Pellet Central Heating Information

Heat from domestically produced wood pellets

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Prepared for the Provincial Territorial Advisory Committee

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1 Introduction

This document has been compiled by the Wood Pellet Association of Canada to familiarize members of the Provincial Territorial Advisory Committee with some fundamentals of pellet central heating using pellets distributed in loose bulk form in boilers and furnaces often certified to EN 303-5 standards as most such boilers are manufactured in Europe.

2 Pellet central heating basics

For many people, pellet heating is synonymous with pellet stoves and bagged wood pellets. The phrase "pellet central heating" has no basis in their experience. The following simple explanation is no substitute for actually seeing a pellet central heating system, but it can help those new to the idea understand what the phrase means.

There are many small-scale pellet boilers in service throughout the world. Most of them are manufactured in EU countries where over one million of them are heating homes, businesses, and public facilities today. Small-scale, as used in this context, applies to boilers of up to 500kW output thermal energy. The largest of these boilers would heat sizable schools and small hospitals; the smallest, modest residences. For the purposes of this explanation, we'll use some industry-produced images created to help introduce pellet central heating to homeowners, so the installations depicted are residential scale boilers.

2.1 Boilers vs furnaces

2.1.1 Furnaces

Buildings that are heated with forced hot air have furnaces to heat that air. There is no significant pressure in the systems, so there are no pressure-related rules impacting their distribution in Canada.

2.1.2 Boilers

Buildings that have systems in which heated water, or some other liquid, is circulated through baseboard radiation, wall heaters, or radiant floor or ceiling piping use boilers to heat the water. These are called hydronic systems. Boilers can be fueled with electricity, natural gas or propane, oil, or biomass. The first four fuel sources are commonly understood, biomass, on the other hand, has various meanings including cordwood, chips, pellets and other biogenic materials. Here we'll talk about densified wood pellets as the renewable, biomass fuel used for heating circulating water.

Boilers using any fuel start on demand when a thermostat in part of the house calls for heat and shut down when the demand is met. Pellet fired boilers occupy the same place in a hydronic heating system an oil or gas boiler would. They start and stop as do electric and fossil fuel boilers, but once started they modulate their heat output level based upon

Figure 1: An Austrian pellet boiler

the scale of the demand. The more heat that is needed the more heat they put out; the lower the demand, the smaller the flame. This helps match output to heat demand making most efficient use of fuel and reducing starts and stops when demand is low.

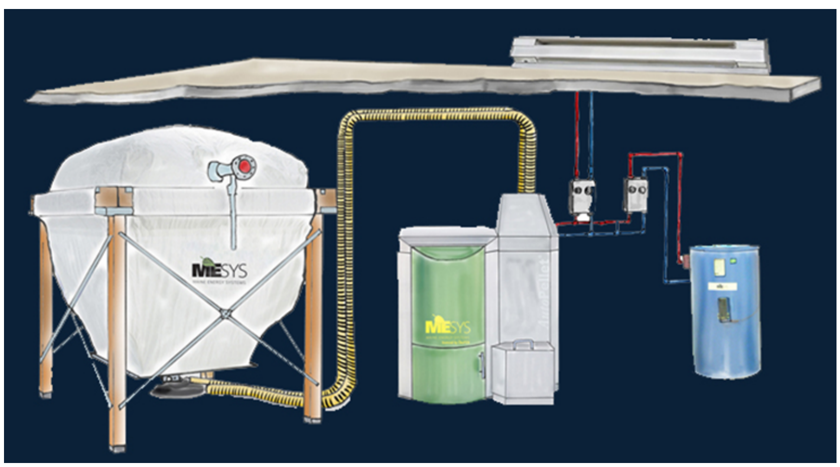

Figure 2: A basic hydronic system with pellet boiler, pellet storage, baseboard radiation, and domestic hot water tank

2.2 Fuel delivery/handling

2.2.1 Fuel delivery

Oil boilers receive fuel deliveries when needed, as do pellet boiler systems. Most people are very familiar with wood pellets commonly sold in plastic bags of 40 lbs. each; however, the same pellets when used for central heating, are delivered by truck. The dry, clean, pellets are blown into storage tanks generally installed near the boiler in the basement, garage, or shed.

