Developing and Implementing an Energy Code with 20% Energy Savings Compared to ASHRAE/IESNA Standard 90.1

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ABSTRACT

In February 2001 the Seattle City Council passed Resolution 30280 directing the Seattle Department of Planning and Development (DPD, Seattle's Building Department) and Seattle City Light (the public utility) to propose Seattle Energy Code amendments to achieve a 20% improvement in energy efficiency for nonresidential buildings compared to ASHRAE/IESNA Standard 90.1. The Resolution 30280 goal is consistent with other city and national initiatives, as Seattle's Green Building Policy requires that all city buildings over 5,000 ft^2 achieve a 20% improvement in energy efficiency and the goal for the next edition of the national standard is also to increase energy efficiency by 20%.

The Seattle Energy Code achieves increases in energy efficiency compared to Standard 90.1 in the areas of building envelope, mechanical systems, and lighting.

This paper will provide an overview of the adoption process, list the Seattle Energy Code requirements, compare them with ASHRAE/IESNA Standard 90.1, summarize the energy savings estimates, and describe implementation.

INTRODUCTION

The City of Seattle has been recognized for its leadership in the adoption and enforcement of energy codes. While the first comprehensive Seattle Energy Code took effect in February 1980 (Seattle 1980), Seattle has had residential insulation requirements since 1974 (Seattle 1974) and the first furnace sizing and duct insulation requirements took effect in 1927 (Seattle 1927). Soon after ASHRAE Standard 90-75 (ASHRAE 1975) was published, the City of Seattle passed Resolution 25257 (Seattle 1976) indicating the city's intent to adopt that standard, subject to revisions. During review of Standard 90-75 by a task force of citizens from the building-related professions, additional energy savings improvements were identified for new construction and there was a recognition that it was essential to have energy-efficiency requirements for alterations to existing buildings. As a result, the 1980 Seattle Energy Code (Seattle 1980) contained building envelope requirements, mechanical system criteria, and lighting power allowances and control requirements that achieved significant energy savings relative to Standard 90-75. Thus, the city and its design professionals learned that ASHRAE Standard 90, while an important baseline, was really only a starting point, that energy codes for building construction could achieve greater energy savings across all construction sectors, including both new construction and alterations to existing buildings.

During the process of making subsequent updates to the Seattle Energy Code in 1984, 1986, 1991, 1994, and 1997, Seattle reviewed the latest versions of Standard 90 (ASHRAE 1980, 1989) and consistently found opportunities to achieve greater energy savings. As a result, in 2001, the city adopted a policy that set goals for future versions of the Seattle Energy Code that, while using Standard 90 as a baseline, recognized the opportunities for greater energy savings.

Resolution 30280 (Seattle 2001a) directed the Seattle Department of Planning and Development (DPD, formerly the Department of Design, Construction and Land Use—DCLU) to include in its review of energy code amendments:

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> options for amending the Seattle Energy Code to achieve energy savings up to 20% beyond the current… ASHRAE/IESNA Standard 90.1, Energy Standard for Buildings Except Low-Rise Residential Buildings. [DPD] shall report to City Council on proposed Energy Code amendments by July 1, 2001, including an analysis of the potential for reduction in total nonresidential building energy consumption if such code amendments are adopted. [DPD] and SCL will propose to the City Council similar options for amendments to the Seattle Energy Code every three years, based on the schedule for amendments to the Washington State Energy Code. These proposed amendments should seek to achieve up to 20% enhanced energy efficiency beyond the current version of ASHRAE/IESNA Standard 90.1.

Note that this language specifically states that calculations are to be done on the basis of "total nonresidential building energy consumption." In addition, the resolution directs DPD to provide amendments for 20% energy savings relative to Standard 90.1 for all future Seattle Energy Code updates.

CODE DEVELOPMENT AND ADOPTION

As happens with each Seattle Energy Code update cycle, staff from Seattle DPD and Seattle City Light (the public utility) reviewed requirements in other energy codes, such as Oregon and California and the International Code Council's (ICC) International Energy Conservation Code (IECC), and reviewed draft addenda being considered by the Standard 90.1 update committee, SSPC 90.1.

In addition, city staff also believed that standard practice in Seattle was more advanced than the codes recognized. Consequently, Seattle City Light hired a consultant to survey buildings recently constructed and occupied in Seattle.

Survey of Energy Efficiency in Seattle's New Nonresidential Buildings: 1995-2000

The "Survey of Energy Efficiency in Seattle's New Nonresidential Buildings: 1995-2000" (Kennedy and Baylon 2001) reviewed a total of 57 projects with the focus on office, retail (including grocery), schools, and laboratory. A total of 300,000 m^2 (3.2 million ft^2) of floor space was examined, representing approximately 30% of the new construction valuation for the time period studied. This included 150,000 m^2 (1.6 million ft^2) of office, 70,000 m^2 (750,000 ft^2) of retail, and 35,000 m^2 (400,000 ft^2) of institutional space. In addition, 140,000 m^2 (1.5 million ft^2) of parking garage associated with the sample projects was examined.

Key findings from the survey were:

1. For HVAC, the predominant system type was variable air volume systems with series fan-powered boxes and electric reheat. Fifty-eight percent of the nonresidential floor area was electrically heated through the use of electric coils in VAV systems. The use of series fan-powered boxes was a major difference from Seattle buildings of ten years earlier when most of the fan-powered boxes used fans in parallel, rather than in series. This was a large step backward in energy efficiency for the sake of perceived occupant comfort.
2. For lighting, T8 and CFL fluorescent fixtures with electronic ballasts were the norm. Overall lighting power densities were 10.7 W/m^2 (0.99 W/ft^2) for offices and 12.7 W/m^2 (1.18 W/ft^2) for schools. The supplemental installed task lighting averaged across the entire sample of buildings was 0.43 W/m^2 (0.04 W/ft^2) and only half of that was actually on during the on-site audits.
3. For the building envelope, 80% of all fenestration had glass with low-emissivity coatings.

Thus, the survey verified greater efficiency in standard practice than had been required by the code.

The contract also asked the consultant to recommend improvements for the Seattle Energy Code. These recommendations included:

1. For HVAC and building envelope, require buildings with electric reheat VAV systems to have building envelopes conforming with the requirements for electrically heated buildings (more stringent).
2. For HVAC, require series fan-powered boxes to have efficient fan motors.
3. For lighting, revise the lighting power allowances.
4. For lighting, require occupancy sensor lighting controls in all closed office spaces.
5. For the building envelope, require low-E coatings on all fenestration products.
6. Also, energy-efficient transformers should be added to the scope of the energy code. EPA Energy Star transformers should be required.

Public Review Process

All versions of the Seattle Energy Code have been developed with public review. This allows the city to benefit from the experience of the private sector and helps to minimize implementation issues. The process works both formally and informally.

For the formal component, the City of Seattle has an officially appointed public advisory group, the Construction Codes Advisory Board (CCAB), that reviews all proposed revisions to the city's construction codes and makes recommendations to DPD. CCAB consists of designers, engineers, contractors, labor, and public interest representatives who are recommended by the mayor and approved by the City Council. For the informal component, DPD uses its newsletter, mailings, and e-mailings to announce public briefings and to solicit comments.

