THE EFFECTIVENESS, EFFICIENCY AND BURDEN OF REGULATION IN A MARKET TRANSFORMATION PROCESS: THE CASE OF CANADA

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Abstract: In Canada, a set of private and public sector initiatives converged starting in 2005 to engage the industry in a major market transformation led by the Canadian GeoExchange Coalition. The growth of ground source heat pump markets has proven directly related to the establishment and deployment of this national market transformation strategy. Five years into the process, industry stakeholders in Canada have identified major problems with current regulations, codes and standards. In addition, some market strategies deployed by utilities and governments proved ill-defined and have restrained industry growth. This paper evaluates the effectiveness, efficiency and burden of current regulation, on the marketplace.

Key Words: ground source heat pumps, market barriers, regulation, market efficiency, standards

1 INTRODUCTION

In 2005, Canada's industry association, in cooperation with federal and provincial levels of government and on behalf of key industry stakeholders, embarked on the creation of a new national quality program as part of a larger initiative at market transformation. This initiative, broadly consulted and partly a product of policymaker consensus, included development of original training courses, a separate professional's accreditation, company qualification, and individual system certification. In its first four years, the industry association – Canadian GeoExchange Coalition, hereafter CGC – has seen national market growth annually of approximately 40%. Stakeholders credit the quality program approach as a key factor.

After reviewing, analysing and certifying more than 14,000 residential ground source heat pump systems from April 2007 to the present, Canadian GeoExchange Coalition (CGC) staff have built a comprehensive inventory of faulty regulation, ineffective labour laws, inadequate municipal by-laws and practises, contradictory standards and like issues. With the advent of the quality approach, CGC staff quickly realised that the vast majority of existing Canadian HVAC regulations, codes and standards – collectively the industry's regulatory framework – were clearly not designed with ground source heat pump (GSHP) systems in mind. Moreover, of the documents specifically designed for GSHP systems, neither the industry as a whole nor consumers have been well served by them.

This paper will focus on two specific examples. We will first look at the case of Canadian standard *CAN/CSA-C448-02 Design and Installation of Earth Energy Systems* (hereafter Standard C448), analysing it in the context of the industry-led market transformation initiative. Our second discussion will focus on the energy performance test procedure *CAN/CSA-C13256-1-01 Water-source heat pumps – Testing and rating for performance – Part 1: Water-to-air and brine-to-air heat pumps*. We will look at this standard both from a technical perspective and from a regulatory and program perspective. We will first review the purpose of regulations generally, discuss the two examples, and then we will evaluate and compare the two documents in light of these purposes.

2 REGULATION, CODES AND STANDARDS

Market transformation is a fairly well-structured and defined policymaker tool. No one will dispute the idea that market transformation leading to the introduction of a new technology, product, or service includes the use of regulation. But regulations, codes and standards can also be negative weapons restraining an industry and therefore these tools require careful consideration by well-informed policy makers and discerning regulators.

The untimely introduction or application of codes and standards can have an adverse impact on the availability of other market transformation tools such as technical training, customer education or infrastructure such as professional accreditations and on the overall performance of utility and government programs. In addition, the misuse of regulations can also significantly damage the business of some industry stakeholders while creating imbalances and biases in favour of others. We have seen each of these cases occur in the past five years in Canada. For this reason policymakers generally need pay careful attention to the stakeholders behind any industry group's composition and position.

Society needs codes, standards and regulations for a variety of reasons including first and foremost, customer protection and worker safety. Electricians or gas fitters are trained on safety procedures to keep them from harming themselves and also to protect the integrity of local buildings and their customers. The same goes for many professions and trades.

Society also elaborates and enforces codes and standards to codify the deployment and use of a technology once it is considered market-mature and technically understood (Rosenberg 2009). The standard attempting to codify a technology before the market or technology has matured, would by definition be incomplete and very likely do not serve its purpose. Furthermore, when an industry or technology is characterized by a number of sub technologies, it is important to codify all of them, at once, in order not to create biases and distortion in the marketplace.

