Energy Technologies 2030

Decarbonising Heating

COMMUNITY REPORT

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The Challenge

The decarbonization of heating presents one of the most challenging aspects in achieving net zero.

The complexity of decarbonizing this sector is increased by the upfront fixed costs and the range of technology options, both in terms of the primary energy supply and the conversion available to support the transition. Additionally, while regional variations in adopted systems exist, the demands of heat vary across economic sectors, such as the supply of affordable warmth to residential customers and high-temperature industrial processes. Further complexity is created by the several variables involved, such as network infrastructure needed to transport the energy vectors, and building efficiency necessary to achieve comfort.

Home heating represents a significant share of overall international final energy demand (final energy describes the energy consumed by end users and neglects delivery and transformation). For example, approximately 25% of final energy consumption in the EU is attributed to residential demand, and residential energy use is responsible for 20% of greenhouse gas emissions in the US.[1] It is expected that there will be an increasingly important role for heat in balancing increasing volumes of intermittent renewable electricity generation in net zero energy systems.

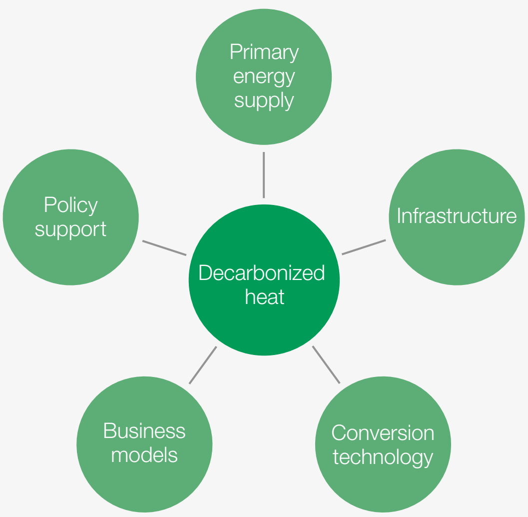
Achieving net zero will require major infrastructure and technology development, along with disruptive solutions, supporting policy and business models that have consumer acceptance and appeal.

It is unlikely, however, that there will be one winning technology, which increases the difficulty of setting clear policy to stimulate the market, therefore creating stagnation within the supply chain. There remains significant social, economic and political challenges, despite the advances made with technical innovation to date.

Collaboration between incumbent heating manufacturers and digital innovators will help to deliver business models, which transform the provision of heat, warmth and thermal comfort into a compelling and intuitive service proposition that captures the value of energy-as-a-service and distributes the associated benefits throughout the value chain.

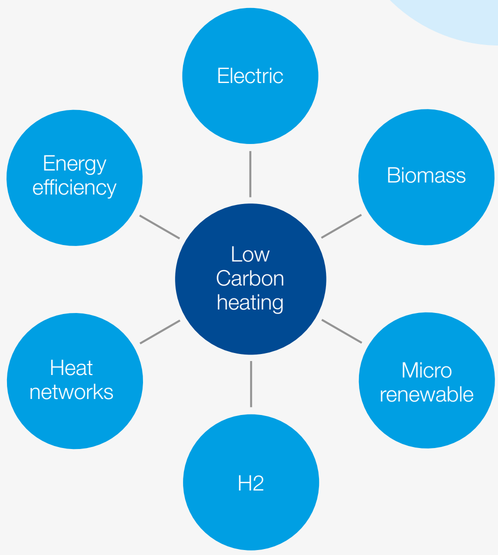
> **Market penetration of low carbon heating technology must increase to 70% by 2030.**

Heat decarbonization has the potential to positively affect people's lives through more efficient, warmer and more comfortable homes and buildings …



… but will require navigation through a complex web of interlinked components.

Technology options and key opportunities to decarbonize heating



Primary energy supply for heating

Low carbon primary energy sources are competing with combined fossil fuel subsidies totaling $500bn/annum in 77 economies (6.5% of global GDP), leading to inefficient market prices that do not accurately reflect externalities.[2] Due to this natural gas has dominated as primary energy source for heating. If fossil fuel prices avoid the externalities associated with their use while low carbon electricity prices include taxes and levies, the transition to decarbonized heating may be slowed.