For this update, DPD and Seattle City Light staff briefed CCAB on the goals for this cycle and ideas being considered. This was done several months in advance of distributing a draft with specific code language proposals. DPD then published a first draft of Seattle amendments that was announced in a mailing to DPD's energy code mailing list and to the Seattle Energy

Code e-mail list. A second draft was announced in the same manner.

DPD conducted 22 weekly meetings for the general public over a six-month period to review the proposals and to provide an opportunity for public comment and recommendations for refinement. The schedule for the meetings, agendas, and supplemental material for the meetings were posted on the Seattle Energy Code Web site. In addition, DPD provided several briefings each for local professional organizations including the Seattle Chapter AIA Environment/Energy Committee and Codes & Environment Task Force, the Puget Sound ASHRAE TEGA Committee, BOMA of Seattle and King County, and the Electric League of the Pacific Northwest. DPD staff also participated in a series of informational meetings and roundtable discussion for architects, developers, and building owners.

All of these meetings were considered informal. Designers, contractors, and other experts in various specialities (e.g., building envelope, mechanical, lighting) attended the particular meetings that addressed areas of the code with which they were most familiar and in which they were most interested. The DPD Energy Code staff moderated the discussion, leading the group through the various proposals and soliciting comments and suggestions. The format was to use an LCD projector to show the proposals and then, as appropriate, use the track-changes mode to show specific wording suggestions or to list questions or issues to follow up on later. For some comments/suggestions, there might be general support. For other comments, there might only be one individual holding that position. DPD staff would then meet to decide later whether to make revisions or to stick with the initial code language proposals and develop supporting material to respond to questions raised. While there were no formal votes, the sessions were usually attended by several CCAB members. DPD staff would later rely on the CCAB attendees to convey their sense of whether issues had been addressed or if there were still outstanding concerns.

Through the course of the general public meetings, DPD staff refined the package of proposals. The formal review began when these refined proposals were presented to CCAB. Notwithstanding the fact that there had been 22 general public meetings, CCAB spent five meetings doing an additional detailed review of each of the proposals. CCAB members who had participated in the informal public review meetings reviewed the discussion at those meetings and offered their thoughts on the topic areas. While a variety of opinions were expressed during the review, the CCAB recommendations were unanimous and identical to city staff recommendations in all but two cases. City staff considered the CCAB recommendations and published city staff recommendations for a public forum. The two-hour general session included opening comments from several City Council members, as well as from Seattle City Light and DPD, followed by a summary of the proposals and public comments. Later, individual hour-long technical discussions addressed the building envelope, mechanical systems, and lighting.

After the mayor forwarded an ordinance to the City Council, the Seattle City Council Energy and Environmental Policy Committee held three public hearings prior to adoption. For implementation, there was a six-month grace period (longer than normal due to the extent of the revisions) where applicants were allowed to use either the new code or the previous code.

KEY MEASURES IN THE 2001 SEATTLE ENERGY CODE

The 2001 Seattle Energy Code requirements (Seattle 2001b) are generally more stringent across the board. Not all of the measures are modeled in the USDOE procedure. The following paragraphs note key differences, including features modeled in the energy-savings analysis. For a more detailed summary, see Appendix A.

Building Envelope

The Seattle Energy Code requirements are generally more stringent across the board. Following the lead of the Washington State Energy Code, the Seattle Energy Code has more stringent requirements for nonresidential spaces with electric resistance space heat. The Seattle Energy Code also has more stringent requirements for semiheated spaces. The requirements for spaces with gas space heat are used here for the purposes of comparison:

1. Roof U-factor (roofs with insulation above deck):

   U-0.360 or R-2.6 ci (U-0.063 or R-15 ci) for Standard 90.1;
   U-0.284 or R-3.7 (U-0.050 or R-21 continuous insulation) for the 2001 Seattle Energy Code.

2. Wall U-factor (metal frame walls):

   U-0.705 or R-2.3 (U-0.124 or R-13) for Standard 90.1;
   U-0.477 or R-2.3 + R-0.7 ci (U-0.084 or R-13 cavity insulation plus R-3.8 continuous insulation over the metal studs to minimize thermal bridging) for the 2001 Seattle Energy Code.

3. Fenestration U-factor (fixed windows, fenestration area 30%-50% of the gross wall area):

   U-2.61/2.67 (U-0.57/0.46) for Standard 90.1;
   U-2.56/2.27 (U-0.45/0.40, double-glazing with a very good low-emissivity coating and a frame with a thermal break) for the 2001 Seattle Energy Code.

4. Fenestration SHGC (fenestration area 30%-50% of the gross wall area):

   0.39/0.26 for Standard 90.1; 0.40/0.35 for the 2001 Seattle Energy Code.

Mechanical Systems

Mechanical requirements fall into two general categories: equipment efficiency requirements and system requirements.

The Seattle Energy Code requirements for equipment efficiency are generally identical to Standard 90.1; the most significant improvements are in the systems area. Key requirements in the Seattle Energy Code:

1. Higher efficiencies for some water-cooled water chillers.
2. Air economizer for smaller units, as low as 6 kW (20,000 Btu/h).
3. Economizer for computer server rooms, electronic equipment, radio equipment, telephone switchgear.
4. Electrically commutated motors in variable air volume systems with series-type fan-powered terminal units.
5. Variable frequency drive for motors over 7.5 kW (10 hp).
6. Automatic controls, both CO sensors *and* either timeclock or occupancy sensor, for parking garage ventilation systems over 15,000 L/s (30,000 cfm).
7. Higher R-value duct insulation.
8. Commissioning as a condition for receiving a certificate of occupancy for the building.

Lighting and Electrical Systems

Lighting requirements also fall into two general categories: installed lighting wattage and lighting controls. The Seattle Energy Code requirements achieve significant energy savings in both areas. The Seattle Energy Code also contains requirements for transformer efficiency. Key requirements in the Seattle Energy Code:

1. Occupancy sensors: none for Standard 90.1; small offices and classrooms for the 2001 Seattle Energy Code.
2. Automatic control of electric lighting in daylight zones: none for Standard 90.1; required for the 2001 Seattle Energy Code.
3. Office lighting W/m^2 (W/ft^2): 14 (1.30) for Standard 90.1; 11/13 (1.00/1.20) for the 2001 Seattle Energy Code.
4. School lighting W/m^2 (W/ft^2): 16 (1.50) for Standard 90.1; 13 (1.20) for the 2001 Seattle Energy Code.
5. Parking garage lighting W/m^2 (W/ft^2): 3 (0.30) for Standard 90.1; 2 (0.20) for the 2001 Seattle Energy Code.
6. Transformer efficiency: none for Standard 90.1; NEMA TP-1 for the 2001 Seattle Energy Code.

Other Opportunities

Seattle continues to look at other opportunities to improve the minimum level of energy efficiency in building construction. Other efficiency measures under consideration for the Seattle Energy Code include:

1. Increased insulation requirements for semiheated spaces.
2. Requirement for demand ventilation controls.
3. Elimination of the waterside economizer option.
4. Capability for partial reduction in exterior lighting.
5. More efficient lighting for other uses.