A standard, code or regulation, in addition to capturing sub-technologies, should not exclude any sub-technologies – it must be comprehensive in order to serve the entire industry and all consumers with safety, minimum performance, and in the name of fundamental competitive market fairness.

A standard or code or regulation likewise should lay out generic principles, broadly applicable, and should not favour specific products but rather should name performance criteria. That is, rather than naming a resin number for pipe composition, a standard must require a minimum tensile strength and other like properties which when followed will help guarantee safe minimum system performance. This regulation in the name of safety, minimum performance, and fundamental market fairness, is in everyone's long-term interest.

Of note, this performance focus is also important in that it should not unduly restrain future components or products, whether innovative or non-innovative, which may be brought to market and help the industry expand and compete. Standards, codes or regulations which name (let alone require) specific products or practises may directly restrict innovation and distort competition. Therefore, the most broad and generic high-level documents which focus on safety and minimum performance will more likely serve industry and consumers – society – best in the longer term.

A design and installation standard excluding one or more specific sub technologies (direct expansion for example), or including any specific product, would likely reflect imbalances or specific interests unduly weighing on standard development committees.

Finally, any design and installation standard, code or regulation should be developed and deployed in proper sequence, that is, only once the prior market transformation steps and phases have been completed (Rosenberg 2009). For example, what is the point of having a detailed standard if the industry is still manoeuvring in its pilot phase, seeking to raise awareness and demonstrate the basic feasibility of the technology? A sound set of community technical guidelines are necessary and sufficient up and until the industry has reached the technology propagation phase. Putting a formal standard in place – with all the effort and cost that entails from industry – before reaching this propagation phase, will only establish barriers and rigidity in the market before the industry is fully in the market. A design and installation standard will be appropriate once the industry has gained – or is positioned and able to gain – some significant market share (NEEA/PSM 2006).

For policymakers in many countries, the temptation to codify a technology immediately, before it is in place as a market option, especially for renewable energy technologies, is overwhelming. It looks like action, after all. To our knowledge however, no one in North America has effectively analyzed the effectiveness of codification on heat pump industry growth, in the past 20 years.

3 CASE NO. 1: CANADIAN STANDARD C448

3.1 Structure

Standard C448 is organized in two main sections. Section one deals with the design and installation of earth energy systems for commercial and institutional buildings, while section two deals with design and installation of earth energy systems for residential and other small buildings. *A priori*, there is nothing wrong with this approach as the design and installation of systems in commercial buildings are more complex than residential applications and require more stringent sets of rules including, among others, the involvement of professional engineers and hydrogeologists.

However, with regard to structure and language within Standard C448, there is a major disconnect with market reality. Rather than spelling out directives for residential applications in the residential section, section two consistently sends the reader back to section one (the section for commercial applications) for reference. Usually this means that the residential section in actual fact requires commercial criteria plus additional criteria for residential work – exactly the opposite of the authoring subcommittee's intention, according to meetings we have attended and/or convened. This referral issue is one of the fundamental flaws of the standard.

An example illustrates this point. In C448.2 2002 (residential), clause 6.1.1 stipulates the following: *The contractor shall ensure that a site survey meeting the requirements of Clauses 6.1.2 to 6.1.4 is conducted prior to undertaking the system design.* To fully understand the consequences, note that standard C448's version 2002 is referred to in Canada's National Building Code. By this reference, standard C448 thereby becomes part of provincial building regulation. This is not an unusual structure.

In our example, the municipal building official in charge of judging and delivering permits for the installation of ground source heat pump systems reads Clause 6.1.1 of C448.2. Upon reading the phrase "*meeting the requirements of Clauses 6.1.2 to 6.1.4*," the building official is referred to Clause 6.1.3 of C448.2 which says: *Water-well and other available geotechnical* *records for the area shall be reviewed by a hydrogeologist to assess general anticipated subsurface conditions, the water table, the potential for encountering a water supply aquifer, and any interference with neighbouring wells, and to recommend the number of test wells.* The Inspector - logically and correctly according to the standard - will require nothing less than a full hydro-geological study and report.