Pellet boiler users never actually see pellets; they are delivered to an enclosed storage unit, fed automatically into the burner, and fired to provide heat without user intervention.

At the residential, light commercial scale, storage tanks typically hold 3 – 10 tonnes of pellets depending upon the size of the building being heated. For reference, 1 tonne of pellets has the energy equivalent of about 500 liters of #2 heating oil. A storage tank measuring about 2m * 2m * 2m holds pellets with the energy of about 1500 liters of #2 heating oil.

Figure 3: Pneumatic delivery of loose, bulk pellets

2.2.2 Pellets

Canadian companies make millions of tonnes of premium grade wood pellets annually. These pellets contain nothing more than pulverized, barkless wood compressed under pressure to form pellets of uniform diameter and density. These pellets are often made from mill by-products and other waste wood.

2.3 Ash

The non-combustible portions of wood pellets, mostly salts, leave very fine, light grey ash to be removed from boilers and furnaces. In automatic pellet boilers, this ash is compressed into small storage containers to be removed occasionally by owners. Since the ash content of premium pellets cannot exceed 1%, there are not more than 10kg of ash in a tonne of pellets. Good pellet boilers should not need to have the ash removed more frequently than about every 2 tonnes of pellets burned(1000 liter oil equivalent). In many EU manufactured pellet boilers, emptying of the ash is simple, clean, and can be accomplished while the boiler is either running or still.

Figure 4: Ash compression box, can be emptied during operation

Wood pellet ash has chemical properties much like those of lime, so it can be applied to the land where lime would be advantageous.

2.4 Chimneys

The flue gas from pellet boilers is cool when compared to that of fossil fuel systems. Therefore, pellet boilers should only be used on lined chimneys because the top of the chimney can become cool and condense the water vapor in the flue gas that could damage block or brick chimneys when it freezes and thaws; either tile or steel liners work fine.

3 Safety in pellet manufacturing and handling facilities

The Wood Pellet Association of Canada (WPAC) membership consists of companies associated with the production of more than 3 million tonnes of densified wood pellets annually. Nearly all of these pellets are exported to European and Asian regions that use them to meet their environmental improvement goals. WPAC is seeking recognition of EU standards in Canadian boiler regulations to facilitate the growth of domestic use of this regionally manufactured renewable heating fuel. WPAC ensures that its industry can reliably meet domestic and global demands for its products through continuous attention to manufacturing and storage safety.

Wood Pellet Association of Canada's Safety Program

by Gordon Murray, Executive Director

September 28, 2020

Wood pellet safety is the top priority of the Wood Pellet Association of Canada ("WPAC"). This is evidenced by the amount of time, effort and financial resources we devote to safety. WPAC's membership covers approximately 98% of Canada's wood pellet production capacity.

WPAC operates an active safety committee ("WPAC SC") with approximately 50 members representing wood pellet producers from across Canada, the majority of whom are represented. WPAC SC's mission is to improve the wood pellet industry's collective safety performance, to earn a reputation with regulatory authorities and the public as an industry that is highly effective at managing safety, and to learn and share best practices regarding safety.

WPAC SC's responsibilities are:

- to develop strategies for continuous improvement of safety and promote such strategies to WPAC's members;
- to communicate to WPAC's membership the importance of developing a safety culture;
- readily and openly share safety, we are committed to not competing on safety; and
- to circulate safety news, developments, and reports to WPAC's members.

WPAC SC members are appointed by WPAC's board of directors and reports back to the board regularly. WPAC SC's board-approved charter provides for the concept "no competition related to safety". All of WPAC's members have committed to openly share safety resources and learnings with each other.

In addition, WPAC is a member of the BC Forest Safety Council (BCFSC). Membership is funded through a WorkSafeBC payroll levy that is passed on to BCFSC.

WPAC SC prepares and publishes an annual work plan that focuses on priority safety concerns, and meets by web conference on the second Wednesday of each month to monitor progress against the work plan. WPAC also meets formally with British Columbia's safety regulator – WorkSafeBC – twice yearly, with the first meeting focusing on the current year work plan and the second meeting to evaluate progress against the work plan and to mutually agree on safety priorities for the ensuing year. It should be noted that in 2020, WorkSafeBC lowered the pellet sector's worker premiums by 15% in recognition of good safety performance.