COMPARISON OF ASHRAE/IESNA STANDARD 90.1-1999 AND THE SEATTLE ENERGY CODE

The U.S. Energy Conservation and Production Act EPAct 1992) provides that whenever ASHRAE/IESNA Standard 90.1 is revised, the U.S. Department of Energy (USDOE) must determine whether the new version saves energy compared to the previous version. The evaluation of the 1999 version was done for the USDOE by the Battelle Pacific Northwest National Laboratory (PNNL). The PNNL analysis was based on seven building types (office, mercantile and service, education, lodging, public assembly, food service, and warehouse and storage) in eleven climates (Seattle as well as Denver, Detroit, Fresno, Knoxville, Los Angeles, Minneapolis, Orlando, Phoenix, Providence, Shreveport, and Tampa) and was done using the BLAST hourly annual energy analysis program. In general, all measures were analyzed as a package for each of the above seven building types; however, separate analyses were done for electric and gas fuels for the space heating system, and separate analyses were done with and without economizer for the space cooling system. The evaluation did not include energy use by elevators, parking garage lighting and ventilation, and exterior façade lighting. For a summary and more details of that national analysis, see http://www.energycodes.gov/implement/determinations_com.stm.

As Seattle was used in the USDOE study, the City of Seattle inquired as to whether it was possible to expand the analysis to consider another Seattle variant. Rather than developing an entire new approach, the City of Seattle worked with PNNL staff on inputs for this additional Seattle option. Using the same methodology employed by the U.S. Department of Energy (USDOE) to evaluate Standard 90.1 under EPAct, the Seattle Energy Code was compared to Standard 90.1-1999 (ASHRAE 1999). The energy-savings calculations were expanded beyond the USDOE analysis to include all of the energy consumption in the building. In particular, estimates were developed for associated energy consumption for elevators, parking garage ventilation, parking garage lighting, surface parking lighting, and perimeter/façade lighting so as to provide a more complete picture of the impacts.

Due to previous updates, it was estimated that the Seattle Energy Code already achieved roughly a 10% improvement in energy efficiency relative to Standard 90.1-1999 (ASHRAE 1999). Consequently, the goal in Resolution 30280 (Seattle 2001a) amounted to a 10% improvement over the Seattle Energy Code in effect.

IMPLEMENTATION

Training

Soon after adoption, DPD used its newsletter, mailings, and e-mailings to announce the revisions to the Seattle Energy Code. Publications and compliance forms were revised. Prior to the effective date, the Seattle Energy Code Web site was updated to reflect the new code language.

While representatives of many organizations may have been involved in the code development process, it is essential that training be done to reach the broadest audience. The goal of this training is to achieve the desired energy savings while minimizing the impact on designers and contractors as well as city building department staff.

Training design professionals should result in modifications of standard specifications so that the initial applications that they submit will more closely correspond with the code requirements and require fewer revisions prior to building permit issuance. This will save time for both designers and city building department plan review staff as correction lists should be shorter.

Training manufacturer's representatives and contractors should result in the initial construction being more code-compliant and require fewer revisions prior to certificate of occupancy issuance. This will save time for both designers and city building department inspection staff as correction lists should be shorter and extra inspections minimized.

DPD arranged and conducted initial training for the Seattle Chapter of AIA, the Puget Sound Chapter of ASHRAE, and Puget Sound IESNA within a month of adoption. Training for each group was tailored to their areas of responsibility. For example, the training for architects focused primarily on the building envelope requirements, with an overview of the mechanical and lighting requirements. As revisions to fenestration criteria were an important feature of this update, the architect training included a detailed review of the National Fenestration Rating Council (NFRC) rating and certification procedures. The NFRC Label Certificate procedure for curtainwalls was discussed, with references made to the NFRC Web site at http://www.nfrc.org/ for more information.

The training for mechanical engineers focused on the mechanical requirements but also included a review of the calculation procedures for building envelope trade-offs, as the mechanical engineer often performs these calculations for the designer if the prescriptive compliance option is not used. Seattle developed a variation of the ASHRAE EnvStd software that reflected the prescriptive building envelope requirements in the Seattle Energy Code. An overview of the Seattle EnvStd software was given in the general training. In addition, a separate training session was given solely on Seattle EnvStd software and references made to the Seattle Energy Code homepage at http://www.seattle.gov/dpd/energy where this software could be downloaded for free. In addition, DPD updated the Director's Rule containing the computer modeling requirements for those wishing to use the annual energy analysis option for code compliance. The baseline training for mechanical engineers included a review of key assumptions in the modeling and reference was made to the Seattle DPD Web page at http://www.ci.seattle.wa.us/dclu/codes/dr/dr2002-11.pdf where publications and forms could be downloaded for free.

The training for lighting and electrical designers and contractors focused on the requirements for lighting and transformers. The training included important features, such as requirements for more efficient lamps and ballasts and for occupancy sensors and automatic control of lighting in the daylight zone. When lighting designers and contractors requested more detailed guidance on the requirements for automatic control of lighting in the daylight zone, DPD developed and published a Director's Rule and provided training with references made to the Seattle DPD Web page at http://www.ci.seattle.wa.us/dclu/codes/dr/dr2003-2.pdf where the publication could be downloaded for free.

Plan Review

Though training is very important, it is not wise to rely on training alone to achieve energy code compliance. Another key component of successful implementation is plan review prior to permit issuance.

Seattle's experience with the first comprehensive energy code left a strong impression. For the first six months, while energy code staff were being hired, the City of Seattle accepted architects' and engineers' stamps in lieu of doing plan review. After energy code staff were hired, inevitably some plans that had previously been approved for permit were returned for revisions. When energy code staff reviewed those plans, they found many instances of noncompliance.

This is *not* to say that the designers were consciously cheating. Most likely there was a lack of knowledge and designers simply followed the same techniques that they had used in previous projects. There will always be a large segment of the design community that does not attend the training. For example, while 50 members of the Seattle Chapter of the AIA attended training sessions on the Seattle Energy Code revisions, the Seattle Chapter has over 1,000 members. Consequently, only 5% of the local AIA members attended one of the training sessions. In addition, designers have many codes that they must keep up with, from land use and zoning through to building, mechanical, boiler, plumbing, electrical, and elevator.

Consequently, the City of Seattle specifically reviews plans before issuing construction permits. Four staff members solely perform review of the energy code and mechanical code for nonresidential buildings and for multifamily residential buildings. (Energy code review for single-family projects is handled by the building code plan reviewers.) Given the widespread use of electronic documents, it is especially important to perform detailed plan review during the first six months to one year of a new or revised energy code. Plan reviewers must conscientiously send out correction lists to make sure that the architects' and engineers' standard notes get updated. This includes everything from maximum window U-factors and solar heat gain coefficient to minimum insulation R-values, from minimum mechanical equipment efficiencies to economizers on small units and electronically commutated motors in fan terminal units, and from maximum installed lighting wattages to occupancy sensors and automatic controls for dimming of electric lights in daylighting zones.

