

Development of a Trade-off Path for HVAC National Energy Code for Buildings 2011 Compliance

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Abstract

In developing the 2011 National Energy Code for Buildings (NECB), the need to simply identify the performance of a proposed heating, ventilating and air-conditioning (HVAC) system relative to a prescriptive building's HVAC system was identified. This paper discusses the development of the trade-off paths for HVAC, and the analysis conducted prior code publication and during the development of an Excel based trade-off path tool. The trade-off path developed, which considered the equipment and controls of the entire systems, allows a mechanical designer to examine a system design and evaluate the overall performance for code compliance.

1 Introduction

Code Development

The Canadian Commission on Building and Fire Codes (CCBFC) develops the National Model Construction Codes through a consensus-based process that relies on the voluntary contributions of public and private sector experts from across Canada. Under the guidance of the CCBFC, nine standing committees review and develop proposed technical changes to the Codes before they are submitted for public review. The changes must then be approved by the CCBFC before publication by the National Research Council of Canada (NRC). (CCC, 2014)

The technical content of the Codes is developed by the standing committees of the CCBFC. Like the Commission, the standing committees consist of volunteers from three sectors (the industry, the regulatory community and general interest groups) and from across the country. These members bring their technical expertise and experience to the code development system. The standing committees make recommendations on the technical content of the codes to the CCBFC and it is the CCBFC that makes the final decision on the content. There are nine standing committees. Typically, the standing committees conduct their work through task groups.

The Standing Committee on Energy Efficiency in Buildings (SCEEB) was established in 2007 to complete the technical update of the 1997 Model National Energy Code for Buildings (MNECB) (CCBFC NRC, 1997). The first meeting was held in December 2007, and the work proceeded on an accelerated basis to produce the 2011 National Energy Code for Buildings (NECB) (CCBFC NRC, National Energy Code for Buildings, 2011). The typical code development cycle is 5 years.

The NECB is enforceable when adopted by provinces and territories. The requirements must be beneficial from a cost and impact analysis, enforceable and constructible.

Being a code, the 2011 NECB differs from an incentive program in that it addresses minimum requirements to be broadly applied for all new construction of buildings covered by Part 3 of the National Building Code (NBC) (CCBFC NRC, National Building Code of Canada, 2010). Labelling or incentive programs may use a code as a benchmark from which to evaluate performance improvements, such as what was done by LEED Canada (Canadian Green Building

Council, 2014) and NRCan's Commercial Buildings Incentive Program (CBIP) (OEE, 2006) with the 1997 MNECB.

Part 5 of the NECB 2011 addresses HVAC systems and is concerned with the HVAC equipment, the controls and components forming part of an HVAC system, and the interfaces between them. The scope of this part includes equipment sizing, equipment efficiency, air distribution systems, fan system design, air intake and outlet dampers, piping insulation, pumping system energy use, temperature control, heat recovery and, shut-off and set-back controls. For the 2011 NECB, the Part 5 technical update work was lead by the Task Group on HVAC and Service Water Heating (TG-HVAC)

NRC's Institute for Research in Construction (NRC-IRC) provides technical, research and administrative support to the CCBFC and its committees, as well as, to the National Model Construction Code Documents development system.

Policy direction of the 2011 NECB

The CCBFC provided policy direction for the 2011 NECB. The policy direction was developed using input from the SCEEB and following consultations with the Provincial/Territorial Policy Advisory Committee on Codes (PTPACC) (NRC, 2014). A notable policy directive from the PTPACC was that the sole objective of the 2011 NECB is energy based (i.e. limiting excessive energy use by a building). By contrast, the NBC has objectives relating to safety, health, accessibility and fire and structural protection of buildings. The NECB addresses excessive use of energy used by the building. It does not codify factors and costs related to energy source and local variations. Some provisions do vary depending on climate zone as determined by heating degree days. (CCBFC NRC C. C., 2013)

The NECB is also in an objective-based format. Code users have the choice of using the "acceptable solutions" prescribed in the codes or demonstrating that a proposed "alternative solution" provides at least an equivalent performance. Converting the 1997 MNECB to an objective-based format has made it more accommodating to innovation by clarifying its scope as well as the intent behind its requirements. Each code provision is now supplemented by clearly stated objectives, functional statements and intents.

