Waste not, want not: prioritizing waste heat as an energy resource

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Abstract

In the U.S., the average electric generating efficiency is 32 %. Waste heat from electric generation as well as industrial processes is routinely ignored as a resource in American energy planning. In contrast, Denmark has a long history of prioritizing heat in its energy planning activities. Denmark's success in decoupling its greenhouse gas emissions from its economic growth is due in large part to the extensive district heating system found throughout the country, and the low-emission sources of heat that supply that system. In certain municipalities industrial waste heat plays a significant role in heat supply, enabling cities to cost-effectively meet their heat needs while providing industrial facilities with a revenue stream for what would otherwise be viewed as a waste product. Using examples from Aalborg, Denmark, as a representative Danish city, this paper identifies the role industrial waste heat has played and could play in the future of Danish district heating. This paper examines the policy construct that supports the leveraging of industrial waste heat resources in Denmark, and discusses whether such a construct might be applicable to other countries with industrial waste heat resources. The United States is used as the primary country of comparison. The paper ultimately finds that much of the policy construct in Denmark could be applicable to existing aspects of American energy activities.

Introduction

A BIG WASTE IN THE U.S.

About two-thirds of the fuel used to generate energy in the United States is lost as waste heat. The sectors most responsible for that waste are transportation, electric generation, and industrial facilities (LLNL 2013). In many cases, the electric generation and industrial sectors generate high-enough quality heat that could, in theory, be used for domestic heating or hot water needs in residential or commercial buildings. However, the physical and political framework that would enable such a use of heat is largely absent in the U.S. For instance, the heat from the electric generation sector is largely located far from potential end-users of heat, and most facilities are not located near district heat transmission systems, leaving no available mode of transmission for the heat. Similarly, industrial facilities in the U.S. are typically located in industrial-zoned areas, deliberately located away from big commercial buildings and residential developments.

The traditional centralized electric generation systems found in the U.S. and throughout the world are also inefficient at the point of generation, and thus not nearly as cost-effective as they could be. Indeed, as noted by (Laitner 2013) the electric production system in the United States is a paltry 32 % efficient. In situations where the electric generation is combined with usable heat production, such in the case of combined heat and power (CHP), electric generation is markedly more efficient in the U.S. (Chittum and Sullivan 2012). However, CHP only represents about 8 % of installed electric generating capacity in the U.S. (DOE 2012).

The U.S. has not traditionally prioritized waste heat as an energy resource, as explored later in this paper. This has lead to a situation in which significant waste heat opportunities are present, but are largely under-utilized. A change in the manner in which the U.S. considers its waste heat could lead to a significant increase in the country's overall energy efficiency.

AN ALTERNATIVE APPROACH IN A MORE EFFICIENT DENMARK

Denmark is one of the most energy-efficient countries in the EU and among the Organization for Economic Co-operation and Development (OECD) countries. While the Danish economy has grown 78 % since 1980, the country's total energy consumption has remained quite flat (Energi Styrelsen 2009). Improvements in energy efficiency and reductions in waste have been prioritized across all sectors, and the country as a whole has worked toward nationwide energy efficiency goals since the late 1970s. Two of the most important factors in Denmark's constantly improving energy efficiency are the increase in the use of CHP and district heating. The last few decades saw a dramatic increase in the use of CHP for electricity production. In 1980 about 18 % of electricity was cogenerated with heat; in 2007 that figure was about 53 % (Energi Styrelsen 2009). District heating has expanded throughout the country in those same years, and has helped to simultaneously improve the efficiency and emissions profile of the heating sector. One analysis found that district heating and CHP were responsible for a reduction of 15 kg of CO_2 per square meter of heated floor area between 1980 and 2010 (Dyrelund et al. 2010), and another found that district heating has reduced Denmark's CO_2 emissions by 20 % since 1990 (Christensen 2009).

District heating remains one of the cheapest ways to heat buildings in Denmark. The aggregating capabilities of district heat systems yield highly cost-effective systems that have been shown to provide heat solutions below the cost of alternative, individual-scale heat solutions. These cost benefits are projected to continue in the future, where district heating is projected by one study to be the most cost-effective way to meet increasingly aggressive energy and emissions goals (Möller and Lund 2010; DEA 2013) by supporting greater integration of low- and zero-emission renewable energy resources.