There are several benefits from this thoroughness. First of all, it should make the plan reviewers work easier in the future—once a designer has updated his or her standard notes, this issue should not come up again until the next code cycle. Second, if the correct information is on the permit drawings, then those bidding on the project will have a contractual as well as a legal responsibility to comply with the code. The architect and engineer thus also assume more of a role for enforcing the code requirements as they are now in the bid package. Third, the designers are more likely to make a good faith effort to comply with the energy code as they see that everyone is being checked. Now designers have clear incentive to comply with the energy code, knowing that if they don't they will receive a correction list and it will take longer for the permit to be issued for their project. Finally, by getting things right on the drawings, the plan reviewers will make life a lot easier for the inspectors who come later. It is *much* easier to change a note on a drawing with a window U-factor or equipment efficiency than it is to take out a piece of equipment once it has been installed.

Inspection

While training and plan review guide the project in the right direction, they clearly do not eliminate the need for field inspection. Similarly to the designers before them, the contractors may simply wish to construct a new project the same way as they did the last project. In addition, anyone familiar with the construction process knows that the project continues to evolve until it is completed. While all of the earlier efforts should limit problems coming up in the field, there will always be multiple requests for change orders. Sometimes these change orders are due to issues that were not addressed in the design. However, the contractor also has an incentive here to find a lower-cost means of completing the project. Not all of the field alternates will have equivalent energy efficiency.

Consequently, the City of Seattle performs field inspections for energy code compliance prior to issuing certificates of occupancy. There are nine building inspection districts where staff inspect for compliance with the energy code building envelope requirements as well as other building code requirements. There are four mechanical inspectors who inspect for compliance with the energy code building envelope requirements as well as other mechanical code requirements. There are nine electrical inspection districts where staff inspect for compliance with the energy code lighting requirements as well as other electrical code requirements. In addition, boiler inspectors check boiler efficiencies, plumbing inspectors check water heater efficiencies and pipe insulation, and elevator inspectors check motor efficiencies. On the inspection side, the challenges are greater when some installed feature does not comply with the code. In some cases, the contractor may be able to make an improvement somewhere else to compensate. However, Seattle has required that contractors remove single-glazed windows in retail storefronts and remove non-complying mechanical equipment.

Here again, there are benefits to this thoroughness. First of all, it should make the inspector's work easier in the future—once a contractor has had to make a change, this issue should not come up again until the next code cycle. Second, the contractors are more likely to make a good faith effort to comply with the energy code as they see that everyone is being checked. Now the designer has a clear incentive to comply with the energy code, knowing that if they don't they may be required to remove some component that they have already installed.

CONCLUSIONS

It IS possible for an energy code to achieve significant energy savings over ASHRAE/IESNA Standard 90.1.

Advanced energy code development is most successful when there is clear policy direction from the mayor and City Council and when there is a public review with participation by designers, engineers, contractors, labor, and public interest representatives.

It is important that training for both city staff and building permit applicants occur both prior to initial implementation and within six months of the effective date (when more designers and contractors are aware that there has been a code change).

Plan review prior to building permit issuance and on-site inspection prior to certificate of occupancy issuance are essential to create a level playing field and to achieve the desired energy savings.

Comparisons with ASHRAE/IESNA Standard 90.1-1999 should be done on an entire building basis, including all the energy consumption in the building so as to not mislead designers, contractors, owners, and developers of public policy on the likely energy savings.

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EPAct. 1992. Section 304 of the Energy Policy and Conservation Act (EPCA, Public Law 94-163), as amended by the Energy Policy Act of 1992 (EPACT, Public Law 102-486).

Kennedy, M., and D. Baylon. 2001. Survey of Energy Efficiency in Seattle's New Nonresidential Buildings: 1995-2000.

Seattle. 1927. Ordinance 52113, regulating the construction, installation, and maintenance of warm air heating furnaces.

Seattle. 1974. Ordinance 103985, amending the Building Code to prescribe standards for thermal insulation in residential buildings.

Seattle. 1976. Resolution 25257, declaring the intent of the City Council and Mayor to adopt ASHRAE Standard 90-75, subject to revisions proposed by the Mayor.

Seattle. 1980. Ordinance 108500, adopting the February 1980 Seattle Energy Code.

Seattle. 2001a. Resolution 30280, calling for acceleration of Seattle's Green Building program.

Seattle. 2001b. Ordinance 120525, adopting the 2001 Seattle Energy Code.

APPENDIX A
COMPARISON OF ASHRAE/IESNA STANDARD 90.1-1999 AND THE SEATTLE ENERGY CODE

Note that the requirements in ASHRAE/IESNA Standard 90.1-2001 (ASHRAE 2001) are very similar to those in Standard 90.1-1999 (ASHRAE 1999). While there were 34 addenda incorporated into the 2001 version, most of these were clarifications. In fact, Standard 90.1-2001 is actually slightly less stringent than Standard 90.1-1999 overall, primarily due to the facts that 90.1-2001 no longer has any requirements for the control of parking garage ventilation systems (former Section 6.2.3.5), now has less stringent requirements for slab insulation in colder climates (Tables B-19 to B-26), now allows vane axial fans with variable pitch blades in lieu of variable frequency drive (Section 6.3.3.2.1), and now allows the use of water-side economizer instead of the more efficient air-side economizer as the base case for trade-offs using the Energy Cost Budget compliance option (11.4.3(e)).

(Note that this summary is brief and thus may not include all of the nuances of a particular requirement. This summary does not supersede the actual requirement.)

The following information was current at the time of publication. For information on the Seattle Energy Code, see the Seattle Energy Code Web site at http://www. seattle.gov/dpd/energy.