The priority focus areas in WPAC's current year safety work plan include:

1. ***Plant operator training and use of alarms –*** we are working with adult-education and industry subject experts on developing a curriculum for the safety training of plant operators and HMI.

2. ***Local nitrogen supply initiative*** – we are investigating central nitrogen storage and transportation for rapid deployment in the event of silo fires.

3. ***Process safety: critical control management and bowtie implementation*** – we are working cooperatively with WorkSafeBC to implement critical control management across the pellet industry, working to a deadline of December 2021.
   plan.

4. ***Combustible dust management – raw product storage areas, general training and combustible dust hazard analysis*** – providing refresher training for industry personnel and cooperating with WorkSafeBC to incorporate best practices developed by the pellet industry into provincial regulations

5. ***Combustible gas and confined space entry*** – completion and publication of a whiteboard video and holding a training webinar.

6. ***Training and supervision of workers –*** developing and implementing a six webinar safety foundation certification program for all industry personnel.

7. ***Incident reporting – review and trend analysis*** - carrying out analysis of trends observed from the regular reporting of incidents and near misses to inform us of potential new safety focus areas.

8. ***Communications*** – developing a clear plan to support safety improvements across all members

WPAC SC normally holds a two-day annual safety conference and several subject-specific in-person workshops every year. Topics are drawn from the current year work plan. In 2020, the annual safety conference was cancelled due to COVID-19. As an alternative, the committee is well advanced in developing a series of six one-hour webinars as follows:

- Two webinars on safe human-machine interface practices,
- One webinar on best practices related to combustible dust and combustible gas,
- One webinar on wood pellet safe storage and off-gassing,
- One webinar on process safety – critical control management, and
- One webinar on preparing a bowtie analysis.

Each webinar comes with a quiz. After passing the quizzes for all six webinars, participants will receive a Wood Pellet Safety Foundation certificate. This webinar series is targeted at all personnel employed in Canada's wood pellet industry.

In addition to the activities of the safety committee, WPAC's research director, Dr. Fahimeh Yazdan Panah, was appointed by the Standards Council of Canada, to be one of Canada's two representatives on ISO Technical Committee 238, Working Group 7 (ISO/TC 238/WG 7) where she is has been a long-term active participant and leader. This working group's mandate is to develop and publish ISO standards for the safety of solid biofuels. Representatives of 24 countries directly participate on ISO/TC 238/WG 7 with a further 19 countries acting as observers.

The current priorities of ISO/TC 238/WG 7 include:

- ISO 20023: Safe handling and storage of wood pellets in residential and other small-scale applications.
- DIS 20024: Safe handling and storage of solid biofuel pellets in commercial and industrial applications.
- WD 20048-1: Determination of off-gassing and oxygen depletion characteristics – Part 1: Laboratory method for the determination of off-gassing and oxygen depletion.
- CD 20048-2: Determination of off-gassing and oxygen depletion characteristics – Part 2: Operational method for screening of carbon monoxide off-gassing .
- CD 20049: Determination of self-heating of pelletized biofuels.

For all the standards, Dr. Yazdan Panah acts as either a contributor or a lead author.

Safety continues to be the top priority of the Wood Pellet Association of Canada and a strong safety culture is of the utmost importance to us.

4 Training for pellet boilers and furnaces for technicians and operators

This represents what a manufacturer's course for technicians might include at a high level of granularity. Much specificity related to the boiler brand and its control and safety paradigms would be central to the course.

4.1 Training course outline

I. **Introduction**
Outline the course content for attendees

II. **Basic product familiarization**
Review product line

III. **Bulk pellet delivery**

IV. **Wood pellets**
Introduce fuel and its classifications

1. Raw material sources
   Mill by-products, low grade thinnings, etc.
2. Manufacturing process
3. Pellet grades and standards
   PFI, ENPlus, CANPlus, ISO
4. Significant pellet components
   Discuss ash content, ash fusion temperature, chlorine, etc.