Impact for Part 5 HVAC

In the 1997 MNECB, there was no option for HVAC other than prescriptive or full building modeling to demonstrate compliance. In developing the 2011 NECB, the TG-HVAC at their first meeting reviewing the 1997 MNECB and identified a need for a new focus on equipment as part of the HVAC system in the building. The change to objective based requirements, highlighted to the TG-HVAC, the importance of acceptability of the entire system in determining HVAC compliance. At their second meeting, this approach was developed further with the presentation of a possible method for calculating overall systems efficiency, by inputting the individual component efficiencies into a formula with weighting factor for each component. From there the trade-off path was developed to provide an acceptable solution for HVAC which considered the system energy performance. This approach was also applied to the Service Water Heating system of Part 6 but for questions of length is not included in this paper.

Part 5 of the 2011 NECB therefore offers three compliance options within the acceptable solutions. The simple prescriptive path, which is like a recipe for compliance: "To comply with the NECB HVAC requirements, simply do x and y." The trade-off path, which considers HVAC system efficiency as a whole, provides more flexibility than the prescriptive requirements. Use of the trade-off option in Part 5 is restricted to HVAC systems only. No trading is permitted with other building parameters such as lighting or envelope components. To accomplish trading between NECB Parts, the third option – the performance compliance path –

must be used. In the performance path, a whole reference building built according to the prescriptive path requirements is compared to the proposed building built according to the performance path provisions.

This paper describes how the trade-off path was developed from this concept of the TG-HVAC, the validation completed and consideration for incorporation into a code.

2 Methodology

The trade-off path was based on the concept that a system's overall or total efficiency will be dependent on the components used and takes these into consideration. For example, the efficiency of heating ventilation air can be traded against how that air is delivered to a space. Considering the efficiency of the system as a whole within Part 5, rather than of individual components, is a change relative to the 1997 MNECB for HVAC designers. To develop the trade-off path, a review of other strategies was conducted, the prescriptive values were reviewed, the impact of individual components was established and simplifications for incorporation into the code were considered when required.

2.1 Review of other approaches for HVAC

At the time of development there were some examples of European standards moving the direction of system efficiencies such as prEN 15316 for SHW system efficiencies and prEN 15243 for HVAC systems efficiencies. (CEN, 2005) These standards are used in implementing the European Energy Performance for Buildings Directive (EPBD) (European Parliament and of the Council, 2002). However at the time, even draft standards such as prEN 15243 did not prescribe calculation procedures for system efficiencies but only presented possible alternatives. The draft standards offered a good view into the potential complexities of defining global efficiencies for HVAC systems with nearly 40 different mechanisms identified as having an impact on the energy required by a system to meet its load. It also mapped these mechanisms to over 20 different types of HVAC systems. In the UK, implementation of the EPBD does not go through simplified analytical equations for system efficiencies but rather through a simplified simulation tool offering an alternative to a full performance approach (SBEM – Simplified Building Energy Model).

System efficiency for complex HVAC systems is usually not dependent only on its components or controls but also on the loads being served. A clear example of this is a constant air volume (CAV) system serving a constant load: as are observed in internal zones. In such a configuration, this system provides a potentially good performance. However, the same system serving zones with varying loads (internal, external) would offer a potentially poor performance.

2.2 Prescriptive requirements of the 2011 NECB

Since the starting point for the trade-off path was the code prescriptive requirements, establishing the prescriptive requirements for the 2011 NECB was an important step. When a code prescriptive requirement existed, it was envisioned that it would only be a matter of defining the value of the baseline efficiency and producing variations from that value.

In practice, this definition was adapted and some absolute values rather than relative efficiencies were used for simplicity in defining a component. For example, it was determined to be easier and much more natural for a user to define the actual total static pressure of a system rather than enter an artificial efficiency defined as the total static pressure divided by a reference code static pressure.

In other instances, a component might not have any numeric quantification attached to it. In these cases, it was necessary for a scale value to be defined. Most control components fall in

this category. For example, there are no numerical values of efficiencies intrinsically linked to the control logic used for modulating the supply air of a variable air volume (VAV) system. In such instances the average impact of the component for the various locations was obtained and efficiency values defined. From a code user's point of view, lookup tables for defining the value to be used in the calculations are provided.

For minimum equipment efficiencies, the 2011 NECB set the prescriptive value to current practice based on the median of sales information. A review of equipment sales was completed and equipment efficiency at the sales median was determined. In certain cases, such as with cooling equipment, if a technical limitation existed or insufficient Canadian sales information was available, the requirements were set to the level of the Energy Efficiency Act (EE) regulations (NRCan, 2014). The NECB prescriptive requirement is higher than the EE regulations, and implies that, if the simple prescriptive path is used, a design is not considered Code-compliant if it includes equipment with efficiencies below the NECB requirements. The reduction of equipment efficiencies to the minimum level set by the EE regulations would be permitted when using either the full building performance path or the newly created trade-off path which was being developed.

