	$22,598	$22,598	$22,598
East Glazing	$8,647	$7,481	$7,481	$8,647	$7,481	$7,481	$7,481	$7,481
South Glazing	$19,706	$19,706	$19,706	$19,706	$22,598	$22,598	$22,598	$22,598
West Glazing	$7,481	$7,481	$7,481	$7,481	$7,481	$7,481	$7,481	$7,481
Total (3 Storey)	$175,295	$171,796	$171,796	$175,295	$180,474	$180,474	$180,474	$180,474
AHU	$125,421	$108,558	$133,954	$149,116	$127,947	$124,791	$146,276	$161,551
Chiller	$140,417	$111,403	$112,124	$103,610	$142,757	$133,336	$121,645	$120,973
Boiler	$3,128	$13,092	$16,845	$17,614	$3,763	$23,128	$21,366	$20,626
Cooling Tower	$0	$0	$0	$0	$0	$0	$0	$0
Economy Cycle	$0	$0	$0	$0	$0	$0	$0	$0
CO_2 Sensor	$0	$0	$0	$0	$11,010	$0	$11,010	$11,010
Heat Exchanger	$0	$0	$0	$0	$0	$0	$0	$0
Lighting	$53,122	$53,122	$53,122	$53,122	$53,122	$53,122	$53,122	$53,122
Grand Total	$518,212	$478,801	$508,670	$516,321	$532,048	$527,825	$538,464	$560,731

Table 278: Breakdown of construction cost for model 9bH (30% WWR).

Climate zone	Zone 5	Zone 6	Zone 7	Zone 8	Zone 5	Zone 6	Zone 7	Zone 8
NCC	NCC2016	NCC2016	NCC2016	NCC2016	NCC2019	NCC2019	NCC2019	NCC2019
North Wall	$2,199	$2,199	$2,199	-	$1,625	$1,625	$1,625	-
East Wall	$728	$728	$728	-	$538	$538	$538	-
South Wall	$2,199	$2,199	$2,199	-	$1,625	$1,625	$1,625	-
West Wall	$728	$728	$728	-	$538	$538	$538	-
Total (10 Storey)	$17,564	$17,564	$17,564	-	$12,975	$12,975	$12,975	-
North Glazing	$22,598	$22,598	$27,557	-	$22,598	$22,598	$22,598	-
East Glazing	$7,481	$9,122	$9,122	-	$7,481	$7,481	$7,481	-
South Glazing	$19,706	$25,709	$25,709	-	$22,598	$22,598	$22,598	-
West Glazing	$7,481	$8,878	$8,878	-	$7,481	$7,481	$7,481	-
Total (10 Storey)	$171,796	$198,920	$213,797	-	$180,474	$180,474	$180,474	-
AHU	$133,257	$147,899	$172,864	-	$138,512	$157,903	$184,112	-
Chiller	$88,485	$101,841	$111,758	-	$112,735	$119,339	$139,507	-
Boiler	$12,697	$14,141	$17,023	-	$13,980	$15,741	$23,063	-
Cooling Tower	$0	$0	$0	-	$0	$0	$0	-
Economy Cycle	$0	$0	$0	-	$0	$0	$0	-
CO_2 Sensor	$0	$0	$0	-	$11,010	$11,010	$11,010	-
Heat Exchanger	$0	$0	$0	-	$0	$0	$0	-
Lighting	$53,122	$53,122	$53,122	-	$53,122	$53,122	$53,122	-
Grand Total	$476,921	$533,487	$586,128	-	$522,808	$550,563	$604,262	-

Table 279: Breakdown of construction cost for model 5A (56% WWR).

Climate zone	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
NCC	NCC2016	NCC2016	NCC2016	NCC2016	NCC2019	NCC2019	NCC2019	NCC2019
North Wall	$857	$857	$857	$723	$143	$143	$143	$143
East Wall	$857	$857	$857	$723	$143	$143	$143	$143
South Wall	$857	$857	$857	$723	$143	$143	$143	$143
West Wall	$857	$857	$857	$723	$143	$143	$143	$143
Total (10 Storey)	$34,299	$34,299	$34,299	$28,922	$5,705	$5,705	$5,705	$5,705
North Glazing	$26,905	$26,905	$26,905	$26,905	$26,905	$26,905	$37,735	$26,905
East Glazing	$38,032	$26,905	$26,905	$38,032	$26,905	$26,905	$37,735	$26,905
South Glazing	$26,905	$19,749	$22,063	$26,183	$26,905	$26,905	$37,735	$26,905
West Glazing	$38,032	$22,063	$26,905	$26,905	$26,905	$26,905	$37,735	$26,905
Total (10 Storey)	$1,298,745	$956,221	$1,027,784	$1,180,252	$1,076,200	$1,076,200	$1,509,398	$1,076,200
AHU	$296,368	$300,382	$350,789	$286,121	$393,950	$315,429	$453,081	$330,274
Chiller	$117,088	$122,840	$119,211	$117,148	$118,494	$121,903	$123,255	$121,350
Boiler	$-	$10,245	$11,666	$8,447	$6,185	$13,663	$14,184	$20,145
Cooling Tower	$35,756	$35,554	$32,614	$31,732	$35,894	$35,441	$33,983	$33,460
Economy Cycle	$-	$57,318	$65,552	$54,988	$-	$-	$-	$52,556
CO2 Sensor	$0	$0	$0	$0	$18,350	$0	$18,350	$18,350
Heat Exchanger	$0	$0	$0	$0	$0	$0	$0	$0
Lighting	$171,360	$171,360	$171,360	$171,360	$171,360	$171,360	$171,360	$171,360
Grand Total	$1,951,081	$1,688,220	$1,813,275	$1,878,970	$1,826,138	$1,739,700	$2,329,316	$1,829,399

Table 280: Breakdown of construction cost for model 5A (56% WWR).