V. **Types of pellet boiler systems**

1. Attention to burner types
2. Thermal storage connected?

VI. **Boiler Room Preparation**

1. Check relevant national, state, local codes
2. Proper boiler sizing (heat load, DHW)
3. Air (venting for fill air, make-up air)

VII. **Boiler controls**

1. Configuration, single boiler

2. End-user level
3. Technician level
4. On-line connections
5. Configuration, cascade

VIII. **Boiler installation**

1. Receiving equipment
2. Boiler placement
3. Venting
4. Flue considerations
5. Clearances

IX. **Fuel storage placement**

1. Auger
2. Pneumatic hoses
3. Grounding
4. Overhead clearance
5. Fill port/external shut-off

X. **Fuel storage unit and fuel feed types and installation**

1. Auger
2. Vacuum-fed
3. Electrical attachments
4. Hydronic connections

XI. **Practical experience**

1. Tear down and re-assemble model boiler
2. Tear down and re-assemble model furnace
3. Assemble and tear down model storage unit

XII. **Start-up and safety checks**

1. Fire boiler/furnace
2. Test all safety devices and procedures

XIII. **Cascade configuration and controls**

1. Use a simulator to configure cascades and experience their operation

XIV. **Furnace technology**

1. Configure furnace and understand remote sensor operation

5 Bulk pellet distribution and staged pellet boiler systems in Canada

The initial challenge in establishing any pellet central heating region lies in acquisition and redistribution of loose, bulk pellets to end-users. The capital investment that must precede market growth is significant, and development of the customer base takes time and patience. Those preparing to enter the bulk pellet redistribution market seek "anchor customers" that can insure substantial pellet purchases annually. These customers are often schools, apartment houses, municipal facilities, and businesses with large heated volumes. Having those customers allows the distributor to cultivate a growing residential market that consumes pellets throughout the year for heating and domestic hot water.

These "anchor customers" very often use staged boiler systems to heat their larger spaces most efficiently and to reduce capital equipment costs. Hence, the bulk pellet distribution story is best told in conjunction with an understanding of staged systems. A piece entitled "Part Load Heating: Savings on Capital Investment and Fuel Costs" is included as Appendix A. This piece was written years ago to help those distributing boiler equipment understand the base load market available to them. The numbers in the piece do not reflect today's energy costs, but the concepts of base load heating, capital cost reduction, and staged systems remain helpful.

5.1 The Northwest Territories

In a region that is sparsely populated and requires heating for 9 months a year, biomass central heating has grown significantly since 2013. The Northwest Territories of Canada face significant challenges in both heating and pellet distribution yet the Territory is among the leaders in adoption of pellet central heating in Canada in large part due to the determination of the government to move away from fossil fuel heating. Most of the biomass heating installations in the NWT are in government buildings, i.e. schools, airports, hospitals, and the like. Commercial applications, such housing facilities for oil field workers and heating in the infrastructure service industry have also found pellet central heating advantageous.

Pellet central heating for private residences hasn't developed in the region due to lack of availability of EN303-5 certified small-scale boilers and the high cost of of those few European boiler models that have been re-certified to meet the ASME requirements in CSA B51. There are no competing Canadian products.

5.2 Bulk pellet distribution

Pellets for heating in the NWT are produced in La Crête, Alberta, and Prince George, BC, from lumber mill by-products. They are transported the 600 to 1,300 miles to regions like Yellowknife, Inuvik and Norman Wells on winter roads and by summer barge, where they are redistributed to various communities.

Local wood pellet distribution requires proper equipment and careful handling to avoid returning the compressed fuel to the small wood bits from which it was made. Green Energy NWT Inc. under the direction of Brian Lickoch imports and redistributes approximately 1300 tonnes of wood pellets a year to serve the pellet boilers they, and others, have provided for installation in Norman Wells and surrounding communities. Pellet resupply is accomplished on winter roads and summer barges only as permanent roads among the communities don't exist. Some other of their installations are in Inuvik, with its own pellet delivery service well north of the Arctic Circle.

The redistribution facility in Normal Wells, a historic oil town, has a current storage capacity of 1300 metric tonnes in large silos. Pellets are moved from storage to end-users in the company's five belly dump trailers and two pneumatic delivery trucks with a third truck under construction at this writing. The economic activity available to Canada in the pellet central heating model is very much in evidence in this example.

