Copenhagen Economics

THE BIGGER PICTURE

Swedish energy requirements in new buildings in a broader perspective

A note for the Swedish Energy Agency
February 2018

Preface

The Swedish Energy Agency has asked Copenhagen Economics to analyse the multiple benefits of increasing the energy efficiency of new buildings. The result is published in the report:

Copenhagen Economics (2018) Low-energy Buildings in Sweden – What are the socio economic costs and benefits?

The current note is a supplement to the mentioned report, and includes Copenhagen Economics' analysis on the use of energy requirement in buildings in Sweden in a broader policy perspective.

Swedish energy and climate objectives in the broader perspective

THE PURPOSE OF ENERGY AND CLIMATE TARGETS

The are two commonly mentioned ultimate purposes of regulating energy use: CO_2 emissions and energy security.

Manmade CO_2 emissions are the main cause of climate change and controlling these emissions have been on the international agenda for several decades with increasing urgency. In the Paris Agreement during the UNFCCC's COP21 the world's nations agreed to limit the increase in average global temperature to well below 2 degrees above pre-industrial levels. This will require massive cuts in CO_2 emissions (and other greenhouse gasses).

Energy security is about securing an adequate supply of energy. The energy sector is a vital part of any economy and society as it both necessary for producing goods (e.g. manufacturing) and enables high living standards (e.g. fast transportation). The cost of inadequate supply of energy can therefore be prohibitively high whereby any risk of such unexpected shortage is taken seriously.

These two objectives lie at the heart of the European Union's energy policies and strategies for instance the Energy Union, the 2030 Energy Strategy, and the Winter Package. These strategies have more detailed targets for the different energy sectors and more specific regulation. For instance requirements for energy efficiency as an more efficient use of energy can both lower CO_2 emissions and improve energy security.

SWEDISH ENERGY AND CLIMATE TARGETS

Sweden has several medium and long term energy and climate targets, which are related to EU's policies.

The 2002 bill on a cohesive climate and energy policy set multiple 2020-targets on CO_2-emissions, deployment of renewables and energy efficiency. Most of these have already been reached. The 2016 Agreement on Swedish Energy Policy specified a 2030 energy efficiency target of 50% improvement, a 2040 target of 100% renewables in electricity production (although nuclear is accepted), and net zero emissions in 2045.

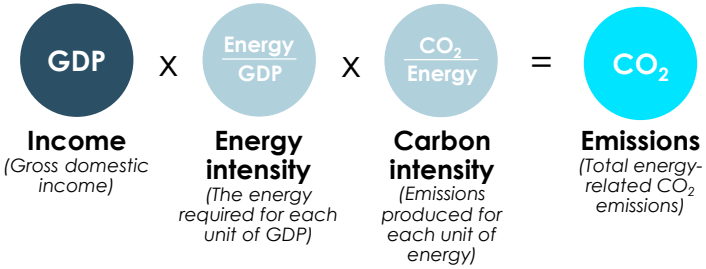
There is an ongoing debate about the role of nuclear power in the future in Sweden. The government is considering a long term target mandating the energy supply to be entirely based on renewable energy meaning a phase-out of nuclear.

The 2030 energy efficiency target is defined for the whole energy system (in relation to GDP). The Swedish authorities will develop sector specific strategies, although these will not be legally binding.

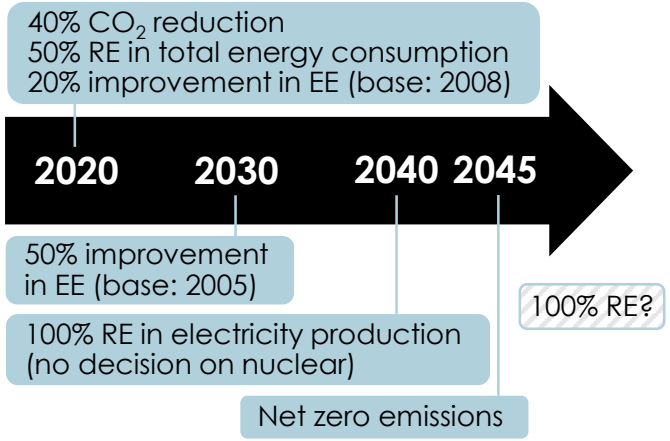
COST-EFFECTIVE REGULATION

With multiple targets and regulating measures it will be important to keep in mind the ultimate purpose of these regulations. The effectiveness of one regulating measure is affected by the other regulating measures. To ensure the lowest possible socio economic cost of achieving CO_2 reductions and better energy security regulators should keep in mind possible interlinkages.