Climate zone	Zone 5	Zone 6	Zone 7	Zone 8	Zone 5	Zone 6	Zone 7	Zone 8
NCC	NCC2016	NCC2016	NCC2016	NCC2016	NCC2019	NCC2019	NCC2019	NCC2019
North Wall	$723	$723	$822	-	$143	$143	$162	-
East Wall	$723	$723	$822	-	$143	$143	$162	-
South Wall	$723	$723	$822	-	$143	$143	$162	-
West Wall	$723	$723	$822	-	$143	$143	$162	-
Total (10 Storey)	$28,922	$28,922	$32,866	-	$5,705	$5,705	$6,483	-
North Glazing	$26,905	$38,032	$33,957	-	$26,905	$26,905	$24,022	-
East Glazing	$26,905	$38,032	$33,957	-	$26,905	$26,905	$24,022	-
South Glazing	$22,063	$25,100	$23,378	-	$26,905	$26,905	$24,022	-
West Glazing	$26,905	$38,032	$33,332	-	$26,905	$26,905	$24,022	-
Total (10 Storey)	$1,027,784	$1,391,967	$1,246,241	-	$1,076,200	$1,076,200	$960,893	-
AHU	$239,736	$256,320	$278,733	-	$275,464	$342,489	$412,500	-
Chiller	$115,148	$117,794	$113,133	-	$118,869	$124,079	$118,031	-
Boiler	$7,933	$8,578	$7,752	-	$14,701	$17,061	$19,941	-
Cooling Tower	$31,971	$32,400	$30,014	-	$33,572	$34,750	$32,019	-
Economy Cycle	$47,410	$50,120	$53,781	-	$45,203	$54,195	$63,588	-
CO_2 Sensor	$0	$0	$0	-	$18,350	$18,350	$18,350	-
Heat Exchanger	$0	$0	$0	-	$0	$0	$0	-
Lighting	$171,360	$171,360	$171,360	-	$171,360	$171,360	$171,360	-
Grand Total	$1,670,264	$2,057,461	$1,933,880	-	$1,759,424	$1,844,189	$1,803,165	-

Table 281: Breakdown of construction cost for model 5A (40% WWR).

Climate zone	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
NCC	NCC2016	NCC2016	NCC2016	NCC2016	NCC2019	NCC2019	NCC2019	NCC2019
North Wall	$1,169	$1,169	$1,169	$986	$257	$257	$317	$257
East Wall	$1,169	$1,169	$1,169	$986	$257	$257	$317	$257
South Wall	$1,169	$1,169	$1,169	$986	$257	$257	$317	$257
West Wall	$1,169	$1,169	$1,169	$986	$257	$257	$317	$257
Total (10 Storey)	$46,772	$46,772	$46,772	$39,440	$10,265	$10,265	$12,666	$10,265
North Glazing	$19,218	$15,760	$15,760	$19,218	$19,218	$19,218	$18,217	$19,218
East Glazing	$19,218	$15,760	$19,218	$19,218	$19,218	$19,218	$18,217	$19,218
South Glazing	$15,760	$13,742	$13,742	$15,760	$19,218	$19,218	$18,217	$19,218
West Glazing	$19,218	$15,760	$15,760	$18,702	$19,218	$19,218	$18,217	$19,218
Total (10 Storey)	$734,131	$610,209	$644,792	$728,974	$768,714	$768,714	$728,671	$768,714
AHU	$304,299	$311,709	$369,720	$270,805	$362,954	$285,567	$460,902	$299,890
Chiller	$121,340	$122,880	$123,057	$117,801	$122,503	$118,500	$127,956	$119,089
Boiler	$4,114	$15,168	$16,812	$17,008	$6,063	$18,104	$25,204	$20,071
Cooling Tower	$35,099	$35,740	$34,274	$31,991	$35,422	$33,770	$35,983	$32,380
Economy Cycle	$-	$59,168	$68,645	$52,486	$-	$-	$-	$48,480
CO2 Sensor	$0	$0	$0	$0	$18,350	$0	$18,350	$18,350
Heat Exchanger	$0	$0	$0	$0	$0	$0	$0	$0
Lighting	$171,360	$171,360	$171,360	$171,360	$171,360	$171,360	$171,360	$171,360
Grand Total	$1,417,114	$1,373,005	$1,475,431	$1,429,865	$1,495,632	$1,406,281	$1,581,092	$1,488,598

Table 282: Breakdown of construction cost for model 5A (40% WWR).

Climate zone	Zone 5	Zone 6	Zone 7	Zone 8	Zone 5	Zone 6	Zone 7	Zone 8
NCC	NCC2016	NCC2016	NCC2016	NCC2016	NCC2019	NCC2019	NCC2019	NCC2019
North Wall	$986	$986	$986	-	$257	$257	$257	-
East Wall	$986	$986	$986	-	$257	$257	$257	-
South Wall	$986	$986	$986	-	$257	$257	$257	-
West Wall	$986	$986	$986	-	$257	$257	$257	-
Total (10 Storey)	$39,440	$39,440	$39,440	-	$10,265	$10,265	$10,265	-
North Glazing	$15,760	$19,218	$19,218	-	$19,218	$19,218	$19,218	-
East Glazing	$15,760	$19,218	$27,166	-	$19,218	$19,218	$19,218	-
South Glazing	$13,742	$17,929	$18,702	-	$19,218	$19,218	$19,218	-
West Glazing	$15,760	$18,702	$18,702	-	$19,218	$19,218	$19,218	-
Total (10 Storey)	$610,209	$750,664	$837,880	-	$768,714	$768,714	$768,714	-
AHU	$276,251	$255,426	$318,131	-	$250,707	$292,487	$397,131	-
Chiller	$121,336	$118,718	$115,700	-	$115,047	$116,435	$114,444	-
Boiler	$16,161	$13,535	$16,372	-	$16,589	$16,661	$21,310	-
Cooling Tower	$34,604	$32,778	$30,719	-	$32,219	$31,927	$30,894	-
Economy Cycle	$53,376	$49,974	$60,217	-	$41,881	$47,486	$61,526	-
CO_2 Sensor	$0	$0	$0	-	$18,350	$18,350	$18,350	-
Heat Exchanger	$0	$0	$0	-	$0	$0	$0	-
Lighting	$171,360	$171,360	$171,360	-	$171,360	$171,360	$171,360	-
Grand Total	$1,322,735	$1,431,895	$1,589,819	-	$1,425,132	$1,473,685	$1,593,994	-

Table 283: Breakdown of construction cost for model 6B (30% WWR).