In the past three years, CGC staff has been repeatedly challenged by municipal building officials insisting on site suitability reports from a registered hydrogeologist. While this requirement makes full sense for commercial applications, it is totally out of proportion to system size and a significant, pointless cost burden for a home owner. Requiring such a report essentially prices a system out of reach for the residential market.

This structural flaw in Standard C448 has been one of a number of significant regulatory barriers to the wider introduction of ground source heat pumps systems in many Canadian communities. It is also a very good example of a standard poorly developed and therefore harming the industry while also working against policymaker objectives.

3.2 Content

From the first lines of C448, a few items stand out. The energy flow principles behind ground source heat pumps imply a wide variety of technologies, methods and approaches. While it is true that brine-to-air heat pumps are most common, direct expansion and standing column well technology, to name a few, have also proven efficient over the years. Strangely enough, these two technologies were specifically excluded from Standard C448 and its predecessor, Standard C445, in the early 1990s.

The purpose of a standard includes defining and helping ensure safety as well as minimum effectiveness standards for a technology. One would question the very raison d'être of a specific standard, if known and proven technologies are excluded. In the past five years, the authors have asked this question to many industry stakeholders, and have never received a clear answer. In the absence of such answer, many respondents have speculated on the motivation behind the creation of the standard in the first place in the early 1990s. Others are more critical about the narrow application of the standard, which focuses exclusively on specific design and installation methods rather that covering all known methods. In any case this exclusion clearly limits GSHP market growth and harms select companies.

As market analysts know, standards, codes and other regulations can become very effective non-tariff market barriers for the introduction of new technologies. An example of this is the way that variation in voltage requirements and plug shapes across different countries works to limit sales of any simple consumer product. With more complex technologies we would expect more complex barrier issues to arise through standards and codes. However, the least we could expect from a standards organization is to ensure proper national technology representation on its committees and adequate (in expertise and in geographic area) field experts at the table to define the broadest consensus in the 'home' market. If the standard process fails from the onset to minimally guarantee these two basic elements, the standard itself will fail since it will reflect the narrow business interests of a few market players, not the interest of the entire industry. In short, a standard can not only be ineffective for what it includes but also for what it excludes.

3.3 General approach

Attempting to certify more than 14,000 systems to Standard C448, within the CGC's Global Quality GeoExchange Program, has been a major challenge for the CGC. Reviewing only a few hundred applications raised the many contradictions contained in the document. This problem caused such concern that the CGC decided to engage industry stakeholders in a national consultation on codes, standards and regulations in 2009, in cooperation with several Canadian governments. This exercise confirmed our hypothesis at the time: the general regulatory environment is not favourable to the sustained growth and expansion of the industry. Far too many loopholes, contradictions, confusions and exclusions exist. More specifically, one of the main conclusions of this exercise was that Standard C448 is actually a random and counterproductive combination of performance and prescriptive based measures (CGC 2010).

For example, as mentioned earlier, there are a certain number of referring standards which frame the GSHP industry in Canada. In terms of the use of pipe for ground heat exchangers, Standard C448 refers to standard *CAN/CSA B137.1 Polyethylene Pipes, Joints and Fittings for Cold Water Piping* (B137.1). Standard B137.1 specifies cell composition numbers 345564 or 345434, in reference to ASTM D3350-01 (2001 edition). At the revision of standard ASTM D3350 in 2005 (ASTM D3350-05), the cell classification limits were changed. The changes imply that PE3608 possesses all the mechanical properties of PE3408 but that PE3408 does not necessarily possess all the mechanical properties of PE3608. To lessen confusion, pipe manufacturers dealing with standard ASTM D3350-05, who wish to produce correctly marked pipe per Standard C448 usually mark their pipe "PE3408/PE3608." Therefore the current version of Standard C448 refers to a product where the mechanical properties are inferior to other products available on the market and which are listed under standard ASTM D3350-05.