Cleaner energy production and efficient use reduce CO_2 emissions



Swedish energy and climate targets



Note: EE = Energy efficiency. RE = Renewable energy.
Source: Swedish government and Agreement on Swedish Energy Policy 2016.

The rational for energy requirements in buildings is typically based on behavioural barriers

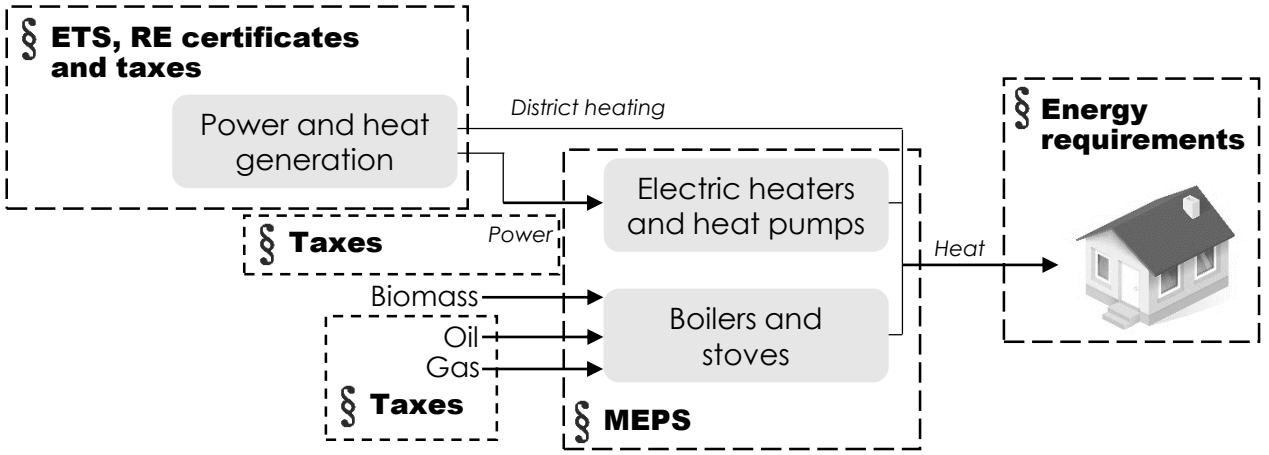
Energy requirements are not the only type of regulation of energy use in buildings and CO_2 emissions. Heat production and consumption is regulated throughout the production value chain (see figure below).

First, the generation of power and heat is regulated by the EU Emission Trading System (ETS), renewable energy certificates and taxes on fuel inputs. Second, the heat production in electric heater, heat pumps, boilers and stoves are regulated by taxes on inputs and minimum energy performance standards on heating devices (EU's EcoDesign). Third, the consumption of heat is regulated by the energy requirements in building by setting maximum levels of the energy use in the buildings.

The economic rational for adding the last layer is typically behavioural barriers like information barriers and principle-agent problems. For instance, some studies indicate that Swedish construction companies can have knowledge barriers, when going beyond the energy requirements defines in the BBR (Cialani and Perman (2014), Nässén et al (2008) and Zalejska-Jonsson et al (2012)).

Energy requirements can be an effective policy tool when they complement other types of regulations by targeting specific market failure, which are not corrected by other type of regulations. When policy instruments do not complement each other, there is a risk of putting unnecessary economic burdens on society.

Regulation of space and water heating happens in all parts of the energy value chain (examples)



Note: MEPS = Minimum Energy Performance Standards. This is not a comprehensive overview of all energy and CO_2 regulation.