Climate zone	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
NCC	NCC2016	NCC2016	NCC2016	NCC2016	NCC2019	NCC2019	NCC2019	NCC2019
North Wall	$1,548	$1,548	$1,548	$1,548	$793	$793	$793	$793
East Wall	$776	$776	$776	$776	$398	$398	$398	$398
South Wall	$1,548	$1,548	$1,548	$1,548	$793	$793	$793	$793
West Wall	$776	$776	$776	$776	$398	$398	$398	$398
Total (3 Storey)	$13,941	$13,941	$13,941	$13,941	$7,143	$7,143	$7,143	$7,143
North Glazing	$13,652	$13,175	$13,175	$13,175	$13,070	$13,070	$13,070	$13,070
East Glazing	$7,556	$6,845	$6,845	$7,317	$6,553	$6,553	$6,553	$6,553
South Glazing	$12,115	$11,905	$11,905	$11,905	$13,070	$13,070	$13,070	$13,070
West Glazing	$6,845	$6,606	$6,606	$6,553	$6,553	$6,553	$6,553	$6,553
Total (3 Storey)	$120,507	$115,591	$115,591	$116,849	$117,737	$117,737	$117,737	$117,737
FCU	$144,448	$131,463	$151,475	$150,510	$145,620	$131,317	$156,100	$165,405
Cooling Tower	$21,117	$18,461	$18,775	$18,276	$22,211	$19,253	$20,500	$20,125
Chiller	$79,339	$67,758	$66,314	$69,015	$83,327	$73,406	$80,420	$79,735
Boiler	$2,102	$8,550	$9,813	$9,970	$5,192	$13,556	$16,515	$17,973
Economy Cycle	$0	$0	$0	$0	$0	$0	$0	$0
CO_2 Sensor	$0	$0	$0	$0	$0	$0	$0	$0
Heat Exchanger	$0	$0	$0	$0	$0	$0	$0	$0
Lighting	$34,272	$34,272	$34,272	$34,272	$34,272	$34,272	$34,272	$34,272
Grand Total	$415,726	$390,036	$410,180	$412,833	$415,502	$396,683	$432,688	$442,391

Table 284: Breakdown of construction cost for model 6B (30% WWR).

Climate zone	Zone 5	Zone 6	Zone 7	Zone 8	Zone 5	Zone 6	Zone 7	Zone 8
NCC	NCC2016	NCC2016	NCC2016	NCC2016	NCC2019	NCC2019	NCC2019	NCC2019
North Wall	$1,548	$1,548	$1,548	-	$793	$793	$793	-
East Wall	$776	$776	$776	-	$398	$398	$398	-
South Wall	$1,548	$1,548	$1,548	-	$793	$793	$793	-
West Wall	$776	$776	$776	-	$398	$398	$398	-
Total (1 Storey)	$13,941	$13,941	$13,941	-	$7,143	$7,143	$7,143	-
North Glazing	$13,175	$13,175	$15,650	-	$13,070	$13,070	$13,070	-
East Glazing	$6,606	$7,607	$7,846	-	$6,553	$6,553	$6,553	-
South Glazing	$11,905	$14,323	$14,323	-	$13,070	$13,070	$13,070	-
West Glazing	$6,553	$7,405	$7,405	-	$6,553	$6,553	$6,553	-
Total (1 Storey)	$114,715	$127,528	$135,671	-	$117,737	$117,737	$117,737	-
FCU	$144,925	$144,360	$149,696	-	$147,180	$159,595	$173,758	-
Cooling Tower	$64,724	$67,776	$64,825	-	$18,359	$19,648	$17,676	-
Chiller	$69,778	$74,331	$69,926	-	$71,017	$76,715	$70,952	-
Boiler	$7,609	$8,434	$10,905	-	$13,077	$14,389	$17,744	-
Economy Cycle	$0	$0	$0	-	$0	$0	$0	-
CO_2 Sensor	$0	$0	$0	-	$0	$0	$11,010	-
Heat Exchanger	$0	$0	$0	-	$0	$0	$0	-
Lighting	$34,272	$34,272	$34,272	-	$34,272	$34,272	$34,272	-
Grand Total	$397,457	$414,359	$425,823	-	$408,784	$429,498	$450,292	-

The HVAC equipment cost could increase or decrease from 2016 models to 2019 models. This is because peak thermal load is impacted by the building façade. The proposed NCC2019 window-wall system DtS provision uses a complete different methodology from NCC2016 DtS provisions for wall and glazing. NCC2016 glazing stringencies are different across the climate zones and orientations. NCC2019 glazing stringencies are different across the climate zones but the same across the orientations except climate zone 8 based on the draft provisions we used to develop the models. In addition, we have selected the cheapest compliant glazing in our glazing database rather than the glazing that on the boundary of the stringency as requested by the CIE. All above reasons result in inconsistency in the HVAC equipment cost variation pattern from NCC2016 to NCC2019.

E.I.II Scenario 2

Table 285: Breakdown of construction cost for model 3A (30% WWR).

Climate zone	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
NCC	NCC2016	NCC2016	NCC2016	NCC2016	NCC2019	NCC2019	NCC2019	NCC2019
North Wall	$1,133	$1,133	$1,133	$954	$627	$487	$627	$627
East Wall	$1,133	$1,133	$1,133	$954	$627	$487	$627	$627
South Wall	$1,133	$1,133	$1,133	$954	$627	$487	$627	$627
West Wall	$1,133	$1,133	$1,133	$954	$627	$487	$627	$627
Total (10 Storey)	$45,330	$45,330	$45,330	$38,146	$25,066	$19,498	$25,066	$25,066
North Glazing	$14,413	$11,820	$14,413	$14,413	$14,413	$14,413	$14,413	$14,413
East Glazing	$20,374	$11,820	$14,413	$14,413	$14,413	$14,413	$14,413	$14,413
South Glazing	$14,413	$10,307	$11,820	$13,446	$14,413	$14,413	$14,413	$14,413
West Glazing	$20,374	$11,820	$14,413	$14,413	$14,413	$14,413	$14,413	$14,413
Total (10 Storey)	$695,756	$457,656	$550,598	$566,866	$576,536	$576,536	$576,536	$576,536
FCU	$324,406	$393,629	$390,454	$380,439	$342,355	$332,190	$374,104	$358,749
Chiller	$113,935	$124,421	$112,697	$105,730	$118,969	$117,525	$111,675	$105,934
Boiler	$-	$11,398	$10,863	$11,189	$-	$14,250	$16,255	$11,991

Climate zone	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
Cooling Tower	$31,743	$36,180	$29,745	$28,964	$34,090	$33,411	$29,965	$27,962
Economy Cycle	$-	$-	$-	$-	$-	$-	$-	$-
CO_2 Sensor	$-	$-	$-	$-	$18,350	$-	$-	$-
Heat Exchanger	$-	$-	$-	$-	$-	$-	$-	$15,866
Lighting	$91,392	$91,392	$91,392	$91,392	$91,392	$91,392	$91,392	$91,392
Grand Total	$1,302,563	$1,160,008	$1,231,079	$1,222,727	$1,206,758	$1,184,802	$1,224,993	$1,213,497

Table 286: Breakdown of construction cost for model 3A (30% WWR).