2.3 Method to determine systems and components to be included in the trade-off path

To develop a total system efficiency code compliance path, a survey of the more commonly used HVAC systems and components was conducted. The first attempts were focused on providing a simple and easy to use compliance approach. More complex systems would be investigated if the initial results were favorable or it was deemed required.

Factors that affect system efficiency such as zoning, outdoor air flow and terminal flow are not considered in this approach since there were many variations possible and the path was intended for code compliance. These simplifications are taken with the knowledge that the trade-off path could not be used to estimate absolute energy use. Also, alternative heat sources and non-standard systems would not be permitted to demonstrate compliance with the trade-off path.

To determine systems and components, the approach would focus on using findings from EE4 and eQuest modeling of individual components that were shown to have a significant impact on system efficiency (CANMET, 2013).

A single archetype building was used as a standard in developing an equation that would accurately describe an overall HVAC system efficiency relationship. For systems and components considered, tests were conducted. The equation developed consider each components efficiency in the simulation and relative to the system's overall performance.

To select an archetype building, several methods were considered. The TG-HVAC sought to quantify the relative impact of components efficiencies on the overall system efficiency. Previous work done by United States Department of Energy (US DOE) towards developing representative archetype was deemed to be a valid starting point. (Office of Energy Efficiency and Renewable Energy, 2014)

The medium office building developed by the US DOE was selected as the basis for testing all the systems and components within this project. This building is relatively simple but large enough to reasonably accommodate all of the systems and components found to be potentially relevant from the initial EE4 and eQuest modeling.

In order to determine individual component impact on efficiency, the archetype 'medium office' building was therefore modelled in eQuest. The humidification set point was 25% RH. 30 year CWEC weather files from EE4 were used for simulations at the following 6 locations: Vancouver, Winnipeg, Toronto, Yellowknife, Montreal and Halifax

2.4 Determining Individual Component Impact on Efficiency

A methodology was needed to quantify the impact of each component on the system efficiency. This could have been achieved analytically through the development of relationships between a component energy impact and the overall energy use, or by running a series of simulations and correlating the results. This later option was retained due to the large number of components and their complex interactions making analytical models impractical.

An initial approach to determine individual components' impact on efficiency was based on a reference simulation run for every system type, in every climate zone. Variations on each individual component were then implemented to determine their overall impact. There were 162 reference cases when considering all selected climate zones and HVAC system types. The estimated total number of simulations required to test all possible configurations under all climate zones amounted to approximately 23 000. An automated Excel spreadsheet was developed to compile all the information from the numerous simulations.

Next, a system efficiency equation to map those results into a set of analytical equations was established. These equations predict the system efficiency based solely on the individual efficiencies of the components. The results demonstrated that the changes could not be correlated by a simple polynomial form. Changes in the coefficients showed no identifiable trends and all attempts to use curve fitting algorithms failed.

A second approach was therefore used. Instead of trying to assess the absolute value of the system efficiency, an approach based on relative changes was considered. Under this approach, a reference system efficiency was established using a simulation. Following this, the impact of a change in a specific component efficiency was mapped against the changes in overall system efficiency. Therefore, the resulting equation did not quantify the expected global efficiency based on a complex set of weighting factors but rather focused on the deviation from a given reference efficiency due to changes to individual components.

One major advantage of this modified approach was analysis simplification: a single component is analyzed at a time. For each component, a set of 5 runs, (1 baseline run and 4 variations) were conducted. Relating individual component efficiency to system efficiency was accomplished with an error minimization routine. This task was programmed in spreadsheets used to compile the results. Coefficients for each combination of system and components for each of the 6 climatic locations studied were obtained.

Maintaining the coefficients previously described for each zone would have resulted in 17500 values. To reduce the number of parameters needed and to be published in the code, the system efficiency was analysed with the goal of obtaining a single set of coefficient for a given component regardless of the location. Heating Degree-Days (HDD) and/or the Cooling Degree-Days (CDD) and Total Degree-Days (TDD) for the representative cities from the NBC tables were used. TDDs were used when a component was affected by both HDDs and CDDs and errors were minimized when accounting for both terms simultaneously. Quadratic curve fitting was used. In each case, the curve fitting routine was applied using independently HDD, CDD and TDD. The best fit was selected for each component.