Tighter energy requirements in buildings have limited effect on Sweden's GHG emissions

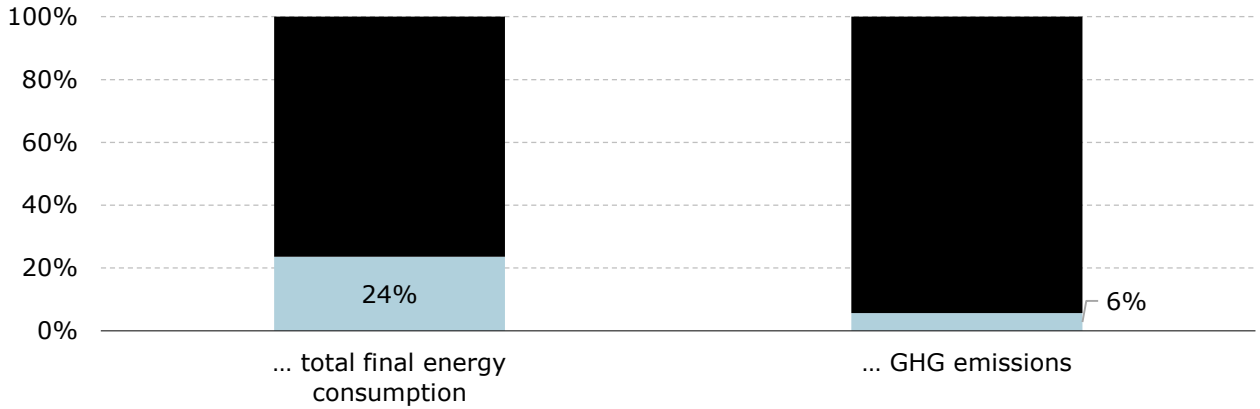
Although about one quarter of Sweden's total final energy consumption is space and water heating in buildings this energy consumption constitute only 6% of Sweden's emissions of greenhouse gasses (GHG).

This is because most space and water heating is supplied by non-CO_2-emitting resources. District heating is generated using biofuels and electricity is generated with nuclear and hydro. In terms of reaching a net zero emissions target, controlling energy use in space and water heating do not play a large role.

The low CO_2 content in energy and residential energy taxes results in very high implicit CO_2 prices in Sweden compared to other countries. The EU ETS and energy taxes alone potentially give rise to very high CO_2 reduction costs on the margin. The regulation of CO_2 emissions in buildings in Sweden is thus already quite comprehensive compared to what is seen in other countries.

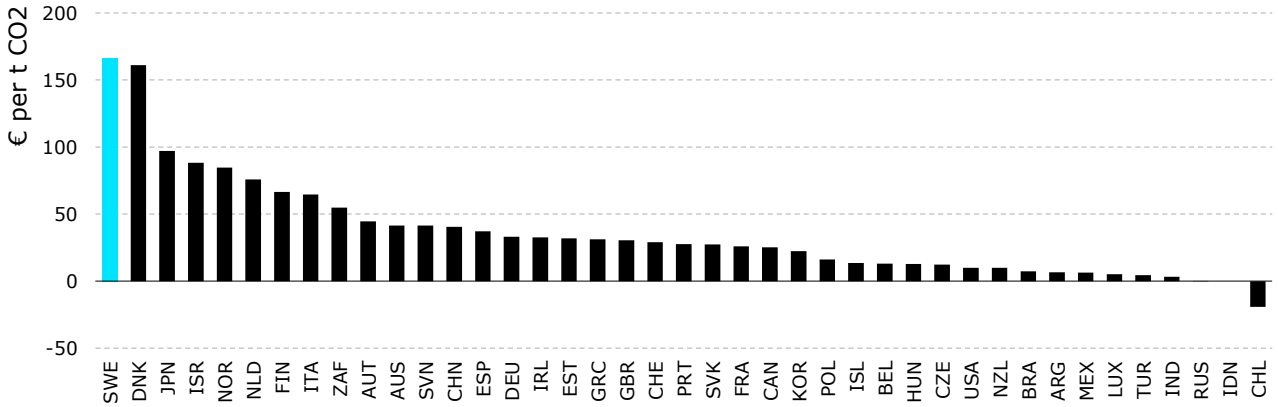
A 100% renewable energy target could be a game changer in this respect. Such a target will require massive investments in renewable energy capacity. Energy efficiency investments could balance out the extra socio economic cost of such investments by reducing primary energy consumption if marginal costs are lower than investments in renewables.