Green gases such as hydrogen could provide a potential option for decarbonizing heat, although at present it is virtually non-existent in the global buildings sector, for economic and technical reasons. The future suitability and cost of hydrogen will be dependant not only on cost of generation, but also on existing gas infrastructure and the ability to repurpose those networks. Alongside the residential sector, hydrogen has the potential to play a very important role in decarbonizing high temperature industrial heating processes and other hard-to abate sectors close to the generation source.

Today (2020)

Heating accounts for more than 40% of global CO_2 emissions due to dominant natural gas[3]

Europe – natural gas supplied >40% consumption

US – ~50% homes use natural gas for heating

China – Coal to gas switching policy supported and has reduced emissions by 33% for heat provision

Natural gas is a short-term transition, not a long-term option for heat decarbonization

Current gas costs estimated to be ~20% lower thanks to subsidies targeted at households – **EU**

Residential fossil fuel subsidies $28bn in 2019 – **OECD**

Wholesale power prices falling but retail costs rising as a result of taxes levied on electricity sales – **EU**

CO_2 emissions 28% lower if fossil fuels priced efficiently – **IMF**

Transition (2030-2050)

By 2050 a large proportion of the 80% share of power generation accounted for by renewables will be used directly for heating[4]

Global wind and solar costs continue to decline with global onshore wind levelised cost of electricity (LCOE) falling to $48/MWh in 2021[5], some regions already as low as $14/MWh

H2

Using renewable electricity to produce green hydrogen through water electrolysis is still faced with cost challenges across the value chain. The cost of producing hydrogen is ultimately dominated by electricity costs, but an input cost of $20/MWh could result in ~$31/MWh final cost of hydrogen. Green hydrogen production is still at demonstration phase but a new 20MW electrolyser has now been commissioned in Becancour, Quebec.[6]

District heating – ~600k km of networks globally. 65% in Europe and China 4th and 5th generation heat networks which recover and use waste heat offer great potential to support 2050 heat decarbonisation goals.

There are currently 4.5k km of hydrogen pipelines in the world. Gas networks would need to be adapted to accommodate hydrogen, the cost of which is likely to be substantial. Blending of 20% H2 by volume will only lead to CO_2 reductions of 8%.

This paper discusses the complexity of heat decarbonisation and highlights the challenge of attempting to select a single winning technology. The range of options available increases the difficulty of setting clear policy to stimulate the market, therefore creating stagnation across the value chain

The conversion – technology, costs and supply

The plethora of heating technology solutions creates a challenge for consumers and policy-makers alike – which one is the right one? Although there is no single winning solution, improving the energy efficiency of existing building stock is a major priority and the residual heating load must be delivered as efficiently as possible using renewable sources. Clean electrification is a critical path to low carbon heating, and heat pumps are a prominent solution. Growth in installer base and up-skilling will likely deliver cost reductions, as 50% of capital cost is apportioned to installation. However, rapid scaling of heat pump deployment is likely to cause supply chain bottlenecks, therefore foresight of demand to enable innovation and up-skilling is required.

There is **no single winning technology**, low carbon technology deployment will need to increase drastically to satisfy decarbonization objectives, supported by policy measures and consumer demand.

The choice of heating solution is complicated due to a range of variables e.g. building use, archetype, consumer persona, infrastructure.

“ 50% new heating technology sales accounted for by fossil fuel equipment.

Scale required – heat pumps meet <3% of global heat needs in buildings. China and North America account for 80% of domestic heat pump market, currently 8.1m and 2.7m respectively.

18m households purchased heat pumps in 2018. Heat pump deployment will need to increase to 253m units by 2050.[7] The impact of heat pumps on carbon emissions will vary depending on their time of use and efficiency but research estimates savings of 46-54% compared to natural gas, and they will likely be a core component of home heating decarbonisation.[8]

22 countries, mainly across MEA, have included solar energy as part of Paris energy actions. Solar thermal satisfied 2.1% of heat demand in 2018. 6,299m^2 required by 2050.