ASHRAE/IESNA Std. 90.1-1999: section no. & title	Mandatory/ Prescriptive	Key Requirements in Standard 90.1 (with corresponding Seattle Energy Code (SEC) information in italics)
5. Building Envelope		
5.2 Mandatory Provisions (5.5 in 90.1-2001)	Mandatory	
5.2.1 Insulation Installation (5.5.1 in 90.1-2001)	Mandatory	5.2.1.3 generally prohibits recessing equipment into insulation unless trade-off calculations are done.
5.2.2 Fenestration and Doors (5.5.2 in 90.1-2001)	Mandatory	U-factors, SHGC, and visible transmittance to be based on NFRC ratings.
5.2.3 Air Leakage (5.5.3 in 90.1-2001)	Mandatory	5.2.3.2 sets maximum air leakage rate for fenestration; 5.2.3.3 requires loading dock weatherseal; 5.2.3.4 requires vestibules.
5.3 Prescriptive Provisions	Prescriptive *(SEC prescriptive)*	Table B-14 on page 104 (page 109 of 90.1-2001) contains the requirements for Seattle. Requirements are subdivided into nonresidential, residential, and semiheated categories as defined in 3.2. “Residential” is defined as spaces for living and sleeping and includes prisons and fire stations. The component-by-component baseline summary below only addresses the nonresidential category, as that is the most common. For residential and semiheated spaces, as defined in 3.2, refer to the appropriate columns in Table B-14. (Note that the SEC requirements are subdivided into other than Group R occupancy, i.e., non-residential; Group R occupancy, i.e., residential; and semiheated space. The SEC requirements also vary by space heat type.)
5.3.1 Opaque Areas	Prescriptive	Note that the opaque envelope categories differ between Standard 90.1 and SEC. U-factors are expressed in W/m^2·K (Btu/h·ft^2·ºF). R-values are for **insulation only** and are expressed in m^2·K/W (h·ft^2·ºF/Btu). “ci” means continuous insulation uninterrupted by framing members. SEC requirements for nonresidential spaces and semiheated spaces with electric resistance space heat and for all residential spaces only allow the use of prescriptive R-values for wood-frame construction; other constructions must comply using the overall assembly U-factor. NR means no requirement.
5.3.1.1 Roofs	Prescriptive (SEC prescriptive) Prescriptive (SEC prescriptive) Prescriptive (SEC prescriptive)	For nonresidential spaces: U-0.360 or R-2.6 ci (U-0.063 or R-15 ci) for insulation entirely above deck, U-0.369 or R-3.3 (U-0.065 or R-19) for metal buildings, U-0.192 or R-5.3 (U-0.034 or R-30) for attic and other. (SEC requirement for electric resistance heat: U-0.176 or R-6.7 (U-0.031 or R-38) for attics, U-0.192 or R-5.3 (U-0.034 or R-30) for all other roofs; SEC requirements for all other space heat types: U-0.204 or R-5.3 (U-0.036 or R-30) for attics, U-0.284 or R-3.7 (U-0.050 or R-21) for all other roofs.) For residential spaces: U-0.360 or R-2.6 ci (U-0.063 or R-15 ci) for insulation entirely above deck, U-0.369 or R-3.3 (U-0.065 or R-19) for metal buildings, U-0.192 or R-5.3 (U-0.034 or R-30) for attic and other. (SEC requirement for all space heat types: U-0.176 or R-6.7 (U-0.031 or R-38) for ceilings, U-0.192 or R-5.3 (U-0.034 or R-30) for vaulted ceilings.) For semiheated spaces: U-1.240 or R-0.7 ci (U-0.218 or R-3.8 ci) for insulation entirely above deck, U-0.551 or R-1.8 (U-0.097 or R-10) for metal buildings, U-0.459 or R-2.3 (U-0.081 or R-13) for attic and other. (SEC requirement for electric resistance heat: U-0.176 or R-6.7 (U-0.031 or R-38) for attics, U-0.192 or R-5.3 (U-0.034 or R-30) for all other roofs; SEC requirements for all other space heat types: U-0.397 or R-4.4 (U-0.07 or R-25) for all roofs.)

ASHRAE/IESNA Std. 90.1-1999: section no. & title	Mandatory/ Prescriptive	Key Requirements in Standard 90.1 (with corresponding Seattle Energy Code (SEC) information in italics)
5.3.1.2 Above Grade Walls	Prescriptive (SEC prescriptive) Prescriptive *(SEC prescriptive)* Prescriptive (SEC prescriptive)	For nonresidential spaces: U-0.857 or R-1.0 ci (U-0.151 or R-5.7 ci) for mass, U-0.642 or R-2.3 (U-0.113 or R-13) for metal buildings, U-0.705 or R-2.3 (U-0.124 or R-13) for steel framed, U-0.513 or R-2.3 (U-0.089 or R-13) for wood framed and other. (SEC requirement for electric resistance heat: U-0.352 or R-3.3 (U-0.062 or R-19) for all opaque walls; SEC requirements for all other space heat types: *U-0.477 or R-2.3+R-0.7 ci (U-0.084 or R-13+R-3.8 ci) for metal frame walls,* *U-0.352 or R-3.3 (U-0.062 or R-19) for wood frame and other than metal frame walls.)* For residential spaces: U-0.592 or R-1.7 ci (U-0.104 or R-9.5 ci) for mass, U-0.642 or R-2.3 (U-0.113 or R-13) for metal buildings, U-0.479 or R-2.3 + R-0.7 ci (U-0.084 or R-13 + R-3.8 ci) for steel framed, U-0.513 or R-2.3 (U-0.089 or R-13) for wood framed and other. (SEC requirement for all space heat types: *U-0.341 or R-3.7 (U-0.060 or R-21))* For semiheated spaces: U-3.293 or NR (U-0.580 or NR) for mass, U-0.761 or R-1.8 (U-0.134 or R-10) for metal buildings, U-0.705 or R-2.3 (U-0.124 or R-13) for steel framed, U-0.513 or R-2.3 (U-0.089 or R-13) for wood framed and other. (SEC requirement for electric resistance heat: U-0.352 or R-3.3 (U-0.062 or R-19) for all opaque walls; SEC requirements for all other space heat types: U-1.420 or R-0.5 ci (U-0.25 or R-3 ci) for mass walls, U-0.795 or R-1.9 (U-0.14 or R-11) for metal frame walls, U-0.500 or R-1.9 (U-0.088 or R-11) for wood frame and other walls.)
5.3.1.3 Below Grade Walls	Prescriptive (SEC prescriptive)	For nonresidential, residential, and semiheated spaces: C-6.473 or NR (C-1.14 or NR) for all below grade walls (does not include air films or soil). (SEC requirement for nonresidential spaces for all space heat types: same as above grade walls. SEC requirements for residential spaces for all space heat types: R-2.6 (R-15) if insulated on the interior, R-1.8 ci (R-10 ci) if insulated on the exterior. SEC requirements for semiheated spaces: electric resistance space heat – same as above grade walls, all other space heat – no requirements.)
5.3.1.4 Floors	Prescriptive *(SEC prescriptive)* Prescriptive *(SEC prescriptive)* Prescriptive (SEC prescriptive)	For nonresidential spaces: U-0.606 or R-1.1 ci (U-0.107 or R-6.3 ci) for mass, U-0.296 or R-3.3 (U-0.052 or R-19) for steel joist, U-0.288 or R-3.3 (U-0.051 or R-19) for wood framed and other. (SEC requirement for electric resistance heat: U-0.165 or R-5.3 (U-0.029 or R-30) for all floors; SEC requirements for all other space heat types: *U-0.318 or R-3.3 (U-0.056 or R-19) for all floors.)* For residential spaces: U-0.496 or R-1.5 ci (U-0.087 or R-8.3 ci) for mass, U-0.296 or R-3.3 (U-0.052 or R-19) for steel joist, U-0.188 or R-5.3 (U-0.033 or R-30) for wood framed and other. (SEC requirement for all space heat types: *U-0.165 or R-5.3 (U-0.029 or R-30) for all floors.)* For semiheated spaces: U-1.825 or NR (U-0.322 or NR) for mass, U-0.390 or R-2.3 (U-0.069 or R-13) for steel joist, U-0.376 or R-2.3 (U-0.066 or R-13) for wood framed and other. (SEC requirement for electric resistance heat: U-0.165 or R-5.3 (U-0.029 or R-30) for all floors; SEC requirements for all other space heat types: U-0.500 or R-1.9 (U-0.088 or R-11) for all floors.)