Industrial Waste Heat in Denmark

Denmark has achieved its efficiency and emissions performance in large part by identifying early on the importance of maximizing the utilization of waste heat resources. Several Danish policies laid the groundwork for these efforts, and remain cornerstones of the Danish approach to energy today. These include policies that:

- Encourage combined heat and power over conventional electric generation;
- Promote local-scale planning of heat resources; and
- Provide a consistent policy framework that encourages industrial facilities to engage in comprehensive on-site energy management.

NATIONAL POLICY CONTEXT

In 1976 Denmark effectively outlawed electricity production that was not also combined with heat production (Danish Parliament 1976). The result of that policy was that a significant number of power plants were converted to CHP, and a base of heat supply could be found throughout the country (Danish Ministry 2012). Several years later the first Heat Supply Act became law, which established a requirement that local heat planning be regularly conducted by local and regional governments. The goal of heat planning was to develop plans for the supply of heat to local areas, prioritizing cost-effective resources and CHP (DEA 1998). Heat planning was to include a physical mapping of heat resources, which would include available industrial waste heat resources, including waste heat from electricity production and industrial processes, as well as other heat resources that may have previously been unknown.

Since these two pieces of legislation in the 1970s, waste heat has always been analyzed as a legitimate heat resource in Denmark. This has always included industrial waste heat, which should be included in any local assessment of available heat resources. Most of the waste heat used in Denmark today is a product of electricity generation, though other sources of waste heat are supplying district heat networks. For instance, in the northern city of Aalborg, the municipal district heating system is supplied with waste heat from a nearby cement plant as well as a crematorium (J. Larsen, 2013).

The waste heat resources used in Denmark are identified as priority resources only after extensive analysis of their cost-effectiveness has occurred. The cost-effectiveness analysis of any future heat sector investment will always include analysis of the environmental and benefits, as well as the impact on both individual consumers and society at large (Danish Parliament 2011, Dyrelund and Overbye, 2013). The decades-old policies encouraging the consideration of waste heat resources deline-

Table 1. United States vs. Denmark. Data Sources: EIA 2014, World Bank 2014, EESI 2011.

	United States	Denmark
Urban population	83 %	87 %
DH share of heat	Minimal	60 %
Installed DH systems	700 systems	400 individual companies
Energy intensity (BTU/USD)	7,329	3,000
Heat planning	Does not occur	Conducted regularly at municipal level
Heat networks used to balance electric markets	No	Yes

ate this, and provide policymakers with a clear starting point from which to assess heat resources and their ability to meet future heat demands.

Importantly, the Danish government operates on a consensus basis, and much of Danish energy policy is the product of consensus agreements by multiple political parties. This continues today, and helps explain why there is so much widespread political support for the energy and climate-related goals that have been adopted by the country. In 2012 the Danish government approved a new wide-ranging energy agreement that was endorsed by most of the country's political parties (Danish Ministry 2012). The agreement established the well-known goal of a fully-renewable Danish energy sector by 2050, and further codified the notion that all sectors of the economy must contribute to the renewable energy future. The Danish government generally views its policies and energy performance as well-positioned to meet existing EU goals for renewable energy, energy efficiency, and emissions reductions.

THE ROLE OF HEAT PLANNING

The Heat Supply Act was amended several times in the past decade, evolving to give more power to municipalities as they undertook their own planning and updated previous analyses of heat resources and heat demands (DEA 1998). Though municipal heat planning is not required in the same sense as it was earlier in the 20th century, existing heat policy now identifies cities as the entity responsible for heat planning, able to require specific actions of heat suppliers and owners of infrastructure. The rules still encourage the maximum amount of CHP and the most cost-effective heat solutions available.

The planning process is very closely coordinated with land use planning and general city and regional development activities, which ensure that developments are considered for connection to existing district heating systems well before ground is broken. It also means that existing industrial waste heat resources are mapped and known, even if they are not actively used to supply a given district heat network. Danish heat planning is predicated on the prioritization of cost-effectiveness, so that resources are prioritized in order of cost-effectiveness to all parties, and a series of price forecasts are provided by the national government in order to ensure that all cost-effectiveness tests begin with the same context and assumptions (Dyrelund and Overbye, 2013, (DEA 2011).