“ Heat pumps provide only 3% of heating in buildings. This share needs to triple by 2030. Clean heat tech sales need to increase to 50% by 2030.

80% of buildings that will exist in 2050 have already been built and therefore improving the energy efficiency of existing stock is a major priority[9] – retrofit rate of 2.1% is required. However, even with subsidy support net present value of energy savings is undervalued relative to its true worth, and therefore uptake is low. Home insulation, thermal storage and time of use tariffs will be key elements of whole house retrofits.

Technology-neutral with wide technology options (including heat pump, H2, hybrid and heat network options), their suitability will depend on regional constraints and must work for consumers.

“ Building envelope performance improvements required to ensure retrofit rates of 2.1%.

Currently, low carbon conversion technology is more expensive than high carbon solutions and consumer willingness-to-pay is low. Conventional gas boilers have a lower capital cost compared with heat pumps and other low carbon technology, plus, the fuel costs of gas boilers will remain below those of heat pumps for as long as government subsidies remain without truly reflective carbon price. Therefore, consumers have very little incentive to install low carbon equipment or decarbonize heat.

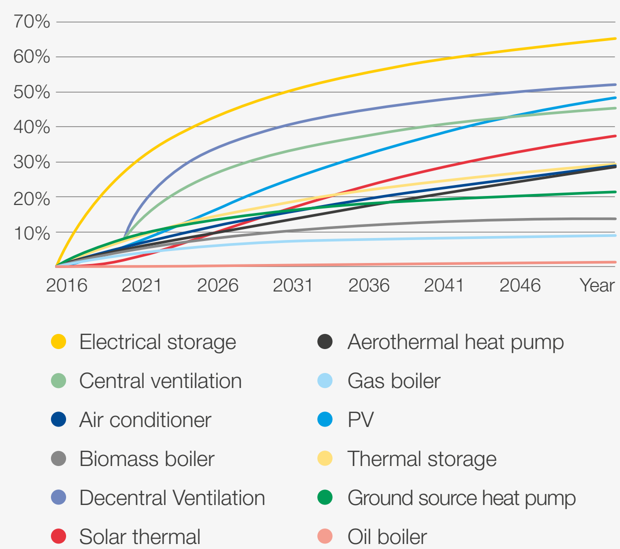
The cost-effectiveness of low carbon technologies will improve over time and learning rates of 9.8% for every doubling of cumulative capacity are forecast.[10] Not all technology will experience the same cost reductions. For example, heat pump componentry is already manufactured in vast quantities for the global heating, ventilation, air-conditioning (HVAC) market, therefore potential cost savings are not as high as for other low carbon technologies such as solar thermal. Market demand and deployment is required to deliver cost savings of high efficiency and renewable technologies, but cost savings alone are not enough to shift the market.

Potential cost reductions of heating technologies

	Potential cost reduction by 2050 (%)	Cost forecast in 2050 (€/kW^{th})
Biomass	14	219
Solar Thermal	38	526
Ground source heat pump	21	1280
Air source heat pump	20	845
Gas Boiler	8	151

*cost reductions dependent on climate of region where installed

Projected capital cost saving of equipment



Advancing systemic efficiency

The integration of digital technology will radically reshape the way we generate, trade, consume and manage energy. Digital devices offer the opportunity for large improvements in energy efficiency of buildings but integration must be steered by policy stability to promote industry and consumer confidence, whilst ensure maximum benefits for the whole energy system through increased efficiency and resilience

Digital productivity gains within the heating sector should help to offset the energy demand growth from electricity and the use of grid aware controls will help to effect physical changes, improve flexibility and optimise energy use.