Climate zone	Zone 5	Zone 6	Zone 7	Zone 8	Zone 5	Zone 6	Zone 7	Zone 8
NCC	NCC2016	NCC2016	NCC2016	NCC2016	NCC2019	NCC2019	NCC2019	NCC2019
North Wall	$954	$954	$954	-	$487	$627	$627	-
East Wall	$954	$954	$954	-	$487	$627	$627	-
South Wall	$954	$954	$954	-	$487	$627	$627	-
West Wall	$954	$954	$954	-	$487	$627	$627	-
Total (10 Storey)	$38,146	$38,146	$38,146	-	$19,498	$25,066	$25,066	-
North Glazing	$14,413	$14,413	$14,413	-	$14,413	$14,413	$14,413	-
East Glazing	$14,413	$14,413	$20,374	-	$14,413	$14,413	$14,413	-
South Glazing	$11,820	$13,446	$14,027	-	$14,413	$14,413	$14,413	-
West Glazing	$14,413	$14,413	$19,999	-	$14,413	$14,413	$14,413	-
Total (10 Storey)	$550,598	$566,866	$688,134	-	$576,536	$576,536	$576,536	-
FCU	$356,413	$366,396	$331,234	-	$365,322	$347,949	$321,215	-
Chiller	$112,795	$106,328	$100,138	-	$116,914	$106,801	$101,483	-
Boiler	$7,644	$9,049	$10,959	-	$10,612	$9,100	$13,618	-
Cooling Tower	$30,924	$29,878	$26,817	-	$32,867	$28,807	$26,681	-
Economy Cycle	$-	$-	$-	-	$-	$-	$-	-
CO_2 Sensor	$-	$-	$-	-	$-	$-	$-	-
Heat Exchanger	$-	$-	$-	-	$15,866	$15,866	$15,866	-
Lighting	$91,392	$91,392	$91,392	-	$91,392	$91,392	$91,392	-
Grand Total	$1,187,913	$1,208,056	$1,286,821	-	$1,229,007	$1,201,517	$1,171,857	-

Table 287: Breakdown of construction cost for model 9bH (30% WWR).

Climate zone	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
NCC	NCC2016	NCC2016	NCC2016	NCC2016	NCC2019	NCC2019	NCC2019	NCC2019
North Wall	$2,167	$2,167	$2,167	$2,167	$1,625	$1,625	$572	$1,625
East Wall	$717	$717	$717	$717	$538	$538	$189	$538
South Wall	$2,167	$2,167	$2,167	$2,167	$1,625	$1,625	$572	$1,625
West Wall	$717	$717	$717	$717	$538	$538	$189	$538
Total (3 Storey)	$17,304	$17,304	$17,304	$17,304	$12,975	$12,975	$4,571	$12,975
North Glazing	$22,598	$22,598	$22,598	$22,598	$22,598	$22,598	$22,598	$22,598
East Glazing	$8,647	$7,481	$7,481	$8,647	$7,481	$7,481	$7,481	$7,481
South Glazing	$19,706	$19,706	$19,706	$19,706	$22,598	$22,598	$22,598	$22,598
West Glazing	$7,481	$7,481	$7,481	$7,481	$7,481	$7,481	$7,481	$7,481
Total (3 Storey)	$175,295	$171,796	$171,796	$175,295	$180,474	$180,474	$180,474	$180,474
AHU	$125,421	$108,558	$133,954	$149,116	$127,947	$124,791	$146,276	$161,551
Chiller	$140,417	$111,403	$112,124	$103,610	$142,757	$133,336	$121,645	$120,973
Boiler	$3,128	$13,092	$16,845	$17,614	$3,763	$23,128	$21,366	$20,626
Cooling Tower	$0	$0	$0	$0	$0	$0	$0	$0
Economy Cycle	$0	$0	$0	$0	$0	$0	$0	$0
CO_2 Sensor	$0	$0	$0	$0	$11,010	$0	$11,010	$11,010
Heat Exchanger	$0	$0	$0	$0	$0	$0	$0	$0
Lighting	$53,122	$53,122	$53,122	$53,122	$53,122	$53,122	$53,122	$53,122
Grand Total	$514,686	$475,275	$505,144	$516,060	$532,048	$527,825	$538,464	$560,731

Table 288: Breakdown of construction cost for model 9bH (30% WWR).

Climate zone	Zone 5	Zone 6	Zone 7	Zone 8	Zone 5	Zone 6	Zone 7	Zone 8
NCC	NCC2016	NCC2016	NCC2016	NCC2016	NCC2019	NCC2019	NCC2019	NCC2019
North Wall	$2,167	$2,167	$2,167	-	$1,625	$1,625	$1,625	-
East Wall	$717	$717	$717	-	$538	$538	$538	-
South Wall	$2,167	$2,167	$2,167	-	$1,625	$1,625	$1,625	-
West Wall	$717	$717	$717	-	$538	$538	$538	-
Total (3 Storey)	$17,304	$17,304	$17,304	-	$12,975	$12,975	$12,975	-
North Glazing	$22,598	$22,598	$27,557	-	$22,598	$22,598	$22,598	-
East Glazing	$7,481	$9,122	$9,122	-	$7,481	$7,481	$7,481	-
South Glazing	$19,706	$25,709	$25,709	-	$22,598	$22,598	$22,598	-
West Glazing	$7,481	$8,878	$8,878	-	$7,481	$7,481	$7,481	-
Total (3 Storey)	$171,796	$198,920	$213,797	-	$180,474	$180,474	$180,474	-
AHU	$133,257	$147,899	$172,864	-	$138,512	$157,903	$184,112	-
Chiller	$88,485	$101,841	$111,758	-	$112,735	$119,339	$139,507	-
Boiler	$12,697	$14,141	$17,023	-	$13,980	$15,741	$23,063	-
Cooling Tower	$0	$0	$0	-	$0	$0	$0	-
Economy Cycle	$0	$0	$0	-	$0	$0	$0	-
CO_2 Sensor	$0	$0	$0	-	$11,010	$11,010	$11,010	-
Heat Exchanger	$0	$0	$0	-	$0	$0	$0	-
Lighting	$53,122	$53,122	$53,122	-	$53,122	$53,122	$53,122	-
Grand Total	$476,661	$533,227	$585,867	-	$522,808	$550,563	$604,262	-

Table 289: Breakdown of construction cost for model 5A (56% WWR).