The nationwide planning structure is one that serves to confer substantial autonomy and control to municipal agencies, which often are part of the same entities that own or at least oversee the local district heat system. As long as municipalities continue to promote and identify projects that are cost-effective, the local decision-makers are able to use a variety of resources and sources of heat to supply their district heat systems (Danish Parliament 2011). For instance, in Aalborg, a group of ten industrial companies are having informal discussions with the city-owned district heat company about whether they might sell waste heat to the system in the future (J. Larsen, 2013). These kinds of discussions are a key part of the heat planning process, whereby potential new sources of heat are identified and incorporated into long-term planning documents. The planners of the Aalborg system are constantly looking forward to determine where future heat resources might come from, and whether the market is offering cost-effective solutions.

The long history of political consensus means that in cities like Aalborg, where a municipal election just brought in new leadership in many areas of government, heat planning remains a constant. It is not subject to changing political winds, as energy policies in other countries may be (Dyrelund and Overbye, 2013). This is generally true in all of Denmark. For instance, national prohibitions against the installation of new individual oil and gas boilers in new buildings has and will continue to transcend election-year politics, forming a policy base in support of communal district heating that individual users and district heat system owners can rely on.

INDUSTRIAL ENERGY EFFICIENCY

The European Union and the Danish national government have established energy efficiency goals for Denmark that impact industrial energy users. The energy efficiency directive issued in 2012 by the EU requires all member states to conduct a "comprehensive assessment" of both CHP and district heating and cooling potential as part of its energy efficiency efforts. An update can then be required every five years at the EU Commission's request. Member states such as Denmark are then asked to develop and implement policies that will help the country acquire the identified cost-effective CHP and district heating and cooling potential. The directive also asks that power plants larger than 20 MW are assessed for the economic feasibility of including combined heating capabilities (EU 2012). Industrial waste heat and other existing heat sources are also identified as important resources to prioritize where deemed cost-effective.

One important aspect of EU policies is that member states are given a good deal of freedom in meeting their goals. Countries devise energy goals in the format desired – for instance, as a measure of energy intensity or absolute energy consumption – and then may develop the policies and programs in support of those goals as they see fit (EU 2013). This mirrors the approach Denmark has also taken for its own national energy goals, which are developed on a per-industry basis. In general, Denmark's own national goals and policies are putting it on the course to meet existing EU energy requirements (Danish Ministry, 2012).

Danish national goals for energy and emission reductions are devised as taxes on industry for certain types of emissions and energy consumption. However, industrial facilities may earn rebates against these taxes if they take it upon themselves to identify and implement energy savings projects and programs (DEA 2012). This kind of self-directed efficiency program means there are no prescriptive measures that companies must adhere to; rather, they are enabled to identify their most cost-effective projects and make investments in their companies knowing that they will receive economic benefit beyond just the project itself. Companies are held to high standards, however: in order to develop an agreement with the national energy agency that could yield rebates against taxes, Danish companies must become ISO 50001 certified and show that they have a well-established internal energy management strategy. Though the program has been scaled down to cover a smaller breadth of industrial energy use, companies that were parties to the voluntary agreements indicated in a program evaluation that the scheme helped them become leaders in the implementation of energy efficiency projects around the world (DEA 2012).

There is yet substantial energy savings opportunities in Denmark. A 2010 assessment of efficiency potential in Denmark found that, considering a two-year simple payback requirement, companies throughout the country had savings opportunities of 10 % (Danish Ministry, 2012). Additionally, with the country's overall goal of reaching 100 % renewable energy by 2050, efforts to identify opportunities for new renewable energy investments in the industrial sector are heating up. A pool of dedicated funds to support a subsidy for new renewable projects and renewable-powered CHP in industry was a key component of the country's 2012 energy agreement (Danish Ministry, 2012).

Industrial Waste Heat in the United States

In the United States, there is no existing programmatic or policy structure that encourages industrial facilities to assess their waste heat or attempt to calculate its potential value to society. This does a significant disservice to industrial facilities and society at large, for there is evidence that significant industrial waste heat resources exist in the U.S. (BCS 2008).

NATIONAL POLICY CONTEXT

The U.S. political machine does not operate on a consensus basis, and obtaining wide-ranging support for aggressive energy or emissions reduction goals is difficult at the state and national level. However, by emphasizing the long-term economic benefits of taking advantage of waste heat resources, U.S. policy makers could help build support for new policies that help industrial firms view their waste heat as an advantage.