Advanced control, digitalization and connectivity will help to reveal customer needs and preferences towards tailored services, not only is this relevant to heat, but also power and mobility. This, moves away from cost as the main selling point and creates market demand leading to scale and potential cost reductions. Importantly, it also allows for better integration of low carbon technology which not only optimises the outcome for the user but also the wider energy system. Digital devices enable the opportunity for large improvements in energy efficiency and the pace and scale of the change is likely to increase dramatically over the decades to come.[11]

Digitalization and advanced control offer an opportunity to develop consumer-centric business models that optimize energy supply, lower costs and create consumer pull…

A greater share of renewables will create challenges for power grids/networks and system balancing costs are likely to rise to ensure security of supply. Consumers should be incentivized to access and respond to real-time price for power to support grid balancing

Advanced control, analytics and interoperable connectivity can radically improve measurement and understanding of energy use in buildings and reveal customer preferences towards tailored services. These tools will reshape the way we generate, trade, consume and manage energy.

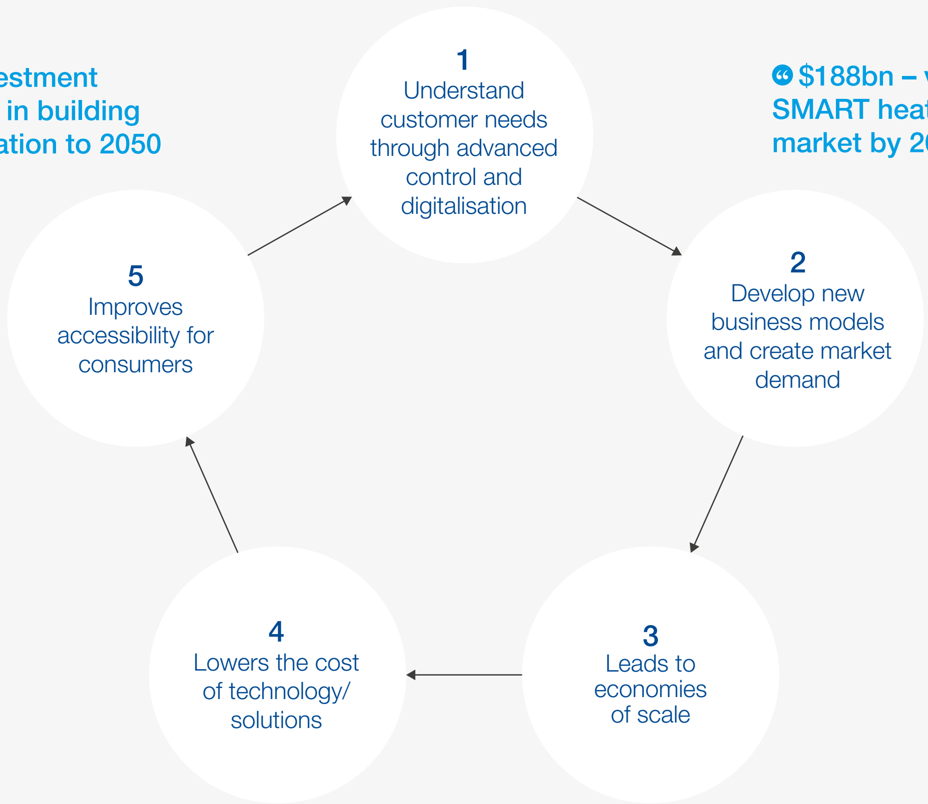
The challenge of decarbonization will be supported through growing the share of renewable energy in the heating sector by coupling heating and electricity. Costs associated with low voltage distribution grid expansion and resilience can be managed using 5G application scenarios e.g. substation monitoring, precise load control and smart meters.

New energy services to end user and system:

- Provide consumers with better comfort outcomes
- Enable integration and optimization of a range of low carbon heating technologies
- Help to overcome the barrier of higher up-front costs
- Flexibility solutions in constraint managed zones

$39tn investment opportunity in building decarbonization to 2050

$188bn – value of SMART heating control market by 2050



Policy mechanisms and incentives

A successful approach will likely combine carbon taxes and credits, planning policy, subsidies, regulation and strong support for skills.[12] Low carbon choices could be rewarded in energy bills, facilitated through a fair and transparent building carbon credit scheme.