5.3 Bulk pellet delivery in eastern Canada

Transport Jedan, St-Christophe d'Arthabaska, PQ, has been delivering loose bulk pellets for some time in Quebec. They serve many of the systems mentioned in an earlier section. The installer of the Quebec staged systems mentioned earlier reports that there are many sources of bulk pellets and pellet deliveries in Quebec Province. He lists the following in Quebec and New Brunswick:

- Lauzon Bois Énergétique
- Transport Tormon
- Granule LG
- Énergie GR
- Granule Valfei
- Énergie GLR
- Groupe Savoie (BSB)

Figure 5: Pellet redistribution facility and pellet delivery truck, Norman Wells, NWT

5.4 Bulk pellet delivery in Ontario

The European pellet central heating marketplace has grown remarkably in its twenty year life. This growth has been fostered in large measure by thoughtful, persistent government policy. Not all bulk pellet delivery efforts in Canada have been successful in part due to changing public policy.

Biothermic Wood Energy Systems in Haliburton, Ontario, is a successful distributor of Fröling pellet boiler systems. To properly introduce the European pellet central heating model in Ontario, Biothermic took on the bulk pellet distribution challenge. The company began delivery with an airlock-style Walinga bulk feed truck. They went on to purchase a far superior fully pneumatic bulk delivery truck. As Ontario government eliminated subsidies for renewable energy projects Biothermic was forced to sell both trucks.

The pneumatic truck with a pressure tank imported from Tropper Maschinen und Anlagen GmbH in Austria mounted on a hook lift truck from Canada was sold to a pellet heating project on Manitoulin Island where it is currently operating.

6 Staged pellet boiler systems

Staging small pellet boilers to serve larger heat loads is common practice wherever pellet central heating is prevalent. It's common for several reasons, among them are reduced capital costs for heating systems and increased efficiency in load matching during most of the heating season. The more sophisticated pellet boilers modulate heat output based on load demand, some over more than 15 levels between 100 percent output and 30 percent output. When several of these boilers are staged to serve larger loads, the output of multiple modulating boilers can very closely match load demand continually resulting in most efficient use of the fuel.

Staged systems (cascades) of small pellet boilers are frequently used in the NWT. These range from two-boiler systems of 56kW output/boiler serving demands of up to 112kW that can be found in many facilities in the NWT to a cascade of ten 56kW boilers heating an oil field dormitory at Trumpeter Camp in Norman Wells (This cascade was later reduced to six 56kW boilers to match the actual load; the remaining four boilers were put in service producing domestic hot water for dormitory residents). This cascade currently provides up to 336kW of usable heat, or about 1.15MM BTUs, providing comfort for oil field workers. This is probably the largest cascade of small boilers in North America. The largest known cascade of small boilers is one comprised of 20 ÖkoFEN 64kW boilers in a large building in downtown Madrid, Spain, where it was impossible to replace existing large boilers with newer replacements.

Figure 6: 2 56kW boilers in a cascade

Cascades are often housed in small boiler rooms external to the heated space with the fuel storage silo adjacent. Note the sharp angle of the cone at the base of the silo; it is likely a 60^o cone. Pellets have an angle of response of 45^o so base cones of greater than 45^o ensure free flow of all the pellets in the silo.

Figure 7: Exterior boiler room housing a two-boiler cascade in Norman Wells

6.1 Trumpeter Camp, Norman Wells

The Trumpeter Camp in Norman Wells has 93 beds and kitchen facilities for 140 people. The facility is heated with a cascade of six 56kW boilers with domestic hot water provided by a cascade of four 56kW boilers. The systems run year-round to provide domestic hot water and heat as needed.

Figure 8: Boiler buildings housing pellet boiler cascades to heat a 93-bed dormitory for oil field workers in Norman Wells, NWT

6.2 Staged boiler systems in Quebec

The Quebec government has provided incentives for pellet central heating systems from time to time. These grants have enabled several technicians in Quebec Province to install and maintain a significant number of boilers. One technician, Luc Lefrançois, of Resomasse in Château-Richer, has installed and provides routine and annual maintenance for 125 boilers around the Province. Of those 125 boilers, there are 52 staged systems of two 56kW boilers, a staged system of four 56kW boilers heating a school, and two churches each heated with a three 56kW boiler staged system. The remaining installations are single boiler systems.