Space and water heating's share of …



Note: Residential and commercial houses' energy use for space and water heating. GHG emissions includes GHG emissions inherent in electricity use for heating and district heating.
Source: Own calculations based on Energimyndigheten and Statistics Sweden.

CO_2-prices in residential and commercial buildings from energy taxes and the EU Emissions Trading System



Source: OECD (2016).

Sweden has limited benefits from improving security of energy supply through energy requirements in buildings

Security of energy supply is a broad concept capturing measures of a country's reliability in terms of energy sources. Historically, energy security has been linked to being dependent on energy sources – primarily oil – from potentially unstable foreign region. More recently, energy security has in some countries been related to dependence on natural gas imports especially from Russia.

Going forward, questions have also been raised regarding availability of biomass, especially if biomass is going to play a large role in transitioning European economies. One common approach to define the concept of energy security is to use the 'four As' framework comprising availability, affordability, accessibility and acceptability (see box).

In Sweden, the key input fuels for space and water heating in buildings are biomass and electricity based on hydro and nuclear power. The two fuels which are typically considered subject to energy security concerns, oil and natural gas, are therefore not affected by reducing energy demand from buildings in Sweden as these are simply not important in electricity and heat generation.

Therefore, lowering energy consumption in buildings will not significantly effect energy security in Sweden.

However, lower energy consumption can lower the dependence of nuclear power which acceptability is continuously debated in Sweden.

ACCEPTABILITY

This is the concern about whether an energy source is considered acceptable in terms of, e.g., environmental and societal elements. Sweden's use of nuclear power is debated in terms of acceptability. Energy savings in large scale will contribute to the economic hardship of the current nuclear plants and may 'push them out of the market'. This will have a positive effect on acceptability.

AVAILABILITY

This is the concern about whether a resource is geologically available in a region, i.e. the existence of the energy resource. In Sweden, the fuels are readily available in Sweden, except potentially regarding biomass.

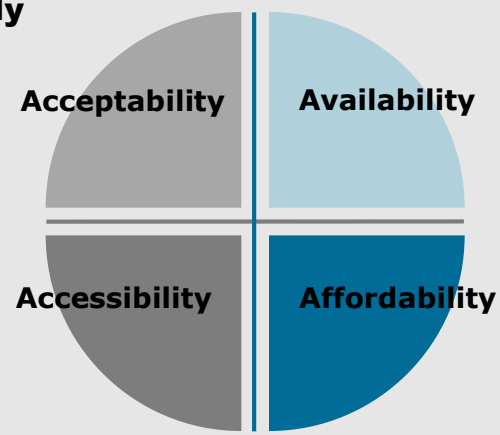
ACCESSIBILITY

This is the concern about whether resources can easily be accessed from other regions. The fuels are readily accessible in Sweden.

AFFORDABILITY

This is the concern about whether energy is available at an affordable price for end consumers, and is profit-able for investors. Reducing energy consumption saves costs of energy but increases other costs, primarily from installing the renovation. If renovations are providing energy savings in addition to the costs, they will have a positive effect on affordability.

The four As: a framework for understanding security of energy supply



Source: Kruyt et al. (2009).

Source: Copenhagen Economics (2016).