Climate zone	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
NCC	NCC2016	NCC2016	NCC2016	NCC2016	NCC2019	NCC2019	NCC2019	NCC2019
North Wall	$712	$712	$712	$712	$188	$188	$188	$188
East Wall	$712	$712	$712	$712	$188	$188	$188	$188
South Wall	$712	$712	$712	$712	$188	$188	$188	$188
West Wall	$712	$712	$712	$712	$188	$188	$188	$188
Total (10 Storey)	$28,493	$28,493	$28,493	$28,493	$7,528	$7,528	$7,528	$7,528
North Glazing	$26,905	$26,905	$26,905	$26,905	$26,905	$26,905	$37,735	$26,905
East Glazing	$38,032	$26,905	$26,905	$38,032	$26,905	$26,905	$37,735	$26,905
South Glazing	$26,905	$19,749	$22,063	$26,183	$26,905	$26,905	$37,735	$26,905
West Glazing	$38,032	$22,063	$26,905	$26,905	$26,905	$26,905	$37,735	$26,905
Total (10 Storey)	$1,298,745	$956,221	$1,027,784	$1,180,252	$1,076,200	$1,076,200	$1,509,398	$1,076,200
AHU	$296,368	$300,382	$350,789	$286,121	$393,950	$315,429	$453,081	$330,274
Chiller	$117,088	$122,840	$119,211	$117,148	$118,494	$121,903	$123,255	$121,350
Boiler	$-	$10,245	$11,666	$8,447	$6,185	$13,663	$14,184	$20,145
Cooling Tower	$35,756	$35,554	$32,614	$31,732	$35,894	$35,441	$33,983	$33,460
Economy Cycle	$-	$57,318	$65,552	$54,988	$-	$-	$-	$52,556
CO_2 Sensor	$0	$0	$0	$0	$18,350	$0	$18,350	$18,350
Heat Exchanger	$0	$0	$0	$0	$0	$0	$0	$0
Lighting	$171,360	$171,360	$171,360	$171,360	$171,360	$171,360	$171,360	$171,360
Grand Total	$1,945,275	$1,682,414	$1,807,470	$1,878,541	$1,827,961	$1,741,523	$2,331,138	$1,831,222

Table 290: Breakdown of construction cost for model 5A (56% WWR).

Climate zone	Zone 5	Zone 6	Zone 7	Zone 8	Zone 5	Zone 6	Zone 7	Zone 8
NCC	NCC2016	NCC2016	NCC2016	NCC2016	NCC2019	NCC2019	NCC2019	NCC2019
North Wall	$712	$712	$809	-	$188	$188	$214	-
East Wall	$712	$712	$809	-	$188	$188	$214	-
South Wall	$712	$712	$809	-	$188	$188	$214	-
West Wall	$712	$712	$809	-	$188	$188	$214	-
Total (10 Storey)	$28,493	$28,493	$32,379	-	$7,528	$7,528	$8,554	-
North Glazing	$26,905	$38,032	$33,957	-	$26,905	$26,905	$24,022	-
East Glazing	$26,905	$38,032	$33,957	-	$26,905	$26,905	$24,022	-
South Glazing	$22,063	$25,100	$23,378	-	$26,905	$26,905	$24,022	-
West Glazing	$26,905	$38,032	$33,332	-	$26,905	$26,905	$24,022	-
Total (10 Storey)	$1,027,784	$1,391,967	$1,246,241	-	$1,076,200	$1,076,200	$960,893	-
AHU	$239,736	$256,320	$278,733	-	$275,464	$342,489	$412,500	-
Chiller	$115,147	$117,795	$113,133	-	$118,869	$124,079	$118,031	-
Boiler	$7,933	$8,578	$7,752	-	$14,701	$17,061	$19,941	-
Cooling Tower	$31,971	$32,400	$30,014	-	$33,572	$34,750	$32,019	-
Economy Cycle	$47,410	$50,120	$53,781	-	$45,203	$54,195	$63,588	-
CO_2 Sensor	$0	$0	$0	-	$18,350	$18,350	$18,350	-
Heat Exchanger	$0	$0	$0	-	$0	$0	$0	-
Lighting	$171,360	$171,360	$171,360	-	$171,360	$171,360	$171,360	-
Grand Total	$1,669,835	$2,057,032	$1,933,393	-	$1,761,246	$1,846,012	$1,805,235	-

Table 291: Breakdown of construction cost for model 5A (40% WWR).

Climate zone	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
NCC	NCC2016	NCC2016	NCC2016	NCC2016	NCC2019	NCC2019	NCC2019	NCC2019
North Wall	$971	$971	$971	$971	$257	$257	$317	$257
East Wall	$971	$971	$971	$971	$257	$257	$317	$257
South Wall	$971	$971	$971	$971	$257	$257	$317	$257
West Wall	$971	$971	$971	$971	$257	$257	$317	$257
Total (10 Storey)	$38,855	$38,855	$38,855	$38,855	$10,265	$10,265	$12,666	$10,265
North Glazing	$19,218	$15,760	$15,760	$19,218	$19,218	$19,218	$18,217	$19,218
East Glazing	$19,218	$15,760	$19,218	$19,218	$19,218	$19,218	$18,217	$19,218
South Glazing	$15,760	$13,742	$13,742	$15,760	$19,218	$19,218	$18,217	$19,218
West Glazing	$19,218	$15,760	$15,760	$18,702	$19,218	$19,218	$18,217	$19,218
Total (10 Storey)	$734,131	$610,209	$644,792	$728,974	$768,714	$768,714	$728,671	$768,714
AHU	$304,299	$311,709	$369,720	$270,805	$362,954	$285,567	$460,902	$299,890
Chiller	$121,340	$122,880	$123,057	$117,801	$122,503	$118,500	$127,956	$119,089
Boiler	$4,114	$15,168	$16,812	$17,008	$6,063	$18,104	$25,204	$20,071
Cooling Tower	$35,099	$35,740	$34,274	$31,991	$35,422	$33,770	$35,983	$32,380
Economy Cycle	$-	$59,168	$68,645	$52,486	$-	$-	$-	$48,480
CO_2 Sensor	$0	$0	$0	$0	$18,350	$0	$18,350	$18,350
Heat Exchanger	$0	$0	$0	$0	$0	$0	$0	$0
Lighting	$171,360	$171,360	$171,360	$171,360	$171,360	$171,360	$171,360	$171,360
Grand Total	$1,409,197	$1,365,088	$1,467,514	$1,429,280	$1,495,632	$1,406,281	$1,581,092	$1,488,598

Table 292: Breakdown of construction cost for model 5A (40% WWR).