Figure 9: This is a two-boiler staged system heating a municipal building in the City of Clermont, Quebec.

Figure 10: This “Flexilo” is an empty 3 ton fabric storage unit. The fabric has copper grounding wires woven in which are grounded via the feedhorn to eliminate the potential for spark in a dusty environment during delivery.

Figure 11: This is the same 3 ton bag as in the previous image that has been filled to capacity. These smaller storage units serve residential and small commercial/institutional applications where a silo isn't required. The frame of this storage unit is 73" long X 53" wide X 77" high.

6.3 Staged systems in Ontario

Biothermic Wood Energy Systems in Haliburton, Ontario, is a supplier of well-respected Fröling pellet boilers with output ranges from 8 to 100kW. As is common with these fully automated EU designed and manufactured pellet boiler systems, cascades of relatively small boilers can handle relatively large load demands.

Figure 12: Staged Fröling biomass boilers

It should be noted that the ÖkoFEN and Fröling boilers pictures in this piece have been specially manufactured to meet the ASME requirements of CSA B51. They are quite expensive due to the special manufacture and represent only a small portion of the significant product lines of these two companies. These and other EU pellet boiler manufacturers routinely improve their product lines releasing more advanced and, often less expensive, products into the market on short cycles. These advances don't make it to the Canadian market.

7 Bordering states' boiler regulation summarization

7.1 Introduction:

The summarization following is presented to provide a basic answer to the question "How do US states bordering Canada treat imported boilers certified to non-ASME standards?" Since the current effort is on relief from the barrier to trade represented by a requirement that all pressure vessels be manufactured to ASME standards, the data gathered and summarization provided relate to pressure vessel-related requirements only. The summary is based on a cursory review of the regulations of each of the US states that border Canada and is not claimed to be thorough.

7.2 Definitions

To help the reader, the following definitions from the North Dakota codes typify distinctions made in regulations between heating boilers and hot water supply boilers. EN 303-5 is expressly for "heating boilers. . . designed for central heating installations where the carrier is water and the maximum allowable temperature is 110^{o}C 230^{o}F and which can operate at a maximum allowable operating pressure of 6 bars[87 psi]," so stipulations regarding steam pressure are irrelevant.

7.2.1 ”Low pressure and heating boiler” means a boiler operated at pressures not exceeding fifteen pounds per square inch gauge [103 kilopascals] for steam or at pressures not exceeding one hundred sixty pounds per square inch gauge [1103.17 kilopascals] and temperatures not exceeding two hundred fifty degrees Fahrenheit [121.1 degrees Celsius] for water.

7.2.2 ”Hot water supply boiler” means a fired boiler used exclusively to supply hot water for purposes other than space heating and includes all service-type and domestic-type water heaters not otherwise exempt by North Dakota Century Code section 26.1-22.1-06.

7.2.3 ”A.S.M.E. code” means the boiler and pressure vessel construction code of the American society of mechanical engineers of which sections I, II, IV, V, VIII (divisions 1, 2 and 3), IX,. . . ”

7.3 Summary

To generalize regulatory positions across the thirteen US states sharing a border with Canada, all thirteen require ASME compliance for most inspectable boilers. Boiler inspectability varies somewhat, but, generally, is required in buildings that invite the public and/or buildings with boiler input energy greater than some value, usually 200,000 BTU/hr (58.6kW). Nearly all of the states expressly exempt boilers for agricultural uses and in residential dwellings from the conditions of the regulations, and exemption for boilers in apartment buildings with five, or fewer, units is also common.

New Hampshire expressly includes approval for EN 303-5 certified boilers, and Vermont approves EN 303-5 for boilers up to 250,000BTU/hr(73.2kW) energy input. Wisconsin and Vermont acknowledge acceptance of CSA standards, and several other states make exceptions for non-standard boilers using other standards, such as UL2523 and API 510, both of which refer directly to ASME standards.

A spreadsheet providing more detail can be found in Appendix B.