ASHRAE/IESNA Std. 90.1-1999: section no. & title	Mandatory/ Prescriptive	Key Requirements in Standard 90.1 (with corresponding Seattle Energy Code (SEC) information in italics)
5.3.1.5 Slab on Grade Floors	Prescriptive *(SEC prescriptive)* Prescriptive *(SEC prescriptive)*	For nonresidential spaces: F-1.264 or NR (F-0.73 or NR) for unheated slabs, F-1.644 or R-1.3 for 600 mm (F-0.95 or R-7.5 for 24 in.) for heated slabs. (SEC requirement for all space heat types: *F-0.93 or R-1.8 for 600 mm (F-0.54 or R-10 for 24 in.) for unheated slabs,* *F-0.95 or R-1.8 under entire slab (F-0.55 or R-10 under entire slab) for heated slabs.)* For residential spaces: F-1.264 or NR (F-0.73 or NR) for unheated slabs, F-1.454 or R-1.8 for 900 mm (F-0.95 or R-10 for 36 in.) for heated slabs. (SEC requirement for all space heat types: *F-0.93 or R-1.8 for 600 mm (F-0.54 or R-10 for 24 in.) for unheated slabs,* *F-0.95 or R-1.8 under entire slab (F-0.55 or R-10 under entire slab) for heated slabs.)* For semiheated spaces: F-1.264 or NR (F-0.73 or NR) for unheated slabs, F-1.766 or R-1.3 for 300 mm (F-1.02 or R-7.5 for 12 in.) for heated slabs. (SEC requirement for electric resistance heat: F-0.93 or R-1.8 for 600 mm (F-0.54 or R-10 for 24 in.) for unheated slabs, F-0.95 or R-1.8 under entire slab (F-0.55 or R-10 under entire slab) for heated slabs. SEC requirement for all other space heat types: no requirements.)
5.3.1.6 Opaque Doors	Prescriptive *(SEC prescriptive)* Prescriptive *(SEC prescriptive)* Prescriptive (SEC prescriptive)	For nonresidential spaces: U-3.975 (U-0.70) for swinging doors, U-8.233 (U-1.45) for non-swinging doors. (SEC requirement for all space heat types: *U-3.407 (U-0.60) for all opaque doors.)* For residential spaces: U-3.975 (U-0.70) for swinging doors, U-2.839 (U-0.50) for non-swinging doors. (SEC requirement for all space heat types: *U-2.271 (U-0.40) for all opaque doors.)* For semiheated spaces: U-3.975 (U-0.70) for swinging doors, U-8.233 (U-1.45) for non-swinging doors. (SEC requirement for electric resistance heat: U-3.407 (U-0.60) for all opaque doors. SEC requirement for other space heat types: no requirements.)
5.3.2 Fenestration	Prescriptive	U-factors are expressed in W/m^2·K (Btu/h·ft^2·ºF)
5.3.2.1 Fenestration Area	Prescriptive	Vertical fenestration area to be 50% maximum, skylight area to be 5% maximum. (SEC does not separate vertical fenestration and skylights and calculates all fenestration area together.)
5.3.2.2 Fenestration U-Factor	Prescriptive *(SEC prescriptive)* Prescriptive	For vertical glazing, U-factor requirements vary by fixed vs. operable windows. (SEC does not separate vertical glazing and skylights and calculates all fenestration area together as a percentage of the wall area. SEC does not distinguish between fixed and operable glazing, or between types of skylights.) For nonresidential spaces, vertical fenestration: 0-40.0% vertical glazing area, % of wall U_{fixed}-3.24, $U_{operable}$-3.80 (U_{fixed}-0.57, $U_{operable}$-0.67), 40.1-50.0% vertical glazing area, % of wall U_{fixed}-2.61, $U_{operable}$-2.67 (U_{fixed}-0.46, $U_{operable}$-0.47). For nonresidential spaces, skylights: 0-5.0% glass skylight with curb, % of roof U_{all}-6.64 (U_{all}-1.17) 0-5.0% plastic skylight with curb, % of roof U_{all}-7.38 (U_{all}-1.30) 0-5.0% all skylights without curb, % of roof U_{all}-3.92 (U_{all}-0.69)

ASHRAE/IESNA Std. 90.1-1999: section no. & title	Mandatory/ Prescriptive	Key Requirements in Standard 90.1 (with corresponding Seattle Energy Code (SEC) information in italics)
5.3.2.2 Fenestration U-Factor (continued)	*(SEC prescriptive)* Prescriptive *(SEC prescriptive)* Prescriptive (SEC prescriptive)	(SEC requirement for electric resistance heat: 0-30% total glazing area, % of wall $U_{verticalglazing}$-2.27, $U_{overheadglazing}$-2.73 ($U_{verticalglazing}$-0.40, $U_{overheadglazing}$-0.48); SEC requirements for all other space heat: 0-30% total glazing area, % of wall $U_{verticalglazing}$-3.12, $U_{overheadglazing}$-3.75, ($U_{verticalglazing}$-0.55, $U_{overheadglazing}$-0.66), >30-45% total glazing area, % of wall $U_{verticalglazing}$-2.56, $U_{overheadglazing}$-3.07 ($U_{verticalglazing}$-0.45, $U_{overheadglazing}$-0.54), >45-50% total glazing area, % of wall *$U_{verticalglazing}$-0.40, $U_{overheadglazing}$-0.48* *($U_{verticalglazing}$-0.40, $U_{overheadglazing}$-0.48.))* For residential spaces, vertical fenestration: 0-40.0% vertical glazing area, % of wall U_{fixed}-3.24, $U_{operable}$-3.80 (U_{fixed}-0.57, $U_{operable}$-0.67), 40.1-50.0% vertical glazing area, % of wall U_{fixed}-2.61, $U_{operable}$-2.67 (U_{fixed}-0.46, $U_{operable}$-0.47). For residential spaces, skylights: 0-5.0% glass skylight with curb, % of roof U_{all}-6.64 (U_{all}-1.17) 0-5.0% plastic skylight with curb, % of roof U_{all}-7.38 (U_{all}-1.30) 0-5.0% all skylights without curb, % of roof U_{all}-3.92 (U_{all}-0.69) (SEC requirement for all space heat types: 0-25% total glazing area, % of floor $U_{verticalglazing}$-2.27, $U_{overheadglazing}$-3.29 ($U_{verticalglazing}$-0.40, $U_{overheadglazing}$-0.58); >25% total glazing area, % of floor $U_{verticalglazing}$-1.99, $U_{overheadglazing}$-3.29, ($U_{verticalglazing}$-0.35, $U_{overheadglazing}$-0.58). For semiheated spaces, vertical fenestration: 0-40.0% vertical glazing area, % of wall U_{fixed}-6.93, $U_{operable}$-7.21 (U_{fixed}-1.22, $U_{operable}$-1.27), 40.1-50.0% vertical glazing area, % of wall U_{fixed}-5.54, $U_{operable}$-5.77 (U_{fixed}-0.98, $U_{operable}$-1.02). For semiheated spaces, skylights: 0-5.0% glass skylight with curb, % of roof U_{all}-11.24 (U_{all}-1.98) 0-5.0% plastic skylight with curb, % of roof U_{all}-10.79 (U_{all}-1.90) 0-5.0% all skylights without curb, % of roof U_{all}-7.72 (U_{all}-1.36) (SEC requirement for electric resistance heat: 0-30% total glazing area, % of wall $U_{verticalglazing}$-2.27, $U_{overheadglazing}$-2.73 ($U_{verticalglazing}$-0.40, $U_{overheadglazing}$-0.48); SEC requirements for all other space heat: 0-10% total glazing area, % of wall $U_{verticalglazing}$-5.11, $U_{overheadglazing}$-6.13, ($U_{verticalglazing}$-0.90, $U_{overheadglazing}$-1.08).)

