Why isn't heat the 'hot topic' in energy system decarbonization?

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Executive Summary: There is currently unprecedented international consensus on the need to reduce our output of greenhouse gases to curtail climate change. As significant sources of these emissions, our energy systems are obvious targets for action. As a result, there has been significant global growth in the deployment of renewable electricity generation technologies. Heat systems, though, are not being decarbonized at the same rate, which is a concern given that heat production accounts for more than half of energy use world-wide. This article examines some of the challenges impeding heat system decarbonization and makes clear the imperative need for action to ensure that heating is not left behind in the renewable energy transition.

Introduction: Renewable Energy and Heating

Following the landmark climate change commitments at the 2015 United Nations Climate Change Conference in Paris, there is relative international consensus on the need to reduce the environmental impact and greenhouse gas emissions associated with our energy systems. At the time of writing, 157 nations have ratified the agreement and have committed to reducing their outputs of greenhouse gas emissions.[1] In line with those national and international commitments on climate change, recent projections from British Petroleum forecast that the amount of electricity generated globally from renewable sources will continue to increase by 7.6% annually for at least the next couple of decades.[2]

Much of that growth can be attributed to increased competitiveness of solar and wind power, but decarbonization of heating energy systems is not keeping pace. Heating currently accounts for 48% of total energy use and one third of greenhouse gas emissions in the United Kingdom.[3] While greenhouse gas emissions associated with the UK's electricity generation have fallen by around 50% since 1990, its heat system remains stubbornly carbon-intensive, with a fall of only 20% in heat-related emissions in the same period.[3] The International Energy Agency's 2014 *Heating without Global Warming* report on heat decarbonization confirms that similar figures apply for the global energy system. It notes that more than half of energy used globally is used to produce heat. The report also acknowledges that globally, the heating sector "receives less attention" than the electricity and transport sectors.[4]

There is a simple explanation for the carbon-intensive nature of the global heat system. Typically, heat is generated by the combustion of gases, oils, or solids like wood, whereas electricity can be generated without combustion. However, a range of technological, geographical, socioeconomic, and political barriers are hampering progress in reducing the impact of existing heat generation and in the deployment of renewable heating technologies. Cognizance of those barriers might yet enable policymakers and individual citizens to turn the tide in favor of heat decarbonization.

Heating Challenges in the UK

The UK provides an excellent case study of some of the technical barriers to decarbonizing heat generation. More than 60% of the end use of heat is in households. Additionally, 80% of households are connected to the country's gas grid,[5] and the

majority of those use boilers which combust natural gas for space and water heating. The high cost of replacing such entrenched infrastructure presents a significant challenge to transition away from fossil fuel-derived heating. A 2016 inquiry into progress towards heat and transport decarbonization by the UK Parliament's Energy and Climate Change (ECC) Select Committee[6] highlights the significant gap between legislating for decarbonization of centralized electricity production and decentralized household-level heat generation. Governments committed to action on climate change and guaranteeing national energy security have different and more widely ranging priorities than individual householders. Also, they can exert more direct influence over a handful of power stations than over millions of individuals procuring heat at the domestic level. A submission to the same inquiry by the UK's Citizens Advice Bureau acknowledged that consumer awareness of "low-carbon" heating technologies is limited,[6] and an additional report by the Parliamentary Office of Science Technology in 2016 found that most consumers simply opt for the cheapest heating option, rather than prioritizing the greenhouse gas emission impact of their heating.[7] While the cost of renewable heat generation technologies such as heat pumps, solar thermal systems, and fuel cells is expected to decrease with wider deployment, high capital cost is a barrier to current decarbonization efforts. Subsidy schemes targeted at heat generation such as the UK's Renewable Heat Incentive may help address the issue. But with the heat system as decentralized as it is, engaging individual citizens and householders is more important for heat than for electricity decarbonization

A further challenge to the UK's efforts towards domestic heat decarbonization is inefficiency resulting from poor household insulation. The EEC Committee's *2020 Renewable Heat and Transport Targets* report identifies 20 million homes in the country that would benefit from an insulation retrofit.[6] Leakiness of insulation is an oft overlooked factor in energy policy and its application, but there is a clear imperative here: increasing the share of renewable heat generation is all well and good, but if that heat is lost through poor insulation, the net benefit is limited. The committee's report acknowledges that further roll out of renewable heating would be supported by improvements in energy efficiency, particularly with improved insulation, by reducing overall demand for heat. A 2014 analysis by the UK's Green Building Council also found that households with insulation retrofits saw average reductions in their greenhouse gas outputs by 40% and average savings of £300 per year on energy bills.[8] However, given that whole-house insulation improvements for a solid walled house cost an average £30,000,[9] there is a need for financial support to assist households in making improvements.