These standards are unfortunately not updated either regularly or in a synchronised manner, and this creates serious interpretation problems when one standard refers to another. Frequently some standards do not reflect current science – either basic or advanced science – or new industry best practises, or are not conceived for design of GSHP systems at all. Further, these other standards referred to by Standard C448 may be changed in a way harmful to the industry or to Standard C448 itself. Additionally many innovations may fall under other standards which are more up to date and reflective of market realities. Interpretation is therefore required more often than it need be, and common sense and logic must therefore prevail when interpreting a set of standards. This need for interpretation creates a further avoidable point of weakness in the regulatory / codes chain, and further puts growth of renewable energy technology deployment at unnecessary risk.

Given that Standard C448 has not been updated in some time, it currently does not reflect the proper cell classification defined in ASTM D3350-05. As a consequence, PE4710 (cell classification 445574) is not part of the 1999 version of standard B137.1, which standard C448 requires. PE3408, for its part, figures largely in C448 but is no longer mentioned in the 2009 version of B137.1, suggesting that the resin is obsolete or in some way dangerous. The effect of this confusing system is to effectively exclude the more modern PE 4710, while requiring piping resins largely no longer used by industry.

Further, according to the older ASTM D3350-01 which Standard C448 requires, PE3408 is the only pipe number allowed. Standard C448, even in its updated version (dated October 2009), still does not reflect the changes made within standard ASTM D3350 in 2005 or in the 2010 update. In the 2005 revision of standard ASTM D3350, PE4710 was given a cell classification including a 445574 resin. Upon comparing cell classification of PE3608 (345564) and PE4710 (445574), one will find that the mechanical properties of PE4710 equal or surpass those of PE3608. The current version of Standard C448 thereby actually excludes superior products and also innovations.

But this is not the end of the story. PE100 is governed under International Standards Organisation (ISO) standards, and first appeared on the European market in 2002. In fact the introduction of this product in North American markets inspired the changes reflected in standard ASTM D3350 in 2005. Improvements in the category of Slow Crack Growth Resistance (SCGR) allowed resin manufacturers to push the boundaries of these resins in other areas. One such area includes hydrostatic strength classification as well as design life. PE100 pipes have higher pressure capabilities as well as a minimum forecast service life of 100 years compared to that of a 50 year service life for other HDPE resins.

The designation number awarded to PE100, as a function of its mechanical properties according to ASTM D3350-05, is PE4710. Currently, according to a list maintained by National Safety Foundation (NSF), cell classification of PE100 is 445576. A unique cell classification distinction between PE4710 and PE100 is the last cell. This means that PE4710 and PE100 respond similarly, with some improvements, to the same fundamental properties – cell classification limits – for density, for fusion index, for flexural modulus, for tensile strength at yield, and for slow crack growth resistance. A major difference, which the last number indicates, refers to the method used for hydrostatic resistance tests. This means the two markings are not tested according to the same hydrostatic resistance standard: standard ISO 12162 was used for PE100 and standard ASTM D2837 for PE4710. The reason for this variance is mentioned in clause B137.0-09 which explains that this second method for determining hydrostatic resistance can establish different pressure capacities for a given pipe, made from that resin.

Finally, we note that at the structural level, Canada's building code system refers to different versions of standard C448, depending on the date of the latest provincial building code review. That is, province of British Columbia may require C-448 from 2002, while the province of Nova Scotia could require the predecessor C-445 (of the same title), from 1995, and its neighbour New Brunswick may not refer to the standard at all.

How is the marketplace reacting to this standards confusion? Some years ago, a major distributor of ground source heat pump equipment attempted to obtain the exclusive distribution rights of PE100 pipes in Canada. The pipe manufacturer declined this offer. This attempt to corner the market failed but the distributor then turned around and used the outdated standard to claim that PE100 pipes were not as good as PE3408 and should therefore be declared illegal. This blatantly cynical attempt to control a portion of the market works against both policymaker and industry long term goals.