Some states, and some federal policymakers, have recently begun to recognize the value of encouraging and incentivizing the identification of waste heat resource and potential uses. For instance, the state of North Dakota gives credit within its renewable energy portfolio standard for projects that capture waste heat and "recycle it," in the form of additional electricity generation. Several other states have similar provisions in their renewable or energy efficiency portfolio standards (ACEEE 2014). However, none of these policies explicitly seeks to promote or even suggestion broader heat planning. These policies are available for those individual that have already decided to invest in CHP or perhaps some heat recovery technology, but they are not designed to encourage a community or municipality to consider the role a new or expanded heat network could play in its energy future.

Similarly, rules promulgated by the U.S. Environmental Protection Agency (EPA) will regulate CO_2 emissions from new and existing power plants.[1] The EPA has a long history of promoting and giving credit to CHP plants as a means of encouraging higher levels of energy efficiency. All signs point to the crediting of the efficiency benefits of CHP in final versions of CO_2 rules, but these rules and EPA's efforts to encourage CHP to date have not included encouraging local policymakers to engage in heat planning, which could offer greater scale for higher levels of CHP.

1. See http://www2.epa.gov/carbon-pollution-standards for details on the current rulemaking processes.

THE ROLE OF HEAT PLANNING

Energy efficiency goals at the state level are most often designed as specific goals for electric and natural gas utilities or other administrators of energy efficiency programming, and do not devise broad energy efficiency goals for heat (Nowak et al. 2011). Increased efficiency in individual electric or natural gas heating equipment may be part of the goals, but there is no framework for an assessment of whether that heating might be better supplied by a communal system. There is, in short, absolutely no framework for regularly assessing the cost-effectiveness of a district heat system anywhere in the U.S.

In some cases district heat systems supplied wholly or in part by industrial waste heat have been developed in the U.S., but these are largely systems that are privately owned at an industrial or institutional facilities, and serve only a private district energy system that serves a small number of buildings. Any heat planning that is conducted in the U.S. is typically an ad-hoc, project-specific effort in response to emerging opportunities. For instance, in Seattle, a cement plant's expression of interest in selling waste heat was what prompted the city-owned utility to consider whether expanding an existing steam-based district heat system to the neighborhood was advisable (Zimmermann 2012). There are some notable exceptions, such as the good work being conducted on the municipal level in Portland, Oregon and Seattle, Washington, but they are not typical of most American cities.

In the U.S. energy planning is most often conducted on the state or utility level. Integrated resource plans (IRPs) are the most common venue for energy planning activities in the U.S. today, and are usually conducted every few years at the behest of a state regulator. IRPs are plans developed by utilities that address the demands and supply of that individual utility only (Wilson and Biewald 2013). IRPs are, then, not the appropriate venue for consideration of waste heat resources, since the electric utility conducting an IRP has no economic interest in encouraging an industrial facility to sell thermal energy to another thermal system. Electricity is usually the primary focus of IRPs, and while some do consider CHP systems in their analysis, they are mostly concerned with the likely electric production of such systems, and only assess CHP systems that might provide excess heat to the single onsite host (as opposed to some potential buyer of heat several blocks away) (Chittum and Farley 2013).

While significant effort has been put into supporting U.S. cities' efforts to develop and meet broad-ranging sustainability goals in the last decade or so, these efforts, such as those supported by the U.S. Conference of Mayors, have largely relegated heat planning to a small niche, one that is most often absent from municipal or regional sustainability plans in the U.S. For instance, a recent assessment of local energy efficiency policies in the U.S. found that, of the 34 largest U.S. cities, only two – the aforementioned Seattle, WA and Portland, OR – had plans in place supporting the development or expansion of district heating systems (Mackres et al. 2013, Mackres 2014).

In the U.S. municipal actors are more limited in their power over local utilities when the municipality itself does not own the utilities – which is mostly the case. State-level regulators have control of prices and energy goals related to efficiency and use of renewable energy. Thermal energy is not a regulated commodity in the U.S., so thermal energy systems that are privately owned are basically on their own to regulate themselves and acquire customers. This makes investment in district heating systems a much riskier proposition in most areas of the U.S., because no codified heat planning or involvement by local municipal planners exists to help ensure that the solutions are cost-effective and the appropriate heat resource for the given community.