2.5 Translating the impact of individual component efficiency to a system efficiency for code compliance

The methodology presented in Sections 2.3 and 2.4 provided equations relating individual components efficiencies to system efficiency. One more step was required for this information to be useful within the scope of an energy code. The value of a given system efficiency provided a benchmark against which, under standardised conditions, system could be compared to the minimum code requirements. The trade-off path uses a system-to-same-system comparison. Therefore the compliance of a system was assessed by subtracting its efficiency

to that of the reference system. A positive result demonstrates compliance. The resulting equation provided in the NECB is Equation (1): found in Section 3 of this paper. This approach, in which the energy consumption of the proposed system must be less than that of the reference system, is consistent with the full building modeling methodology of Part 8 of the 2011 NECB.

Since neither the MNECB nor the 2011 NECB Part 8 provide credits for changes to scheduling, any components which has its efficiency based on a scheduling parameter was excluded from the trade-off system efficiency approach. Its efficiency was set to identical values for the proposed and reference systems. Specifically the following components are based on scheduling: fan control, heating set point control and cooling set point control. The decision to allow or not to credit for individual components was considered to be coherent with that permitted under an updated performance path of Part 8 the 2011 NECB.

3 Results

Once the methodology was developed and the prescriptive requirements of the 2011 NECB had been submitted for public review, the coefficients for the equation were recalculated based on the final prescriptive requirements of the 2011 NECB.

The trade-off path in the 2011 NECB includes 27 typical system types, such as constant-volume reheat and packaged variable volume. They are listed in Table 1. Depending on the system, up to 32 input parameters can be traded thus allowing small adjustments to the HVAC system to be made without having to complete full building performance path modeling. The components in the 2011 NECB are listed in Table 2 and include heat source generator efficiency, heat-recovery system efficiency, return fan motor efficiency, piping insulation and pressure losses.

The general equation used to determine compliance with the trade-off path is Equation (1). The first summation in the equation characterises the efficiency of the proposed system while the second evaluates the base value from the prescriptive requirements. The α , β and γ are weighting factors whose values for each component and system are listed in look-up tables.

Other look-up tables are provided to help determine which components must be included as part of a particular system type. Although the calculations can be completed by hand, it is likely that a computer spreadsheet will be used.

The trade-off index ($HVAC_{TOI}$) achieved must be greater than 0 in order to demonstrate compliance.

$$HVAC_{TOI} = \sum_{i=1}^{32} (\alpha_i \cdot ToV_i + \beta_i \cdot ToV_i^2) \cdot \gamma_i - \sum_{i=1}^{32} (\alpha_i \cdot BaV_i + \beta_i \cdot BaV_i^2) \cdot \gamma_i \quad (1)$$

Where:

- i = counter for number of components included in proposed *building's* HVAC system,
- α_i = first order weighting factor linking the component efficiency variations of component i to the system efficiency variations determined by referring to tables
- β_i = second order weighting factor linking the component efficiency variations of component i to the system efficiency variations determined by referring to tables
- ToV_i = trade-off value of component i for the proposed *building*: determined by referring to tables
- BaV_i = base value for component i for the reference *building*: determined by referring to tables; and
- γ_i = factor to determine components to be included determined by referring to tables for the given HVAC system.

Table 1: HVAC System Description

HVAC-1 Built-up variable-volume
HVAC-2 Constant-volume reheat
HVAC-3 Packaged single duct – single zone
HVAC-4 Built-up single duct – single zone
HVAC-5 Packaged variable-volume
HVAC-6 Packaged constant-volume with reheat
HVAC-7 Built-up ceiling bypass VAV
HVAC-8 Packaged ceiling bypass VAV
HVAC-9 Powered induction unit
HVAC-10 Built-up multi-zone system
HVAC-11 Packaged multi-zone system
HVAC-12 Constant-volume dual-duct system
HVAC-13 Variable-volume dual-duct system
HVAC-14 Two-pipe fan coil with optional make-up air unit
HVAC-15 Four-pipe fan coil with optional make-up air unit
HVAC-16 Three-pipe fan coil with optional make-up air unit
HVAC-17 Water-loop heat pump with optional make-up air unit
HVAC-18 Ground-source heat pump with optional make-up air unit
HVAC-19 Induction unit – two-pipe
HVAC-20 Induction unit – four-pipe
HVAC-21 Induction unit – three-pipe
HVAC-22 Packaged terminal AC – split
HVAC-23 Radiant (in-floor, ceiling) with optional make-up air unit
HVAC-24 Active chilled beams with optional make-up air unit
HVAC-25 *Unit heater*
HVAC-26 Unit ventilator
HVAC-27 Radiation with optional make-up air unit