In response to this issue, CGC wrote and published an extensive technical note on this issue in September 2010 (Hénault et al. 2010). Most of this section is directly inspired by this document. It is our view that the technical note should have been done by the organization who wrote the standard, not the national industry association. While we first thought this was a waste of time and energy, the exercise in the end opened our eyes. We realized that this is a classic case of an industry stakeholder trying to control the market through a narrow reading of a standard.

A second and possibly more serious marketplace reaction concerns us more: industry stakeholders, including participants in the national quality program who have thereby committed to a higher ethical standard, have asked the authors to allow technically illegal practises, and in other cases, must simply ignore the letter of the law.

These circumstances – particularly the prescriptive nature of Standard C448 – conspire against the expansion of the industry. Highly ethical companies wishing to work in two or more provinces may actually violate a provincial law by using current and identified best practise in either province. Meanwhile, ethical contractors in a province with no standard are at the mercy of less honest competitors, as less-than scrupulous competitors may correctly refer to outdated practise as the only legal option.

Taken together these reactions offer a perfect example of how a standard can fail if developed without considering industry needs and, most importantly, without comprehensively considering market reality.

4 CASE NO. 2: CANADIAN STANDARD C-12356

Standard C-13256, a Canadian variation on ISO 13256, is an energy performance test procedure for brine and water-source heat pumps. The standard determines the coefficient of performance (COP) of heat pumps under particular laboratory specifications. According to Standard C448, all heat pump equipment used in compliant systems must meet the requirements of this performance standard.

Energy performance standards for gas furnaces or refrigerator appliances however do not compare directly to those for ground source heat pump systems. Plugging a refrigerator in, in almost every home in Canada will likely draw a comparable amount of energy under comparable conditions because the unit can be considered as an entire system – all components are pre-designed and matched to the various appliance motors. With a plug-in appliance, design and installation considerations are essentially included with every unit at the time of performance testing.

We mentioned above that performance tests are executed under particular specifications. In the case of heat pumps in North America, the performance test is done at a specific entering water temperature, namely 32^{o} F / 0^{o} C. In the field however, entering water temperature varies throughout the year. We conclude that the theoretical COP of the heat pump unit will not be the same as the seasonal COP (SCOP) of either the unit or the entire system.

This means that a heat pump connected to a ground loop does not behave like a refrigerator. At the risk of oversimplifying, a ground source heat pump system has three important components: (1) the ground loop and the surrounding soil conditions; (2) the heat pump itself, including the installation; (3) the distribution system, whether water to air or water to water. These components are all linked and may be optimised through proper design and good installation practise. In our experience, undersized equipment, mismatched equipment, designer errors, installation errors, unexpected or badly evaluated ground conditions, and changes in operator behaviour will all have significant impact on the overall annual system performance. The rated heat pump COP will only make, if any, a marginal impact on the overall annual system performance. Among these components, in developing actual reliable efficiency targets for installed GSHP systems, less importance should be attributed to the heat pump and its theoretical or laboratory-defined coefficient of performance.

A study done by Manitoba Hydro (Andrushuk 2008) on ten homes in the province of Manitoba showed that the average system COP was roughly 15 % less, on average, than the heat pump COP.

(Hénault and Tanguay 2011) also analysed a sample of the 14,000 systems certified by the CGC since 2007 and found that in many cases, SCOP of the systems were lower than the theoretical heat pump COP for the higher ranking heat pump, while lower heat pump appliance COPs actually correlated with higher system SCOP.