INDUSTRIAL ENERGY EFFICIENCY

Presently, one small trade association, Heat is Power, is involved in advocating for industrial waste heat as a resource in the U.S. It has only been around for several years, and represents only the small "heat to power" element of waste heat. There is little public information and awareness about waste heat, and waste heat that exists today in the U.S. is typically only viewed as a resource if that facility producing it recognizes it as such. One important opportunity, though, is the strong presence of industrial energy efficiency programs, which are very robust in many states and utility service territories. These programs have long standing relationships with their industrial clients, and are well positioned to engage them in discussions about their potential waste heat opportunities. Industrial energy efficiency goals are embedded in many of the state-level energy efficiency goals that are manifest as binding savings targets for utilities. By better assessing industrial waste heat potential and considering waste heat as a resource, these energy efficiency programs could help improve public awareness of waste heat and provide the initial technical guidance to industrial facilities that might wish to understand their waste heat opportunities.

Lessons to be Learned and Applied

A BLIND SPOT IN ANALYZING HEAT POTENTIAL

If heat were to be prioritized in the U.S. as a resource and assessed like other energy resources, policymakers and planners might find that significant potential exists. Recent studies of CHP potential find ample remaining potential just in existing U.S. buildings e.g. (Chittum and Sullivan 2012), and a 2008 assessment of industrial waste heat opportunities found similarly encouraging results (BCS 2008). Importantly, though, these studies and others like it assess the potential for these technologies completely absent any new investments in district heating infrastructure. ICF International, which conducts the official assessments of CHP potential for the U.S. Department of Energy and most U.S. states, considers only an individual facility's existing onsite thermal energy demand (Chittum and Sullivan 2012). It does not consider the extent to which additional thermal demand, such as that which would be presented by new district heating networks, would increase the amount of CHP that is feasible and cost-effective. This is an important omission in their analysis, though it is easy to argue that assuming some significant degree of new district heating development is not a defensible assumption. There is little work to better integrate consideration of district heat systems (and district cooling) into state-wide or region-wide energy planning. In fact, the region of the U.S. best known for collaborative energy planning – the Pacific Northwest – focuses its region-wide efforts solely on electricity, due to the federal rules that established the planning framework in the first place.

Similarly, energy efficiency analyses consider the industrial sector to offer tremendous efficiency potential, but do not typically analyze the sector for its waste heat resources and potential uses. This is because policymakers and utilities in the U.S. tend to consider building-level efficiency opportunities, rather than system-level efficiency opportunities, when looking for efficiency potential in the built environment. This is a bit of a chicken-and-egg conundrum: individual utilities tasked with acquiring new efficiency resources by their state regulators do not look system-wide for efficiency opportunities because they can only count efficiency savings at their customers' sites towards their efficiency goals. But they can only count the efficiency savings at their customers' sites towards their goals because they only plan efficiency programs for their individual customers' sites when devising their energy efficiency programs. To add additional complexity, state regulators are usually bound by statute to approve the funding of energy efficiency programs for specific utilities and/or sets of customers. They have very little flexibility in approving energy efficiency programs that might consider system-wide or multi-party efficiency savings.

Additionally, heat networks could play a very important role in balancing the intermittent renewable energy resources that will be necessary to meet greenhouse gas goals of tomorrow. Denmark also offers a compelling example of how district heat networks combined with CHP can offer grid-balancing capabilities that enable a much higher concentration of installed wind capacity (DEA 2012a). Current planning activities for distribution and transmission systems in the U.S. are just beginning to seriously address non-transmissions alternatives and alternative sources of generation that will offer capacity capabilities that resources like wind generally cannot (Chittum and Farley 2013). However, the role of heat planning and district heat networks is not clearly delineated as an important consideration in any of these efforts (NWPCC 2010).

The U.S. can make great strides in appreciating the value of industrial waste heat and supporting well-structured heat planning. Here are several suggestions for how to better assess the true resource potential of industrial waste heat.

Suggested Policy and Programmatic Changes in the U.S.

SEEK SYSTEM EFFICIENCIES

States around the country could consider whether their existing energy efficiency standards might be the right venue in which to encourage and incentivize projects and programs that seek system-wide efficiencies. For instance, new legislation in the state of Oregon allows natural gas utilities to earn efficiency credit for projects that reduce CO_2 emissions overall, even if they increase onsite natural gas use (Chittum and Farley 2013). Giving utilities and energy efficiency program administrators clear guidelines for how they might assess system-wide efficiency opportunities is the first step to encouraging them to pursue those opportunities. This would model the Danish approach to viewing most heat resources from a holistic perspective, that examines the overall costs and benefits to the local energy system and considers and compares CO_2 emissions from all available sources.