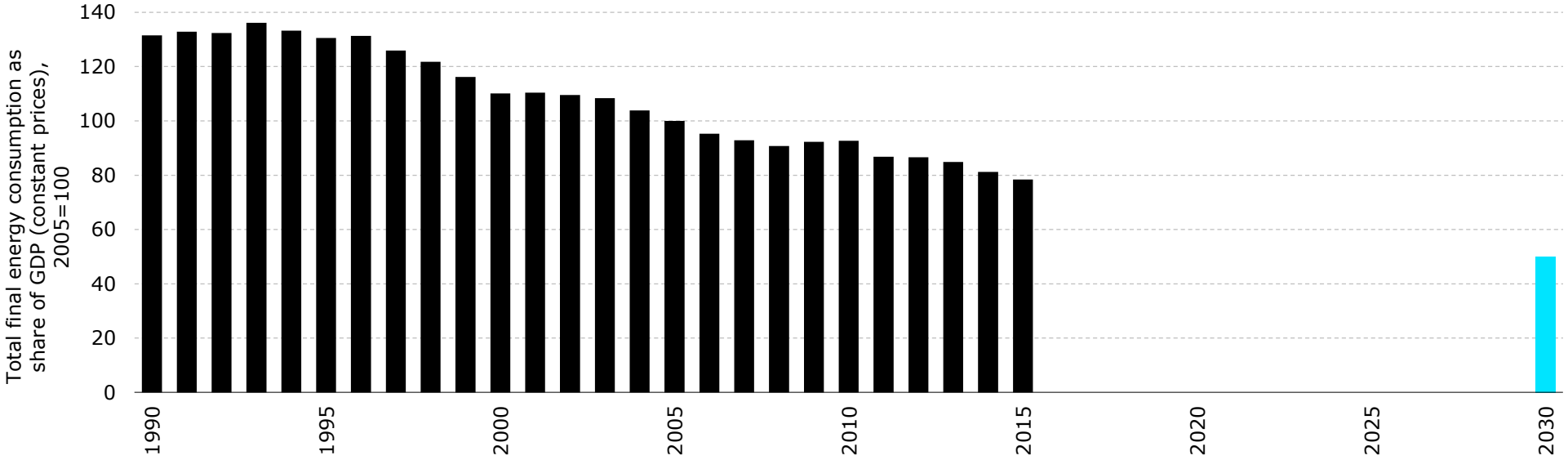
In meeting the energy efficiency target, buildings should be compared to other energy sectors to ensure cost efficient measures

Sweden has a politically agreed target of improving energy intensity (i.e. energy consumption as share of GDP) by 50% by 2030 relative to 2005. This leaves an open question as to how much the different energy sectors (e.g. transport, industry and buildings) needs to contribute to fulfil this target. Energimyndigheten will be responsible for developing sector specific strategies.

An economy-wide target like this one is achieved most cost-effectively with economy-wide instruments. Applying the same regulation measures on all energy sectors will enable the market to choose the cheapest energy efficiency investments. This could be done by imposing the same energy tax on energy consumption regardless of whether this energy is consumed in the transport, buildings or industry sector (taking into account also potential effects on international competitiveness).

Setting sector-specific targets runs the risk of conducting expensive measures in one sector, when less expensive measures could have achieved the same objective in other sectors. If sector-specific targets such as energy requirements for buildings are set anyway, it will be beneficial to assess the relative cost of additional measures in each sector and define different targets for different sectors. This approach however, will inevitably rely on uncertain measurements of cost efficiency, which will significantly increase in uncertainty going further into the future.

Sweden's energy intensity historically and 2030 target



Note: The official target does not specify whether energy consumption should be interpreted as total primary energy supply or total final energy consumption.
Source: Own calculations based on data from Energimyndigheten and IMF.

EU's EPBD requires EU Member States to achieve 'nearly zero energy buildings' by 2021 in a cost-optimal basis

One of the primary drivers of Sweden's revisions of their energy building codes is the EU's directive on the energy performance of buildings (EPBD). This directive requires all EU Member States to implement measures in order for all new buildings in 2021 to be so-called 'nearly zero energy buildings' (nZEB).

The concept of nZEB should be seen in the light of the objective of the EPBD, which is to improve energy security and reduce CO_2 emissions. These objectives are the same as the objectives of Sweden's energy and climate policy. Further, the EPBD specifies that these objectives are to be met cost-effectively, and that no EU Member State shall be required to implement requirements, which are not cost-effective (EPBD, article 4).

In principle, it is up to each EU Member State to define the meaning of nZEB although it should be set to achieve at least (or close to) cost-optimal levels of energy requirements. EU Member States are free to set more stringent requirements than the cost-optimal levels if they wish to do so.

Looking across EU Member States there is a wide diversity in the definition of what a nZEB is. This can reflect different levels of cost-optimality, but also different levels of ambition.