In Canada, the Government of Manitoba established a retroactive tax credit program in early 2009 requiring a minimum heat pump (unit) COP. While we are convinced that this tax credit regulation was designed with good intentions, the reliance on a unit performance standard had an unexpected effect. A local heat pump manufacturer who, at the time, didn't have all his heat pumps rated at the minimum required COP suffered greatly from this regulation and saw his sales dive accordingly. Fortunately, the manufacturer eventually recovered from this ill advised regulation, thanks to his own resilience.

In reviewing actual installed systems, we have discovered GSHP systems equipped with a 3.8 COP heat pump providing a seasonal COP of 3.2 while we have discovered other systems equipped with a 3.2 COP heat pump, providing a seasonal system COP of 3.8. Financial assistance programs requiring minimum heat pump COP are therefore asking for something which is unrelated to and may not deliver the expected energy savings while excluding models which are no less capable of delivering the expected savings.

Adequate design and verification of proper installation are the key factors in delivering performance in the field – hence Canada's national quality program focuses on certifying these steps.

5 THE CODES AND STANDARDS PURPOSE TEST[1]

Codes and standards are usually developed with three objectives in mind. The first is the desire to reach effectiveness, that is, capacity to resolve existing or likely issues or problems. The second objective is to attain efficiency, meaning to help the value chain work productively with minimum wasted effort or expense. Finally, the standard is expected to avoid imposing a burden on industry or consumers while defining absolute minimums for safety purposes.

Examining codes and standards in light of these objectives and asking to what degree the document meets these three criteria forms a *de minimus* or simple purpose test. Any design and installation standard for GSHP technology – a standard which defines the bare, legal minimums - should pass this test.

5.1 Does Standard C448 Pass The Purpose Test?

Considering the discussion above, the next logical step is to gauge whether Standard C448 passes this purpose test.

Is Standard C448 effective? The answer is clearly no. Standard C448 is full of incoherence, particularly the cross references between the residential and commercial sections of the standard. Furthermore, many critical aspects are not discussed or covered. Fundamental areas such as defining what a system is are not addressed. Rather than resolve existing or likely issues, this standard creates additional problems for the vast majority of stakeholders.

Is Standard C448 efficient? Once again, the answer is no. The standard is generally counterproductive. We have documented a set of contradictions above, with the piping section a vivid case in point. Throughout, the standard is out of touch with market reality. The standard simply by requiring many cases of industry interpretation, actually creates inefficiencies.

Is Standard C448 a burden? Yes. By focussing on only a subset of the industry and excluding certain technologies, the standard itself restrains or kills innovation and certainly harms the commercialization of new products and methods. Here again, the debate around PE100 is a very good example; exclusion of direct expansion systems was extremely harmful for the industry once governments and utilities decided to refer to the standard for their financial assistance program. Exclusion has also generally contributed to delay research and development activities around new technologies.

[1] This test was established by CGC staff as an analytical framework to study and comment on existing and proposed codes, standards and regulations.

One final matter must be mentioned: standard development processes are very expensive, take a lot of industry time and are only reviewed, at maximum in the Canadian context, every five years or so. This means that if an industry stakeholder happens to be ready to introduce a new product in the market the day after a new standard is put in place, it will take another 5 to 7 years before his or her technology or method is considered in the standard. In the specific case of Standard C448, because it is referred to in the building code, the new technology (including new methods) may well be disallowed by building officials. This is not a very efficient way to move an industry forward. It is nonetheless the Canadian market reality.

5.2 Does Standard C-13256 Pass The Purpose Test?

Standard C-13256 does not address or anticipate these larger issues implicit in Standard C448, but as a product standard limits itself to the laboratory performance of the appliance. By limiting its scope, Standard C-13256 performs its job of checking minimum component performance and helping ensure basic equipment safety.

Is Standard C-13256 effective? We conclude affirmatively: C-13256 has the capacity to produce the intended result, which is establishing a comparative performance rating. We question however the meaning of this number as applied in the field.

Is Standard C-13256 efficient? Yes. We find no evidence that this standard involved wasted effort or expense. The standard seems relatively benign for Canadian industry, except that it requires humidity test conditions not usually found in Canada.