Climate zone	Zone 5	Zone 6	Zone 7	Zone 8	Zone 5	Zone 6	Zone 7	Zone 8
NCC	NCC2016	NCC2016	NCC2016	NCC2016	NCC2019	NCC2019	NCC2019	NCC2019
North Wall	$971	$971	$971	-	$257	$257	$257	-
East Wall	$971	$971	$971	-	$257	$257	$257	-
South Wall	$971	$971	$971	-	$257	$257	$257	-
West Wall	$971	$971	$971	-	$257	$257	$257	-
Total (10 Storey)	$38,855	$38,855	$38,855	-	$10,265	$10,265	$10,265	-
North Glazing	$15,760	$19,218	$19,218	-	$19,218	$19,218	$19,218	-
East Glazing	$15,760	$19,218	$27,166	-	$19,218	$19,218	$19,218	-
South Glazing	$13,742	$17,929	$18,702	-	$19,218	$19,218	$19,218	-
West Glazing	$15,760	$18,702	$18,702	-	$19,218	$19,218	$19,218	-
Total (10 Storey)	$610,209	$750,664	$837,880	-	$768,714	$768,714	$768,714	-
AHU	$276,251	$255,426	$318,131	-	$250,707	$292,487	$397,131	-
Chiller	$121,336	$118,718	$115,700	-	$115,047	$116,435	$114,444	-
Boiler	$16,161	$13,535	$16,372	-	$16,589	$16,661	$21,310	-
Cooling Tower	$34,604	$32,778	$30,719	-	$32,219	$31,927	$30,894	-
Economy Cycle	$53,376	$49,974	$60,217	-	$41,881	$47,486	$61,526	-
CO_2 Sensor	$0	$0	$0	-	$18,350	$18,350	$18,350	-
Heat Exchanger	$0	$0	$0	-	$0	$0	$0	-
Lighting	$171,360	$171,360	$171,360	-	$171,360	$171,360	$171,360	-
Grand Total	$1,322,150	$1,431,310	$1,589,234	-	$1,425,132	$1,473,685	$1,593,994	-

Table 293: Breakdown of construction cost for model 6B (30% WWR).

Climate zone	Zone 1	Zone 2	Zone 3	Zone 4	Zone 1	Zone 2	Zone 3	Zone 4
NCC	NCC2016	NCC2016	NCC2016	NCC2016	NCC2019	NCC2019	NCC2019	NCC2019
North Wall	$1,309	$1,309	$1,309	$1,309	$793	$793	$793	$793
East Wall	$656	$656	$656	$656	$398	$398	$398	$398
South Wall	$1,309	$1,309	$1,309	$1,309	$793	$793	$793	$793
West Wall	$656	$656	$656	$656	$398	$398	$398	$398
Total (3 Storey)	$11,792	$11,792	$11,792	$11,792	$7,143	$7,143	$7,143	$7,143
North Glazing	$13,652	$13,175	$13,175	$13,175	$13,070	$13,070	$13,070	$13,070
East Glazing	$7,556	$6,845	$6,845	$7,317	$6,553	$6,553	$6,553	$6,553
South Glazing	$12,115	$11,905	$11,905	$11,905	$13,070	$13,070	$13,070	$13,070
West Glazing	$6,845	$6,606	$6,606	$6,553	$6,553	$6,553	$6,553	$6,553
Total (3 Storey)	$120,507	$115,591	$115,591	$116,849	$117,737	$117,737	$117,737	$117,737
FCU	$144,448	$131,463	$151,475	$150,510	$145,620	$131,317	$156,100	$165,405
Cooling Tower	$21,117	$18,461	$18,775	$18,276	$22,211	$19,253	$20,500	$20,125
Chiller	$79,339	$67,758	$66,314	$69,015	$83,327	$73,406	$80,420	$79,735
Boiler	$2,102	$8,550	$9,813	$9,970	$5,192	$13,556	$16,515	$17,973
Economy Cycle	$0	$0	$0	$0	$0	$0	$0	$0
CO_2 Sensor	$0	$0	$0	$0	$0	$0	$0	$0
Heat Exchanger	$0	$0	$0	$0	$0	$0	$0	$0
Lighting	$34,272	$34,272	$34,272	$34,272	$34,272	$34,272	$34,272	$34,272
Grand Total	$413,577	$387,887	$408,031	$410,684	$415,502	$396,683	$432,688	$442,391

Table 294: Breakdown of construction cost for model 6B (30% WWR).

Climate zone	Zone 5	Zone 6	Zone 7	Zone 8	Zone 5	Zone 6	Zone 7	Zone 8
NCC	NCC2016	NCC2016	NCC2016	NCC2016	NCC2019	NCC2019	NCC2019	NCC2019
North Wall	$1,309	$1,309	$1,309	-	$793	$793	$793	-
East Wall	$656	$656	$656	-	$398	$398	$398	-
South Wall	$1,309	$1,309	$1,309	-	$793	$793	$793	-
West Wall	$656	$656	$656	-	$398	$398	$398	-
Total (3 Storey)	$11,792	$11,792	$11,792	-	$7,143	$7,143	$7,143	-
North Glazing	$13,175	$13,175	$15,650	-	$13,070	$13,070	$13,070	-
East Glazing	$6,606	$7,607	$7,846	-	$6,553	$6,553	$6,553	-
South Glazing	$11,905	$14,323	$14,323	-	$13,070	$13,070	$13,070	-
West Glazing	$6,553	$7,405	$7,405	-	$6,553	$6,553	$6,553	-
Total (3 Storey)	$114,715	$127,528	$135,671	-	$117,737	$117,737	$117,737	-
FCU	$144,925	$144,360	$149,696	-	$147,180	$159,595	$173,758	-
Cooling Tower	$17,271	$18,048	$16,514	-	$18,359	$19,648	$17,676	-
Chiller	$64,724	$67,776	$64,825	-	$71,017	$76,715	$70,952	-
Boiler	$7,609	$8,434	$10,905	-	$13,077	$14,389	$17,744	-
Economy Cycle	$0	$0	$0	-	$0	$0	$0	-
CO_2 Sensor	$0	$0	$0	-	$0	$0	$11,010	-
Heat Exchanger	$0	$0	$0	-	$0	$0	$0	-
Lighting	$34,272	$34,272	$34,272	-	$34,272	$34,272	$34,272	-
Grand Total	$395,308	$412,210	$423,674	-	$408,784	$429,498	$450,292	-

E.II Façade vs Services Contribution Models

Table 295: Breakdown of construction cost for model 3A (30% WWR).