Heating Challenges Abroad: International Comparisons

Such heating challenges are less apparent for governments in northern European countries. For example, in Denmark, Sweden, and Finland, more than 50% of households are supplied heat by district heating networks,[10] in which heat is generated by a centralized boiler or similar source and piped to individual homes. District heating networks are more efficient than household-by-household heat production systems in part because their scale allows for more complete combustion. More importantly, district heating prevents energy waste when meeting single household needs. For example, hot water can be accessed immediately from the network and in exactly the required volume, rather than one household having to boil an entire tank just to wash dishes. Such networks further offer significant opportunity to integrate combined heat and power systems—whereby the heat normally vented by power stations is instead piped straight to homes. Centralized networks also facilitate greater oversight by regional or metropolitan authorities who can limit the heat available to a given household if necessary, or monitor consumption to identify households which might benefit from insulation improvements or training aimed at behavior change. Direct intervention by authorities may not always be popular, but it is certainly easier to influence the heat consumption behavior of a household whose heat is produced externally than those that produce it individually.

Looking to the other side of the Atlantic, the United States Energy Information Administration stated in its *Annual Energy Outlook 2017*[11] that heat demand in the country is falling as people increasingly move to warmer parts of the country. Despite falling demand, it is likely to be geology rather than geography that keeps the heat system in

the US thoroughly carbonized, though. Abundant shale gas resources limit the economic competitiveness of renewable heat generation technologies and could see the country locked in to fossil fuel-based heating. While shale gas exploitation offers the US significant advantages in terms of energy security and industrial competitiveness, it may prove obstructive to progress in reducing greenhouse gas emissions arising from heat production without policy intervention.

Actionable Policy Recommendations

One potentially transformational option available to the global heating sector is large scale electrification. Moving households and commercial users away from fossil fuel-fed heat generation towards electrified space and water heating has myriad potential benefits in terms of safety, costs, reliability, and environmental sustainability.[12] Electric heating systems do not cause localized emissions; those living in homes with such systems do not have to worry about carbon monoxide poisoning. Technologically speaking, electric systems have fewer moving parts so are less likely to break down, and, at a systems level, countries without gas resources could reduce their energy import dependence by shifting heat demand towards electricity. Provided that renewables continue to make up an increasing percentage of electricity generation, then electrification has strong potential as a decarbonization mechanism for heat. However, greenhouse gas emission reductions are unlikely to follow if the increased electricity demand is met by the combustion of coal or other fossil fuels.

The focus on heat decarbonization is generally placed squarely on the residential sector, and rightly so. As stated, 60% of the UK's heat, for example, is used in the domestic sector. The other 40% still deserves attention, though. With the recent re-shoring of manufacturing and heavy industry back to Europe, the US, and other developed economies,[13] industrial energy use is of important consideration for policy makers and leaders in manufacturing. Debate continues surrounding the offshoring of manufacturing emissions, and whether responsibility for those emissions should rest with the exporting or importing nation.[14] Fully answering those questions is beyond the scope of this article. However, there are significant global energy policy implications and opportunities associated with any re-shoring of energy-intensive industries. Those companies and governments investing in manufacturing facilities and infrastructure in developed countries have an opportunity—and indeed a responsibility—to ensure that the design of new facilities promote energy efficiency and renewable electricity and heat generation.

Conclusion

In summary, heat decarbonization has been neglected relative to electricity decarbonization, and limited progress has been made. The contribution of renewables to the electricity grids of the countries mentioned here has been climbing steadily, but heat generation has remained thoroughly carbon-intensive. There are multiple reasons for the continued carbon-dependence of heating. The generation of heat is essential to many industrial and manufacturing processes, so attention to the system's decarbonization should be paid in those sectors too. Domestic heat, however, is much more decentralized, with heat generally produced locally by end users. As such, heat generation is influenced by individual citizens to a far greater extent than electricity generation.

Human behavior and convenience is an underlying feature in many of the aspects discussed. Successful policy interventions will likely target individuals and households through directly providing information and support for decarbonization initiatives or by removing individuals from the decision-making process by centralizing heat generation. The options and mechanisms preferred by governments and policy makers will likely depend on political ideology, and that is part of the problem. Rapid changes in policies with the transition of successive governments of varying political ideologies hamper progress in areas of energy policy because they inherently require long-term commitments and market stability. A call for coherent consensus among policy makers of differing ideologies in the countries described—or at a global level—would be optimistic, but perhaps greater awareness of the challenges set out might facilitate policy making with a more comprehensive, long-term focus.

Heat makes up the largest portion of our energy use in the northern hemisphere and it is time that our policy making reflected its importance and the unique challenges associated with its

decarbonization. The energy system is not and should not be synonymous with the electricity system. The sooner that global, regional, and national energy policies reflect the complexity of the system, the better.

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