Is Standard C-13256 a burden and an industry weakness? On balance, no. Standard C-13256 requires expensive testing for verification, which is currently unavailable at any independent laboratory in Canada. This burden however is not directly caused by the standard.

5.3 Is Canada's Industry Well Served by its Codes, Standards, and Regulations?

While engaged in the certification of more than 14,000 residential systems over four years, CGC staff has concluded that the answer to the above question is a resounding no. This conclusion is also supported by our 2009 industry consultation on codes, standards and regulations (CGC 2010). Almost none of the existing codes, standards and regulations were developed for the ground source heat pump industry, and the current body of often conflicting technical documents are unevenly enforced.

Additionally, we have found that specific labour regulations – developed for traditional HVAC products and services – were not equally enforced by authorities having jurisdiction, and in some cases, were simply not enforceable because of conflicting legislation or regulation. As a consequence, a significant portion of GSHP systems in both the residential and commercial markets in Canada could be considered illegally installed although they are working safely and meet common-sense interpretation criteria, and were installed by licensed trades-people.

We also found that federal and provincial governments' policies are often in conflict with municipal policies and by-laws. Finally, government procurement policies often refer to older versions of codes and standards, adding to the already complex confusion between suppliers and customers.

At the time of publication of this paper, a new version of Standard C448 is in final preparation. Before engaging in this process, no one questioned the need for a standard. In fact, the real question should be whether there is a specific need for a *design and installation* standard. The authors believe it is at least worth asking the question.

In fact, there are more questions that should be asked at various points before and after beginning a standards development process. Are we as an industry trying to fix something so problematic, that it will only get worse? What are we trying to accomplish? Do we have the right set of industry specialists involved? What should be the nature of the standard? Are we covering all technologies? Is the process transparent? Are we taking all the time required to prepare a relevant product or are we trying to finish up the job in a rush to move on to another file? Are we establishing regulatory market barriers, safety minimums or defining broad basics? Are we effectively killing research and development efforts? These are fundamental open questions which remain unanswered by the standards development process or organisations. We conclude that these questions can best be addressed by credible, professional national industry associations, working with their membership and governments.

6 CONCLUSION

There are many surprising lessons to be learned from these recent Canadian experiences.

The first and perhaps least obvious lesson is that any design and installation standard should be performance based, not prescriptive. The CGC experience in dealing with piping issues is probably the best example. Piping materials should be referred in a standard according to minimal physical properties, not their colour of their wall thickness as in the current standard.

Second, because they cross reference each other, codes, standards and regulations can not only be a burden for industry but also can serve as very effective market barriers to competition, to research and development activities, to introduction of new technologies and to overall market expansion or growth. For example, while we can speculate on the full reasons why direct expansion technology was excluded from Standard C448, the answer must lay to a great degree within the committee composition. If the consensus of a subcommittee - competitors all - is to exclude a technology, chances are it will be excluded and the group did not have full industry representation. Proponents of direct expansion (principally manufacturers and installers) suffered great financial losses in Canada when the ecoENERGY incentive program offered financial assistance only if the system was Standard C448 compliant. All technologies not covered by the standard (notably direct expansion and standing column wells) were thereby excluded, de facto, from participating in this government incentive program.

The third lesson is that equipment performance ratings for ground source heat pump appliances are not correlated with system performance, and should not be used in market transformation initiatives and programs. Only a program which reviews and verifies installed system performance individually, is likely to achieve expected or reliable savings.

Finally, the authors have reached the conclusion that a standard for the process of design and installation – expensive, and inevitably and structurally behind current market realities, cumbersomely bureaucratic, subject to interpretation and uneven application, and also often subject to human failings in the editing process – is counterproductive to the goals of enabling effective and efficient market growth. Product standards to cover the components used within GSHP design and installation however, helping to ensure safety and minimum performance, are helpful, are enforceable and present many fewer opportunities to work against an industry’s overall development.

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