APPRECIATE DIFFERENT VARIETIES OF WASTE HEAT

A common notion among policymakers in the United States is that industrial waste heat is too low-temperature to be used for much. While historically this may have been true, new technologies and applications have been demonstrated in a variety of locations that showcase the untapped resource that is lower-temperature heat. For instance, the Danish 4DH research center is currently working on assessments of various scenarios that incorporate low-temperature heat,[2] and examples of low-temperature district heat networks can be found around the world (Wiltshire 2012).

MEASURE AND VIEW INDUSTRIAL WASTE HEAT AS RESOURCE

As discussed above, industrial waste heat resources and potential opportunities related to that heat are not often assessed at the state or local level. There is tremendous industrial waste heat available, but its disbursed nature makes it more difficult to locate and consider than, say, a centralized power plant or boiler. However, given its low cost and emissions profile, it begs to be taken seriously and to especially be considered in areas where potential users of the heat resources are already located nearby. This kind of assessment, one that would look at a number of different privately-owned enterprises to assess the possible synergies of energy demands and supplies, could be conducted by a city or state entity, absent any effort by the local utility. There is precedent for this in existing local and regional heat plans in Denmark, where industrial waste heat resources are identified as potential sources for district heating systems, and local energy planners are empowered to explore establishing contracts with such industrial heat resources to provide heat to heat networks.

EMBED HEAT PLANNING IN LAND USE PLANNING

Local land use planners know more about future developments and future energy needs than most other local or state agencies. They have information about building permits, changes in land ownership, and which areas of a city or region are being prioritized for new development. This perspective lends itself well to heat planning, which takes as an input the known development priorities of a region. While electric and natural gas utilities develop forecasts and models to understand how the energy use of their customer base might change over time, they do not work directly with land use planners to determine whether the most cost-effective energy solution for a given area is being pursued. The Danish approach to involving the same entities responsible for land use planning and heat and energy planning helps ensure that appropriate information, including growth assumptions and future development plans, are shared among all planners and integrated into complementary plans.

PROMOTE TRUE "SOCIETAL" COST-EFFECTIVENESS TESTS

When state energy regulators and utilities consider investments in energy efficiency or renewable energy, they usually must show that a given project, program, or portfolio of programs, satisfies some pre-determined cost-effectiveness test. Typically these tests consider the costs and benefits to the utility itself as well as the participant in the project. Much more rarely these tests consider some societal costs and benefits, as in Vermont, where environmental costs in particular are considered. These tests, though, are rather static: something either satisfies a test, or it does not. In Denmark, the cost-effectiveness considerations are more dynamic: energy planners look to promote solutions that maximize the cost-effectiveness to society, individuals, and the local utility company (Dyrelund and Overbye, 2013). In this way, the overall societal goal of reducing energy-related emissions is pursued, but not at the expense of any particular party. Rather, a broad assessment of how to most cost-effectively meet energy needs, considering the cost of emissions, is conducted for a given neighborhood or town or region, depending on the planning need. In this way the Danish energy system continues to march forward toward reduce emissions, but maintains its highly cost-effective traits for all major parties.

2. See http://www.4dh.dk/projects for a list of current projects of the 4DH Research Center.

Conclusion

Denmark's success in constantly improving its energy efficiency and reducing its emissions while maintaining strong economic growth owes much to its long tradition of heat planning and support of district heating. As it moves to supply 100 % of its energy needs with renewable resources by 2050, Denmark views its district heat systems as critical partners to reach that goal in a cost-effective manner.

Unfortunately the United States, which has tremendous potential for district heat systems and industrial waste heat recycling, does not currently integrate heat planning in any of its major energy planning activities. Though Denmark's heating sector and heat planning efforts are not perfect, they do offer an excellent example of how well-considered heat-related policy might look on the ground.

The U.S. could:

- Examine the manner in which Denmark treats and values heat and waste heat within planning, policy, and programmatic efforts;
- Consider viewing renewable and energy efficiency resources from a system-wide perspective and incentivizing them based on their benefits to the system as a whole;
- Better connect energy planning with land use planning at the local, state, and regional level; and
- Consider whether different and enhanced cost tests structures and cost-benefit analyses would better serve the long-term energy and environmental goals of the country.

As U.S. states work toward future energy aggressive efficiency and renewable energy goals, their citizens would be poorly served by policies that failed to fully consider the ability of heat networks and heat planning to yield clean and highly cost-effective future energy resources.

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