Table 2 : Component Trade-off Values, ToV_i, for the Proposed Building

ToV₁ Supply fan mechanical efficiency
ToV₂ Supply motor efficiency
ToV₃ Return fan mechanical efficiency
ToV₄ Return fan motor efficiency
ToV₅ Supply temperature control.
ToV₆ Airflow control efficiency
ToV₇ Supply fan total static pressure
ToV₈ *Supply duct* insulation
ToV₉ Return fan total static pressure
ToV₁₀ Heating coil design temperature drop
ToV₁₁ Baseboard heater design temperature drop
ToV₁₂ *Boiler/furnace*/heat pump heating efficiency
ToV₁₃ Chillers/direct expansion system/heat pump cooling efficiency
ToV₁₄ Rejection fan input power ratio
ToV₁₅ Cooling by direct use of outdoor air (air economizer)
ToV₁₆ Outdoor airflow control
ToV₁₇ Exhaust air heat-recovery efficiency
ToV₁₈ Cooling by indirect use of outdoor air (water economizer)
ToV₁₉ Piping insulation – hot water
ToV₂₀ Piping insulation – chilled water
ToV₂₁ Piping pressure losses – hot water
ToV₂₂ Piping pressure losses – chilled water
ToV₂₃ Pump mechanical efficiency – hot water
ToV₂₄ Pump mechanical efficiency – chilled water
ToV₂₅ Pump motor efficiency – hot water
ToV₂₆ Pump motor efficiency – chilled water
ToV₂₇ Hot water pump control
ToV₂₈ Chilled water pump control
ToV₂₉ Hot water loop temperature control
ToV₃₀ Chilled water loop temperature control
ToV₃₁ Hot water flow control
ToV₃₂ Chilled water flow control

4 Discussion and Analysis

The following section details three types of analysis completed for the trade-off path. The first is a peer review of the coefficients prior to publication of the 2011 NECB. The second is a supplementary analysis completed for a proposed publication of the 2015 NECB. The third consists of findings from on-going work in developing a macro-enabled Excel tool to assist in demonstrating compliance through the trade-off path.

The values predicted by the trade-off path were verified for range by comparing to a minimum Part 5 HVAC prescriptive compliant system.

Many energy modelers and mechanical engineers provided comments throughout the validation process. The TG-HVAC and SCEEB members were most active but feedback was also provided by interested individuals. This participation was facilitated through meetings or specific analysis as noted below.

4.1 Analysis prior to code publication

Enermodal Engineering performed a peer-review of the coefficients prior to code publication. The variables, along with a corresponding list of coefficients, were supplied. The impact on system efficiency of changing each trade-off variable from a base (reference) value was examined to determine for trending in the proper direction. Each system and variable was tested for the Toronto region. An improvement over the reference BaV_i (such as increasing motor efficiency) would theoretically produce a positive trade-off index, and the opposite was expected for making a variable worse than the BaV_i .

The results showed the trade-off variables were generally working as intended. However certain changes were recommended. Lowering the temperature difference of reheat coils resulted in a 1×10^{-4} increase in efficiency and therefore this temperature difference was removed from the list of variables that could be traded off. Similarly, removal of cold thermal storage showed an increase in system efficiency. Since cold thermal storage is not a common feature in buildings it was also removed from the trade-off path.

Originally, increasing the baseboard temperature drop from 20°F to 30°F lowered the system efficiency. This effect was not the anticipated result as a higher temperature difference typically indicates more effective heat transfer and less pumping when a lower flow rate is required. Furthermore, going to a higher temperature drop meant the boiler would operate at higher part load for shorter periods. The older part-load curve of DOE2 could also have been a factor. Operating at higher part load usually equates to higher efficiency for regular efficiency boilers. A new set of polynomial coefficients were developed with a narrower range based on 20°F. Similarly increasing the heating coil design temperature drop of a unit ventilator system lowered the system efficiency. A new set of polynomial coefficients were developed based on 20°F, rather than on the original 40°F.