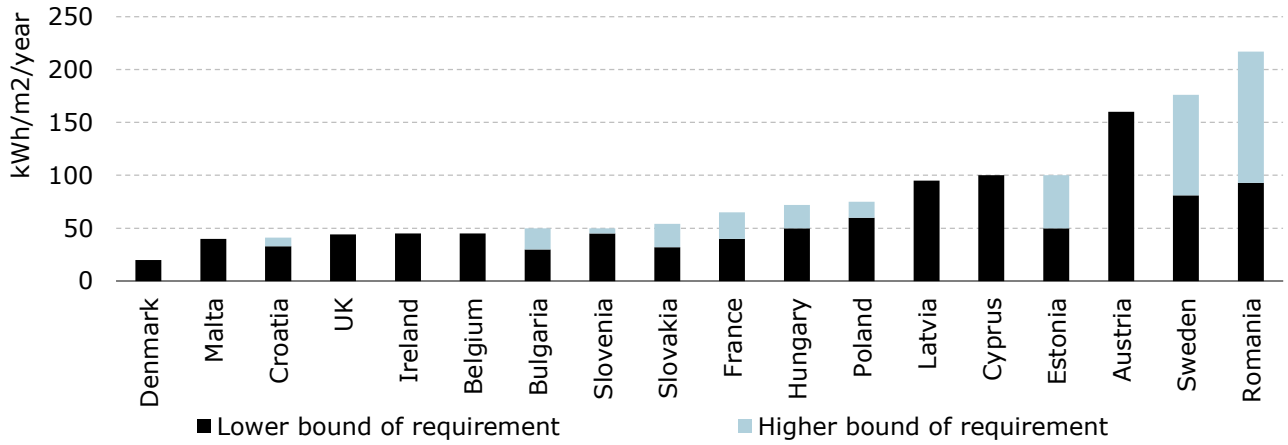
EU's EPBD focus on improving energy security and reducing CO_2 emissions cost-effectively

> *Reduction of energy consumption […] in the buildings sector constitute important measures needed to reduce the Union's **energy dependency** and **greenhouse gas emissions.***

> *Member States shall take the necessary measures to ensure that minimum energy performance requirements for buildings or building units are set with a view to achieving **cost-optimal levels**.*

Source: EU's DIRECTIVE 2010/31/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 May 2010 on the energy performance of buildings. Quotes are from preample and article 4.

nZEB definitions for new residential buildings across EU Member States



Note: Graph shows only countries with a specific energy requirements defined in the unit kWh/m2/year.
Source: BPIE (2015). For Sweden, the range is our estimate based on information from the Swedish Energy Agency.

EPBDs requirement of using primary energy factors can create skewed incentives

PRIMARY ENERGY FACTORS

Primary energy factors reflect the primary energy (e.g. coal) needed to supply one unit of energy (e.g. electricity) in the building. The EPBD specifies that a building's energy performance should be measured in primary energy. The primary energy factors are used to convert a building's actual energy use into primary energy use. Changing the primary energy factors thus change the energy requirement of buildings. Hence, the values of the factors are important and very influential for the requirements.

The table show examples of primary energy factors in a selection of countries. Usually at least electricity has a factor other than 1. This reflects the energy losses in the conversion and distribution process from the power plant to the building. In Sweden, the factor for electricity is 1.6, which has the consequence that electricity heated buildings have stricter energy requirements than non-electricity heated buildings. For instance, the maximum energy use in a residential single family building in climate zone 4 is 80 kWh/m2 when it is non-electricity heated and 50 kWh/m2 when it is electricity heated.

WHY THEY CAN BE A PROBLEM

There are some issues with use of primary energy factors in energy requirements in buildings looking at them from an economic perspective. The problem is, that primary energy factors create a wedge between the building owner's incentives to increase energy efficiency and the socio economic benefits of doing so. Energy efficiency is a means to achieve socio economic benefits through lower CO_2 emissions, less local air pollution, better energy security, but energy efficiency is not a goal in itself. The factors are the same regardless of whether or not these benefits are effectively obtained. Therefore, using primary energy factors can be an ineffective tool to reach these socio economic benefits. For instance, if electricity is produced with renewable energy, the factors make the incentive to save energy in electricity heated buildings higher than in non-electricity heated buildings without any apparent socio economic benefit.

Primary energy factors can also give rise to regulatory failures as the factors can be exploited to comply with regulations, but not fulfilling its purpose. For instance, a dual fuel boiler can be claimed to use only one of the fuels (the one with the lower primary energy factor), but in reality use the other fuel (see BPIE (2017)).