Climate zone	Zone 2	Zone 5	Zone 6	Zone 2	Zone 5	Zone 6	Zone 2	Zone 5	Zone 6
NCC	NCC2016	NCC2016	NCC2016	Mixed	Mixed	Mixed	NCC2019	NCC2019	NCC2019
North Wall	$1,133	$954	$954	$1,133	$954	$954	$487	$487	$627
East Wall	$1,133	$954	$954	$1,133	$954	$954	$487	$487	$627
South Wall	$1,133	$954	$954	$1,133	$954	$954	$487	$487	$627
West Wall	$1,133	$954	$954	$1,133	$954	$954	$487	$487	$627
Total (10 Storey)	$45,330	$38,146	$38,146	$45,330	$38,146	$38,146	$19,498	$19,498	$25,066
North Glazing	$11,820	$14,413	$14,413	$11,820	$14,413	$14,413	$14,413	$14,413	$14,413
East Glazing	$11,820	$14,413	$14,413	$11,820	$14,413	$14,413	$14,413	$14,413	$14,413
South Glazing	$10,307	$11,820	$13,446	$10,307	$11,820	$13,446	$14,413	$14,413	$14,413
West Glazing	$11,820	$14,413	$14,413	$11,820	$14,413	$14,413	$14,413	$14,413	$14,413
Total (10 Storey)	$457,656	$550,598	$566,866	$457,656	$550,598	$566,866	$576,536	$576,536	$576,536
FCU	$393,629	$356,413	$366,396	$392,539	$418,563	$365,059	$332,190	$365,322	$347,949
Chiller	$124,421	$112,795	$106,328	$128,624	$127,381	$110,204	$117,525	$116,914	$106,801
Boiler	$11,398	$7,644	$9,049	$17,825	$14,473	$9,697	$14,250	$10,612	$9,100
Cooling Tower	$36,180	$30,924	$29,878	$37,685	$36,855	$29,939	$33,411	$32,867	$28,807
Economy Cycle	$0	$0	$0	$0	$0	$0	$0	$0	$0
CO2 Sensor	$0	$0	$0	$0	$0	$0	$0	$0	$0
Heat Exchanger	$0	$0	$0	$0	$15,866	$15,866	$0	$15,866	$15,866
Lighting	$91,392	$91,392	$91,392	$91,392	$91,392	$91,392	$91,392	$91,392	$91,392
Grand Total	$1,160,008	$1,187,913	$1,208,056	$1,171,053	$1,293,275	$1,227,170	$1,184,802	$1,229,007	$1,201,517

Table 296: Breakdown of construction cost for model 9aC (30% WWR).

Climate zone	Zone 2	Zone 5	Zone 6	Zone 2	Zone 5	Zone 6	Zone 2	Zone 5	Zone 6
NCC	NCC2016	NCC2016	NCC2016	Mixed	Mixed	Mixed	NCC2019	NCC2019	NCC2019
North Wall	$7,949	$6,983	$6,983	$7,949	$6,983	$6,983	$6,017	$6,017	$6,017
East Wall	$7,949	$6,983	$6,983	$7,949	$6,983	$6,983	$6,017	$6,017	$6,017
South Wall	$7,949	$6,983	$6,983	$7,949	$6,983	$6,983	$6,017	$6,017	$6,017
West Wall	$7,949	$6,983	$6,983	$7,949	$6,983	$6,983	$6,017	$6,017	$6,017
Total (1 Storey)	$31,797	$27,932	$27,932	$31,797	$27,932	$27,932	$24,066	$24,066	$24,066
North Glazing	$19,699	$19,699	$19,699	$19,699	$19,699	$19,699	$19,699	$19,699	$19,699
East Glazing	$19,699	$19,699	$24,022	$19,699	$19,699	$24,022	$19,699	$19,699	$19,699
South Glazing	$17,178	$17,178	$22,411	$17,178	$17,178	$22,411	$19,699	$19,699	$19,699
West Glazing	$19,699	$19,699	$23,378	$19,699	$19,699	$23,378	$19,699	$19,699	$19,699
Total (1 Storey)	$76,276	$76,276	$89,510	$76,276	$76,276	$89,510	$78,798	$78,798	$78,798
AHU	$37,512	$41,282	$50,336	$44,909	$50,461	$61,730	$45,585	$52,539	$73,061
Chiller	$45,301	$44,910	$46,779	$47,444	$46,437	$49,555	$46,870	$47,647	$52,558
Boiler	$2,972	$2,823	$2,648	$4,887	$4,672	$4,682	$5,082	$4,818	$5,444
Cooling Tower	$11,198	$10,911	$11,221	$12,215	$11,805	$12,411	$12,067	$12,117	$13,155
Economy Cycle	$3,836	$4,044	$5,216	$0	$0	$5,256	$0	$0	$5,828
CO_2 Sensor	$0	$0	$0	$0	$0	$0	$0	$0	$0
Heat Exchanger	$0	$0	$0	$0	$0	$0	$0	$0	$0
Lighting	$18,088	$18,088	$18,088	$18,088	$18,088	$18,088	$18,088	$18,088	$18,088
Grand Total	$226,979	$226,266	$251,730	$235,616	$235,670	$269,163	$230,556	$238,073	$270,998

Table 297: Breakdown of construction cost for model 9bH (30% WWR).