The behaviour of two values were found to produce results consistent with modeling software but not desired for the simplified approach of the trade-off path. Namely, increasing the pump mechanical efficiency in an induction unit (two pipe) system resulted in lowered system efficiency. The behaviour was determined to be reflective of the whole building modeling results¹. To encourage the use of higher efficiency pumps, new coefficients were developed which took advantage of the decreased electrical pumping energy, while decreasing the effect of the increased heating energy. The result was more representative of current design

¹ Higher mechanical efficiency means there is more waste heat going from the pump into the building, causing the boiler to run less than it would if the pump had a higher efficiency. Since the boiler used in the models is regular, non-condensing, 80% efficient boiler the interactive effect between waste heat generation, and boiler operation was amplified.

practices, where boilers tend to have a higher efficiency, and where interactive effects between pump heat loss and increased boiler load would be minimal. Similarly, decreasing the piping pressure losses lowered the system efficiency.² To encourage the design of more efficient piping systems, new coefficients were developed.

The remaining components and systems included in the trade-off path are presented in Tables 1 and 2.

4.2 Additional analysis for the proposed 2015 code

As code requirements change, the trade-off path needs to reflect these changes. For the 2015 edition of the Code, a number of changes were proposed to the piping and duct requirements in Part 5 (HVAC) by the Task Group on Piping and Duct Insulation. Modifications were made to the thickness requirements to align the latest version of the NECB with the requirements of ASHRAE 90.1-2010. (ASHRAE, 2010) These changes were submitted for public review in the fall of 2013.

The TG-HVAC of the 2011 code made a comprehensive review of the HVAC equipment efficiency (Table 5.2.12.1). Where the efficiency of equipment covered by the Energy Efficiency (EE) Regulations had surpassed those of the NECB, the Code requirements were aligned with those of the EE regulation. It was proposed that Part 5 of the 2015 edition of the NECB have the following new requirements: heating efficiency for packaged rooftop units (RTUs), maximum pumping allowances for hydronic system pumps, and performance requirements for heat rejection equipment (chillers).

The concept of the Trade of Path (TOP) is unchanged from the 2011 edition of the Code. It is based on the overall systems efficiency of 27 HVAC systems. If a system is not listed in the Code, compliance cannot be demonstrated using the trade-off path.

4.3 Analysis during tool development

An Excel macro enable tool is under development by NRCan to ease demonstration of compliance with the Part 5 trade-off path.

5 Conclusions

A 'system' approach to HVAC was developed and included in the 2011 NECB as Sub-section 5.3. The trade-off path for HVAC was entirely new relative to the 1997 MNECB. The approach recognizes the relationship between individual components of an HVAC system and overall performance of the entire system. It also allows evaluation of compliance without full building envelope or lighting design information. With a system approach the 2011 NECB therefore had three compliance paths for HVAC: a prescriptive path, a trade-off path that allows for trade-off of individual parts, and a performance path. This permits greater design flexibility for the mechanical designer to demonstrate compliance within the acceptable solutions.

Given the complexity of predicting energy use, the trade-off path in its current form should be considered as it was intended: as a compliance mechanism, rather than an energy assessment method. The pass/fail provided by the index is relative to the minimum acceptable HVAC system permitted by the code's prescriptive requirements. The validation process

² A lower pressure loss allows less pumping energy to be used to move the same volume however the results were representative of building modeling software output. Higher pressure losses means there is more waste heat going into the building, causing the boiler to run less than it would if the losses were lower. Since the boiler used in the models is regular, non-condensing, 80% efficient boiler, the interactive effect between waste heat, and boiler operation was amplified.

of the trade-off path coefficients isolated modeling result of individual components in an HVAC system. The effect of individual components less significant in a whole building simulation but were highlighted when the HVAC system alone was analyzed. Notably, the authors find interesting how certain variables produced results were expected by some energy modellers and mechanical engineers involved but not others. Future work may examine the proper balance between ease of compliance, adaptability of code provisions to technology changes and the level of details needed.

Agreement throughout discussions was that not considering the inter-relationship of elements of an HVAC system can lead to a poor energy performance. Given the purpose of the NECB to reduce excessive use of energy of buildings by providing a minimum performance level, the trade-off path is deemed useful in facilitating that determination.

6 Nomenclature

HVAC – Heating, Ventilating and Air-Conditioning

MNECB – Model National Energy Code for Buildings

NECB – National Energy Code for Buildings

SCEEB – Standing Committee on Energy Efficiency in Buildings

TG – Task Group

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