8 Appendix A

"Why would I replace the whole system when replacing half the system gives me 90% of the savings?"

Part load Heating: Savings on Capital Investment and on Fuel

Community leaders and business owners in the Northeast regularly confront the question, "Is the time right for me to replace my large fossil fuel heating system with a pellet-fired system for the savings that are available in fuel prices?"

This question is generally followed by a cost-benefit analysis in which the capital investment required includes the full replacement of the oil-based system. When the analysis results in an acceptable payback term for the community, institution, or business, the project is completed. When the fuel cost difference doesn't lead to a payback period that satisfies the decision-makers, the project is put on hold for another time.

While the question is often considered a simple one with only two possible system configurations, all oil or all renewables, there is a third option that deserves careful consideration when doing a cost-benefit analysis to decide when the time is right for your organization to switch to renewable fuels for all the benefits that entails. A part- load capacity renewable heating system has most of the fuel savings benefits of full system replacement with only 60-70% of the capital costs.

Part-load capacity heating simply means the creation of a hybrid heating system in a building through partial replacement or supplementing of the existing fossil fuel system with a pellet boiler system. To consider part load heating, imagine a commercial building with a peak load demand of 2,000,000 BTU/hour. That means that on the coldest days of the year, the total heating system would be required to provide 2MM BTU/hour to meet the heat needs of the building's occupants. Therefore, the installed total heating system must be able to provide that amount of heat.

However, in the climates of New York and New England, most of the heating over the course of a year is done at temperatures of 25°F, or higher, when only 1,000,000 BTU/hour or less would be required to heat the same building. So, if the building were retrofitted with pellet boilers to provide up to1MM BTU/hour and retained oil boilers to provide up to 1MM BTU/hour additional heat during the coldest days of the year, the pellet boilers would provide between 92% and 94% of the heat required for the building over the course of the heating year. The pellet boilers would operate during the entire heating season providing all the heat for the building down to an outdoor temperature of approximately 20°F. Below 20°F the pellet boilers would continue to operate at maximum capacity but the heat would be supplemented by the oil-fired boilers only as necessary to make up the difference between the pellet boiler capacity and actual heating load.

In our geographic region, this hypothetical building would have heat provided during 4838 hours (the number of hours/year that outdoor temperature is below 55°F) over the course of the year providing a total of 3,144 MM BTUs. For most of New England and Upstate New York, there are only about 850 hours during the heating season when the outdoor temperature is below 25°F.

Assuming comparable efficiencies for large oil boilers and pellet boilers, fuel consumption for those 3,144 MM BTUs would be as follows:

Annual Fuel Consumption for All-pellet or All-oil Boiler Options

Fuel	BTU/unit	BTU demand/yr	Consumption
Pellet	16MM/ton	3,144 MM	245 tons
Oil	138,700/gallon	3,144 MM	28,334 gallons

Pellet only retrofit model

With a retrofit of pellet boilers for the entire heating load, savings would be driven by the difference in cost of energy between pellets and oil. For example, if the difference in price between pellets and oil in fuel cost reduction/gallon equivalents were $1.50/gallon, the savings realized by a complete conversion from oil to pellets would be $42,501/year (28,334 gallons * $1.50).

The payback period then, on a full-system replacement would be capital costs/$42,501

The payback term on a full-system replacement assuming boiler replacement was necessary anyway would be

capital cost, pellet boiler installation - capital cost, oil boiler replacement
$42,501

Hybrid retrofit model

Retrofitting this model building with pellet boiler capacity to handle 50% of the peak demand, or 1,000,000 BTU/hour, while leaving an oil boiler in the system to provide heat when higher demands are present would produce surprising results. Capital savings can be 30-40% over a complete retrofit, but fuel savings do not drop proportionally because *in our climate 92-94% of the heat load of the building is provided by the pellet boiler having capacity equal to 50% of the peak heating load of the building*. That is, in this example the pellet boilers would provide the vast majority of the heat required for the building over the course of the year. Fuel consumption for this building under each of the three retrofit scenarios in a typical year in the New York/New England region, are represented in the chart below.