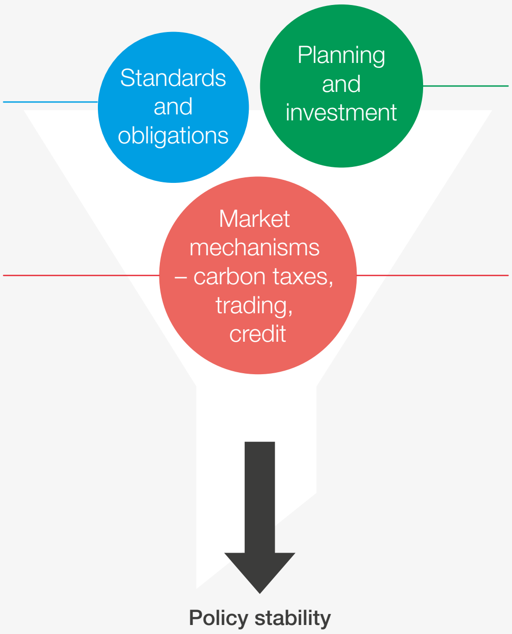
If the market can demonstrate demand and give confidence to policy-makers then international evidence shows that setting clear and stable policy through a package of mechanisms will deliver low carbon heat quicker…

Standards and regulations in combination with subsidies have helped to enhance the reputation of the heat pump market in Germany and Switzerland. **However, regulations cannot encourage people to use less heat**.

The **average price of carbon emissions** worldwide is $2 per tonne, yet the IMF has quoted a price of $75 per tonne to meet the Paris agreement.[13]

Only three countries have a carbon tax on heat – Sweden (€110/tCO_2), France (€22/tCO_2), Finland (€35/tCO_2).[14]

Only Sweden's price is above the IMF's price recommendation.



Policy will be influenced by the **availability of resources** and absence of indigenous natural gas production e.g. Sweden and Finland have a plentiful supply of biomass for heat networks.

Incentive-based policy frameworks should target upstream, midstream and downstream markets to achieve successful transformation

Alignment of primary energy subsidies is required to remove distortion in retail prices, but reforms require care and consideration to ensure the vulnerable and fuel poor are not penalized.

Learning from Sweden

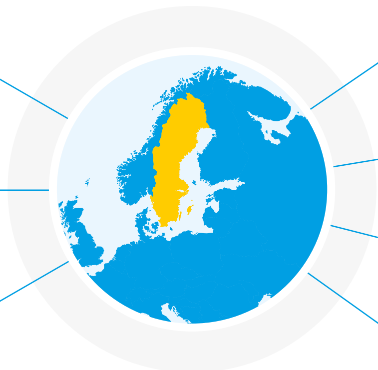
Sweden have combined incentives, standards, and investments to create a low carbon heating market. However, their success in leading the way for decarbonising heating hasn't happened over night, there has been a focus on policy stability since the 1990s.

How?

Deployed policy stability alongside packages that combine finance with information, regulation, standards and supporting planning framework.

Investment grants used for heat networks to justify initial capital expenditure in a liberalized energy market.

Policies introduced in early 1990s, are 30 years later, on track for achieving 2030 32% share of RE target.



So, what?

Sweden has the highest carbon tax on natural gas in Europe – which generated €2.4bn in 2018.

SMART electricity prosumers with 77% PV self-consumption in some examples.[15]

Certain districts are capable of delivering 50%-75% heat demand through excess heat from prosumers.[16]

Sweden successfully built low-carbon heat markets through carbon tax, policy stability and discrete subsides for heat pumps – 1.8m heat pumps.

Deployment of low carbon heating technology is critical and requires addressing primary energy subsidies, creating consumer demand through new business solutions and long term policy stability. Ultimately it will be a market led transition, but will require significant policy support to accelerate at the pace required.

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Endnotes

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