ASHRAE/IESNA Std. 90.1-1999: section no. & title	Mandatory/ Prescriptive	Key Requirements in Standard 90.1 (with corresponding Seattle Energy Code (SEC) information in italics)
5.3.2.3 Fenestration SHGC	Prescriptive *(SEC prescriptive)* Prescriptive *(SEC prescriptive)* Prescriptive *(SEC prescriptive)* Prescriptive (SEC prescriptive)	For vertical glazing, SHGC requirements vary by north-facing vs. all other orientations. (SEC does not separate vertical glazing and skylights and calculates all fenestration area together as a percentage of the wall area. SEC does not distinguish between orientations, or between types of skylights.) For nonresidential spaces, vertical fenestration: 0-10.0% vertical glazing area, % of wall $SHGC_{all}$-0.49, $SHGC_{north}$-0.49, 10.1-40.0% vertical glazing area, % of wall $SHGC_{all}$-0.39, $SHGC_{north}$-0.49, 40.1-50.0% vertical glazing area, % of wall $SHGC_{all}$-0.26, $SHGC_{north}$-0.36. For nonresidential spaces, skylights: 0-2.0% glass skylight with curb, % of roof $SHGC_{all}$-0.49, 2.1-5.0% glass skylight with curb, % of roof $SHGC_{all}$-0.39, 0-2.0% plastic skylight with curb, % of roof $SHGC_{all}$-0.77, 2.1-5.0% plastic skylight with curb, % of roof $SHGC_{all}$-0.62, 0-2.0% all skylights without curb, % of roof $SHGC_{all}$-0.49, 2.1-5.0% all skylights without curb, % of roof $SHGC_{all}$-0.39. (SEC requirement for electric resistance heat: 0-20% total glazing area, % of wall $SHGC_{all}$-0.40, >20-30% total glazing area, % of wall $SHGC_{all}$-0.30; SEC requirements for all other space heat: 0-45% total glazing area, % of wall $SHGC_{all}$-0.40, >45-50% total glazing area, % of wall *$SHGC_{all}$-0.35.)* For residential spaces, vertical fenestration: 0-10.0% vertical glazing area, % of wall $SHGC_{all}$-0.49, $SHGC_{north}$-0.49, 10.1-40.0% vertical glazing area, % of wall $SHGC_{all}$-0.39, $SHGC_{north}$-0.49, 40.1-50.0% vertical glazing area, % of wall $SHGC_{all}$-0.26, $SHGC_{north}$-0.36. For residential spaces, skylights: 0-2.0% glass skylight with curb, % of roof $SHGC_{all}$-0.49, 2.1-5.0% glass skylight with curb, % of roof $SHGC_{all}$-0.39, 0-2.0% plastic skylight with curb, % of roof $SHGC_{all}$-0.77, 2.1-5.0% plastic skylight with curb, % of roof $SHGC_{all}$-0.34, 0-2.0% all skylights without curb, % of roof $SHGC_{all}$-0.49, 2.1-5.0% all skylights without curb, % of roof $SHGC_{all}$-0.39. (SEC requirement for all space heat types: *no requirements.)* For semiheated spaces, vertical fenestration and skylights: no requirements. (SEC requirement for all space heat types: no requirements.)
6. Heating, Ventilating, and Air Conditioning		

ASHRAE/IESNA Std. 90.1-1999: section no. & title	Mandatory/ Prescriptive	Key Requirements in Standard 90.1 (with corresponding Seattle Energy Code (SEC) information in italics)
6.2 Mandatory Provisions	Mandatory	
6.2.1 Mechanical Equipment Efficiency	Mandatory (SEC mandatory)	Tables 6.2.1A through 6.2.1G list minimums, with a second tier of equipment efficiencies that was effective on 29 October 2001. 90.1-2001 added Tables 6.2.1H through 6.2.1M. (SEC Table 14-1C groups all water-cooled water chillers together into four size categories and thereby establishes higher efficiency requirements for reciprocating, rotary screw and scroll units. SEC 1411.1 requires electric furnaces over 15kW to have a minimum of two stages of control for heating. SEC 1411.3 lists minimum efficiency requirements for combination space and service water heating systems. SEC 1411.4 requires that packaged and split system electric heating and cooling equipment with a cooling capacity greater than 20,000 Btu/h to be a heat pump.)
6.2.2 Load Calculations	Mandatory (SEC prescriptive)	Requires load calculations to be done, but does not set limits on allowable equipment size. (SEC 1421.1 provides prescriptive equipment limits for space heating equipment output at 16 Btu/h per square foot of gross conditioned floor area and for space cooling equipment output at 25 Btu/h per square foot of gross conditioned floor area. SEC 1431.2 provides an alternate where space heating and/or space cooling systems are to be sized no greater than 125% of the design load.)
6.2.3 Controls	Mandatory *(SEC mandatory)* Mandatory *(SEC mandatory)*	6.2.3.2 requires automatic shutdown, setback controls, optimum start controls, shutoff damper controls, and zone isolation controls for all units with heating or cooling capacity over 65,000 Btu/h and fan power greater than ¾ hp. (SEC 1412.4 requires automatic controls with a minimum 7-day timeclock with a full-load demand over 6,826 Btu/h.) 6.2.3.5 required automatic controls, <u>either</u> CO sensors or timeclock or occupancy sensors, for parking garage ventilation systems over 30,000 cfm. **Note that this section was deleted in 90.1-2001.** (SEC 1412.8 requires automatic controls, <u>both</u> CO sensors and either timeclock or occupancy sensor, for parking garage ventilation systems over 30,000 cfm.)
6.2.4 HVAC System Construction and Insulation	Mandatory	6.2.4.2 and Tables 6.2.4.2A & B require R-1.1 (R-6) insulation for ducts located on the exterior, R-0.6 (R-3.5) insulation for ducts in unconditioned spaces, and no insulation for ducts located within conditioned space regardless of the temperature of the air within the duct. (SEC 1414.2 and Table 14-5 require R-1.2 (R-7) insulation for ducts located on the exterior, R-1.2 (R-7) insulation for ducts located within unconditioned spaces, and R-0.6 (R-3.3) insulation for ducts within the conditioned space that convey air warmer than 40 C (105 °F) or cooler than 4 C (40 °F).) 6.2.4.3 specifies duct sealing requirements. 6.2.4.4 requires duct leakage testing for ducts operating in excess of 3 in. w.c.
6.2.5 Completion Requirements	Mandatory	(Use SEC 1416.)
6.3 Prescriptive Path	Prescriptive	
6.3.1 Economizers	Prescriptive (SEC prescriptive)	Equipment 65,000 Btu/h and larger to have an air or water economizer. (SEC 1423 requires economizers on units having a cooling capacity greater than 20,000 Btu/h., and limits the total capacity of all units without economizer to 240,000 Btu/h per building.) 6.3.1.1 requires return air and outside air dampers to have a maximum air leakage rate of 20 cfm/ft^2 at 4.0 in. w.g. 6.3.1.3 requires both air and water economizers to have integrated control so that they are capable of providing partial cooling in addition to the mechanical cooling. 6.3.1.4 prohibits systems that increase building system energy use. According to the 90.1 User's Manual, the following system types would not comply with this requirement: single-fan dual-duct systems and some multizone systems (Figure 6-R, pages 6-53 to 6-54) and some water economizer systems (Figure 6-O, page 6-50, and Example 6-OO, page 6-53).
6.3.2 Simultaneous Heating and Cooling Limitation	Prescriptive	6.3.2.1, exception (a) – the compliance option used by most systems – sets a 10% tolerance for volume controllers and temperature restrictions for supply air temperatures. 6.3.2.2 requires bypass and two-position valve for water source heat pump loops