Climate zone	Zone 2	Zone 5	Zone 6	Zone 2	Zone 5	Zone 6	Zone 2	Zone 5	Zone 6
NCC	NCC2016	NCC2016	NCC2016	Mixed	Mixed	Mixed	NCC2019	NCC2019	NCC2019
North Wall	$2,167	$2,167	$2,167	$2,167	$2,167	$2,167	$1,625	$1,625	$1,625
East Wall	$717	$717	$717	$717	$717	$717	$538	$538	$538
South Wall	$2,167	$2,167	$2,167	$2,167	$2,167	$2,167	$1,625	$1,625	$1,625
West Wall	$717	$717	$717	$717	$717	$717	$538	$538	$538
Total (3 Storey)	$17,304	$17,304	$17,304	$17,304	$17,304	$17,304	$12,975	$12,975	$12,975
North Glazing	$22,598	$22,598	$22,598	$22,598	$22,598	$22,598	$22,598	$22,598	$22,598
East Glazing	$7,481	$7,481	$9,122	$7,481	$7,481	$9,122	$7,481	$7,481	$7,481
South Glazing	$19,706	$19,706	$25,709	$19,706	$19,706	$25,709	$22,598	$22,598	$22,598
West Glazing	$7,481	$7,481	$8,878	$7,481	$7,481	$8,878	$7,481	$7,481	$7,481
Total (3 Storey)	$171,796	$171,796	$198,920	$171,796	$171,796	$198,920	$180,474	$180,474	$180,474
AHU	$108,558	$133,257	$147,899	$108,894	$133,418	$148,052	$124,791	$138,512	$157,903
Chiller	$111,403	$88,485	$101,841	$129,717	$104,790	$111,994	$133,336	$112,735	$119,339
Boiler	$13,092	$12,697	$14,141	$20,088	$12,709	$14,130	$23,128	$13,980	$15,741
Cooling Tower	$0	$0	$0	$0	$0	$0	$0	$0	$0
Economy Cycle	$0	$0	$0	$0	$0	$0	$0	$0	$0
CO_2 Sensor	$0	$0	$0	$0	$11,010	$11,010	$0	$11,010	$11,010
Heat Exchanger	$0	$0	$0	$0	$0	$0	$0	$0	$0
Lighting	$53,122	$53,122	$53,122	$53,122	$53,122	$53,122	$53,122	$53,122	$53,122
Grand Total	$475,275	$476,661	$533,227	$500,921	$504,148	$554,532	$527,825	$522,808	$550,563

Table 298: Breakdown of construction cost for model 5A (40% WWR).

Climate zone	Zone 2	Zone 5	Zone 6	Zone 2	Zone 5	Zone 6	Zone 2	Zone 5	Zone 6
NCC	NCC2016	NCC2016	NCC2016	Mixed	Mixed	Mixed	NCC2019	NCC2019	NCC2019
North Wall	$971	$971	$971	$971	$971	$971	$257	$257	$257
East Wall	$971	$971	$971	$971	$971	$971	$257	$257	$257
South Wall	$971	$971	$971	$971	$971	$971	$257	$257	$257
West Wall	$971	$971	$971	$971	$971	$971	$257	$257	$257
Total (10 Storey)	$38,855	$38,855	$38,855	$38,855	$38,855	$38,855	$10,265	$10,265	$10,265
North Glazing	$15,760	$15,760	$19,218	$15,760	$15,760	$19,218	$19,218	$19,218	$19,218
East Glazing	$15,760	$15,760	$19,218	$15,760	$15,760	$19,218	$19,218	$19,218	$19,218
South Glazing	$13,742	$13,742	$17,929	$13,742	$13,742	$17,929	$19,218	$19,218	$19,218
West Glazing	$15,760	$15,760	$18,702	$15,760	$15,760	$18,702	$19,218	$19,218	$19,218
Total (10 Storey)	$610,209	$610,209	$750,664	$610,209	$610,209	$750,664	$768,714	$768,714	$768,714
FCU	$311,709	$276,251	$255,426	$378,567	$335,463	$341,552	$285,567	$250,707	$292,487
Chiller	$122,880	$121,336	$118,718	$126,661	$124,718	$125,916	$118,500	$115,047	$116,435
Boiler	$15,168	$16,161	$13,535	$16,986	$18,075	$18,320	$18,104	$16,589	$16,661
Cooling Tower	$35,740	$34,604	$32,778	$36,937	$35,806	$35,397	$33,770	$32,219	$31,927
Economy Cycle	$59,168	$53,376	$49,974	$-	$53,252	$54,069	$-	$41,881	$47,486
CO2 Sensor	$0	$0	$0	$0	$18,350	$18,350	$0	$18,350	$18,350
Heat Exchanger	$0	$0	$0	$0	$0	$0	$0	$0	$0
Lighting	$171,360	$171,360	$171,360	$171,360	$171,360	$171,360	$171,360	$171,360	$171,360
Grand Total	$1,365,088	$1,322,150	$1,431,310	$1,379,575	$1,406,088	$1,554,483	$1,406,281	$1,425,132	$1,473,685

Table 299: Breakdown of construction cost for model 6B (30% WWR).

Climate zone	Zone 2	Zone 5	Zone 6	Zone 2	Zone 5	Zone 6	Zone 2	Zone 5	Zone 6
NCC	NCC2016	NCC2016	NCC2016	Mixed	Mixed	Mixed	NCC2019	NCC2019	NCC2019
North Wall	$1,309	$1,309	$1,309	$1,309	$1,301	$1,301	$793	$793	$793
East Wall	$656	$656	$656	$656	$652	$652	$398	$398	$398
South Wall	$1,309	$1,309	$1,309	$1,309	$1,301	$1,301	$793	$793	$793
West Wall	$656	$656	$656	$656	$652	$652	$398	$398	$398
Total (3 Storey)	$11,792	$11,792	$11,792	$11,792	$11,716	$11,716	$7,143	$7,143	$7,143
North Glazing	$13,175	$13,175	$13,175	$13,175	$13,175	$13,175	$13,070	$13,070	$13,070
East Glazing	$6,845	$6,606	$7,607	$6,845	$6,606	$7,607	$6,553	$6,553	$6,553
South Glazing	$11,905	$11,905	$14,323	$11,905	$11,905	$14,323	$13,070	$13,070	$13,070
West Glazing	$6,606	$6,553	$7,405	$6,606	$6,553	$7,405	$6,553	$6,553	$6,553
Total (3 Storey)	$115,591	$114,715	$127,528	$115,591	$114,715	$127,528	$117,737	$117,737	$117,737
FCU	$131,463	$144,925	$144,360	$126,635	$142,017	$144,767	$131,317	$147,180	$159,595
Cooling Tower	$18,461	$17,271	$18,048	$18,913	$17,809	$19,016	$19,253	$18,359	$19,648
Chiller	$67,758	$64,724	$67,776	$72,705	$69,027	$74,557	$73,406	$71,017	$76,715
Boiler	$8,550	$7,609	$8,434	$13,141	$11,955	$13,123	$13,556	$13,077	$14,389
Economy Cycle	$0	$0	$0	$0	$0	$0	$0	$0	$0
CO_2 Sensor	$0	$0	$0	$0	$0	$0	$0	$0	$0
Heat Exchanger	$0	$0	$0	$0	$0	$0	$0	$0	$0
Lighting	$34,272	$34,272	$34,272	$34,272	$34,272	$34,272	$34,272	$34,272	$34,272
Grand Total	$387,887	$395,308	$412,210	$393,047	$401,510	$424,980	$396,683	$408,784	$429,498

[i] Note figures are rounded