Fuel	**Total heat load**	**Oil consumption**	**Pellet consumption**
Oil system	3,144,000,000 BTU	28,334 gallons	0 tons
Pellet system	3,144,000,000 BTU	0 gallons	245 tons
Hybrid system*	3,144,000,000 BTU	2062 gallons	228 tons

*assumes pellet boilers provide 1MM BTU/hour and oil provides 917,000 BTU/hour

With a retrofit of pellet boilers for half of the heat demand (baseload) savings would again be driven largely by the difference in energy cost between pellets and oil. If the difference in price between pellets and oil in fuel cost reduction/gallon equivalents were $1/50/gallon, the savings realized by a part load conversion from oil to pellets would be $ 39,408/year, or 92.7% of the savings for 60-70% of the capital investment.

Summary

When considering retrofits of existing oil heated commercial or institutional facilities, decision-makers should carefully consider the hybrid model in which pellet boilers provide 50% of the heat load and an efficient oil boiler provides the additional heat during the very small part of the year when 50% heat load is insufficient. Capital costs for the retrofit are substantially reduced and fuel cost savings are nearly as good as with a full system retrofit.

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9 Appendix B

Boiler regulation summary for US states sharing borders with Canadian provinces

State	Expressly accepted standards	Inspectable	Exemptions	Notes
Maine	ASME	>200,000BTU/hr (58.6kW)	Hot water heating boilers* Hot water supply boilers* Steam heating boilers* In residences and apartment houses of <6 apartments** When heat input ≤200,000 BTU/hr, water temp <200F, or water capacity <120 gal** Agricultural bldgs.	*Boilers, except in schoolhouses ** Pressure vessels
New Hampshire	ASME, EN 303-5:1999 for biomass boilers	>200,000BTU/hr (58.6kW); water temp ≥210F	In residences and apartment houses of <3 apartments	
Vermont	ASME, CSA, EN 303-5 (up to 250,000BTU/hr (73.2kW), 60 gal, 30 psig MAWP, larger with permission of commissioner	>200,000BTU/hr (58.6kW); water temp ≥210F in "public buildings" as defined	"most residences"	Exemptions not clearly articulated. Vermont uses adjusted EN 303-5 data for emissions testing
New York	ASME	All boilers except those exempted.	Agricultural bldgs. Steam boilers >15psig, in apartments of <6 families. Hot water boilers in dwellings occupied by <6 families. Boilers <100,000BTU/hr	
Pennsylvania	ASME	All boilers except those exempted.	Agricultural bldgs. In single family residence or apartment bldg <u>≥4 dwelling units</u>	
Ohio	ASME	All boilers except those exempted	Steam boilers >15psig, in apartments of <6 families. Hot water boilers <u>≤160psig, or water temp</u> <250F in private residences and dwellings occupied by <6 families.	
Michigan	ASME, UL2523 for solid fuel*, NFPA 85 for boilers greater than 12,500,000BTU/hr input		1 and 2 family dwellings	*UL 2523 requires ASME vessels
Wisconsin	ASME with provisions for accepting other standards; CSA B51 approved under those provisions. Special non-ASME provisions for "solid-fueled water heating appliance" (outdoor wood heater). "Boilers and pressure vessels designed to other national or international standards may be approved if the design has been accepted by a nationally recognized independent third party and the department, or if the standard has been accepted by the department."	All boilers except those exempted	"Heating boilers in dwelling units"; "installations at one- or two-family dwellings."	
Minnesota	ASME	"Qualifying boilers," ≥200,000BTU/hr capacity	In buildings solely for residence with accommodations for <6 families	
North Dakota	ASME	All boilers except those exempted.	Noncode steel boilers can't exceed 15psig MAWP(existing boilers). Boilers installed in private residences and apartment bldgs with <6 units	All boilers require North Dakota stamp
Montana	ASME			
Idaho	ASME	All boilers except those exempted. Non-ASME vessels tested under API 510	When heat input ≤200,000 BTU/hr, water temp <200F, or water capacity <120 gal**; boilers installed in private residences and apartment bldgs with <6 units	** Pressure vessels All boilers/pressure vessels equire an Idaho identification number
Washington	ASME	All boilers except those exempted.	Hot water heating boilers <30 psi operating pressure, private residences and <6 unit apartment bldgs.	