ASHRAE/IESNA Std. 90.1-1999: section no. & title	Mandatory/ Prescriptive	Key Requirements in Standard 90.1 (with corresponding Seattle Energy Code (SEC) information in italics)
6.3.3 Air System Design and Control	Prescriptive (SEC prescriptive)	6.3.3.1 sets a maximum fan system efficiency in hp/1000 cfm 6.3.3.2 establishes performance requirements for part load fan control for fans 30 hp and larger (SEC 1437 requires electronically commutated motors for series fans < 1 hp, SEC 1438 sets threshold at greater than 10 hp, has a prescriptive option of variable frequency drive, and has a performance option similar to 6.3.2.2.)
6.3.4 Hydronic System Design and Control	Prescriptive (SEC prescriptive)	6.3.4.1 establishes performance requirements for part load fan control for pumps exceeding 50 hp (SEC 1438 sets threshold at greater than 10 hp, has a prescriptive option of variable frequency drive, and has a performance option similar to 6.3.4.1.)
6.3.5 Heat Rejection Equipment	Prescriptive (SEC *prescriptive*)	6.3.5.1 establishes performance requirements for part load fan control for fans 7.5 hp or larger (SEC 1438 sets threshold at greater than 10 hp, has a prescriptive option of variable frequency drive, and has a performance option similar to 6.3.4.1.)
6.3.6 Energy Recovery	Prescriptive	6.3.6.1 specifies exhaust air heat recovery of 50% for systems with over 5,000 cfm and 70% outside air 6.3.6.2 specifies service water heating heat recovery of 60% for systems with over 6,000,000 Btu/h of heat rejection and load over 1,000,000 Btu/h
6.3.7 Exhaust Hoods	Prescriptive	6.3.7.1 requires 50% untreated makeup air for kitchen hood systems with over 5,000 cfm 6.3.7.2 requires VAV or heat recovery for fume hood systems with over 15,000 cfm
6.3.8 Radiant Heating Systems	Prescriptive	6.3.8.1 requires radiant heating in unenclosed spaces
6.3.9 Hot Gas Bypass Limitation	Prescriptive	Prohibits the use of hot gas bypass unless the system has multiple steps of unloading
7. Service Water Heating		
7.2 Mandatory Provisions	Mandatory	7.2.3 requires pipe insulation for recirculating systems (SEC 1452 prohibits the use of electric resistance as the primary heating source for pool heating for pools over 2,000 gallons.)
7.3 Prescriptive Path	Prescriptive (SEC prescriptive)	7.3.1 and 7.3.2 specify efficiencies for combination space and water heating systems (SEC 1411.3 lists minimum efficiency requirements for combination space and service water heating systems.)
8. Power		
8.2 Mandatory Provisions	Mandatory	8.2.1 specifies maximum voltage drop for feeders and branch circuits 8.2.2 contains completion requirements for drawings and manuals
9. Lighting		
9.2 Mandatory Provisions	Mandatory	
9.2.1 Lighting Controls	Mandatory	9.2.1.1 requires interior lighting in all buildings over 5,000 square feet to have automatic shut-off controls 9.2.1.4 hotels and motels to have a master switch at the door (SEC 1513.3 requires automatic daylighting controls for all daylight zones. SEC 1513.6 requires occupancy sensors for offices < 300 ft^2)
9.2.2 Tandem Wiring	Mandatory	One- or three-lamp fixtures to have tandem wiring
9.2.3 Exit Signs	Mandatory	Exit signs over 20 W to have minimum efficacy of 35 lumens/W
9.2.4 Installed Interior Lighting Power	Mandatory	Lighting calculations to include all lighting power
9.2.5 Luminaire Wattage	Mandatory	Lighting calculations generally to be based on maximum labeled wattage of the fixture
9.2.6 Exterior Building Grounds Lighting	Mandatory	Exterior luminaires over 100 W to have minimum efficacy of 60 lumens/W
9.3 Prescriptive Path	Prescriptive	

ASHRAE/IESNA Std. 90.1-1999: section no. & title	Mandatory/ Prescriptive	Key Requirements in Standard 90.1 (with corresponding Seattle Energy Code (SEC) information in italics)
9.3.1 Interior Lighting Power	Prescriptive (SEC Lighting Power Allowance)	Allows projects to use either the Building Area method (9.3.1.1) or Space-by-Space method (9.3.1.2) for lighting. However, 11.3.8 requires the use of the Building Area method for lighting if the Proposed lighting system has not been designed. The Building Area values in Table 9.3.1.1 on page 51 are recommended for simplicity and must be used unless lighting calculations are done for each space in the building. Table 9.3.1.1 has the following maximum lighting power allowance values: Office: 1.3 W/ft^2 Retail: 1.9 W/ft^2, plus exception 9.3.1.2.1(c) School/university: 1.5 W/ft^2 Hotel: 1.7 W/ft^2 Dining, family: 1.9 W/ft^2 Dining, cafeteria/fast food: 1.8 W/ft^2 Dining, leisure: 1.5 W/ft^2 Gymnasium: 1.7 W/ft^2 Parking garage: 0.3 W/ft^2 (SEC Table 15-1 has the following max. lighting power allowance values: Office & administrative areas: 1.0 W/ft^2 Retail A/B: 1.5 W/ft^2, plus footnote 10 School: 1.2 W/ft^2 Institution: 1.5 W/ft^2 Hotel banquet halls: 2.0 W/ft^2 Dining, cafeteria/fast food: 1.5 W/ft^2 Dining, restaurant: 1.0 W/ft^2 Assembly/auditorium/gymnasium: 1.0 W/ft^2 Parking garage: 0.2 W/ft^2 per Section 1532) (SEC 1521 provides a prescriptive lighting option. This approach does not provide a means for comparison with the lighting power allowance in ASHRAE/IESNA 90.1. Consequently, SEC 1521 is NOT an acceptable compliance option.)
9.3.2 Exterior Building Lighting Power	Prescriptive (SEC lighting power allowance)	Table 9.3.2 contains the following maximum exterior lighting power allowance values: Building entrance with canopy: 3 W/ft^2 of canopy area Building entrance without canopy: 33 W/lineal ft of door width Building exit: 20 W/lineal ft of door width Building façade: 0.25 W/ft^2 of illuminated area (SEC 1532 contains the following maximum exterior lighting power allowance values: Covered parking: 0.20 W/ft^2 Open parking and outdoor areas: 0.15 W/ft^2 Building façade: 0.15 W/ft^2 of illuminated area.)
10 Other Equip.		
10.2 Mandatory Provisions	Mandatory	Electric motors to comply with efficiencies in Table 10.2