It is unclear whether the EPBD allows for setting all primary energy factors to 1, thereby effectively cancelling their impact on the energy requirements. Such an approach would be in line with an objective to secure buyers of new buildings the cost-optimal level of energy efficiency investments, when these requirements are set to reflect cost-optimality. This is also the recommended approach by others e.g. Building Performance Institute Europe (see BPIE (2017)).

RELATION TO THE ENERGY SYSTEM

Setting all primary energy factors to 1, thereby cancelling their effect on energy requirements does not mean that energy requirements in buildings should not be aligned with the energy systems the buildings are in. As noted in the previous slides, the level of energy requirements should consider all other energy regulations (e.g. taxes) and the fossil fuel dependency of the energy system.

Primary energy factors in a selection of countries

	Electricity	District heating	Biofuels	Natural gas	Oil
Sweden	1.6	1.0	1.0	1.0	1.0
Denmark	2.5	0.8	1.0	1.0	1.0
Finland	1.7	0.7	0.5	1.0	1.0
Germany	2.50	1.30	1.20	1.10	1.10
United Kingdom	3.07	-	1.04	1.22	1.10

Source: Swedish Energy Agency.

Ambitious energy standards may either support or obstruct Swedish companies in reaping export potentials fostered by the green transition

THE GREEN TRANSITION WILL REQUIRE HUGE INVESTMENTS ON A GLOBAL SCALE

At the United Nations Climate Change Summit in Paris in December 2015, 195 countries agreed that global warming should be limited to 2°C. A successful 2˚C energy transition will require huge CO2 reductions and likewise huge investments for the next many years (see figure). One estimate predicts SEK 850,000 billion to be invested in sustainable infrastructure from 2015 to 2030 on a global scale – that corresponds to 190 times Sweden's annual GDP.

SWEDISH BUSINESSES ARE IN PLACE TO REAP FUTURE EXPORT POTENTIALS

The needed global investments imply massive business potentials for those companies that succeed in getting a piece of the cake. In spite of its small size, Sweden has number of companies well suited to take advantage of the export potentials and thereby gain a share of the growth, productivity and job creation fostered by the green transition. This is supported by the fact that Sweden currently is one of the most energy technology exporting countries in the EU (see figure).

ENERGY STANDARDS MAY SUPPORT OR OBSTRUCT SWEDISH EXPORT POTENTIALS

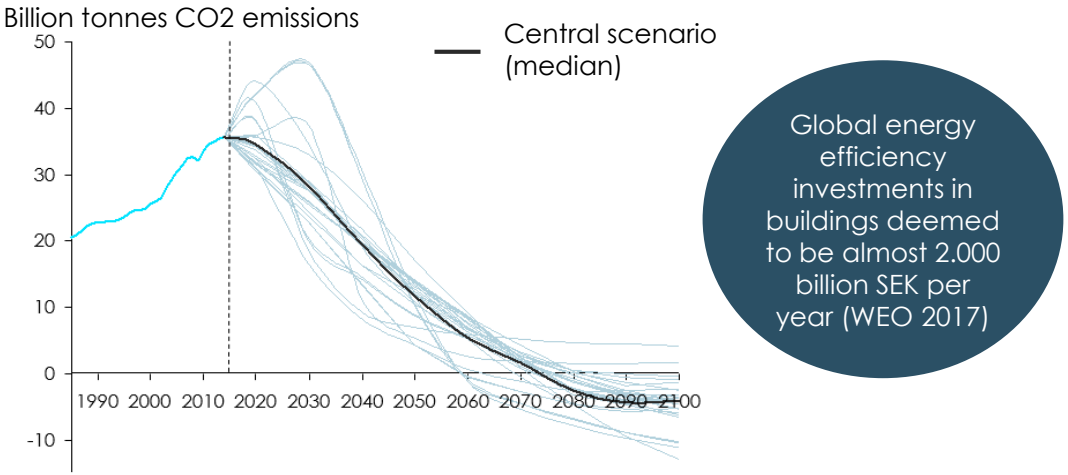
Implementing ambitious energy standards in Sweden will promote innovation in the form of new products, services and types of collaboration across the value chain (to be elaborated on next slide). This innovation will benefit the domestic Swedish market, but is *only* valuable for export purposes if other countries demand same types of solutions.

Whether this is the case, highly depends on the design of the new energy standards. Two important points (to be elaborated on next slide again):

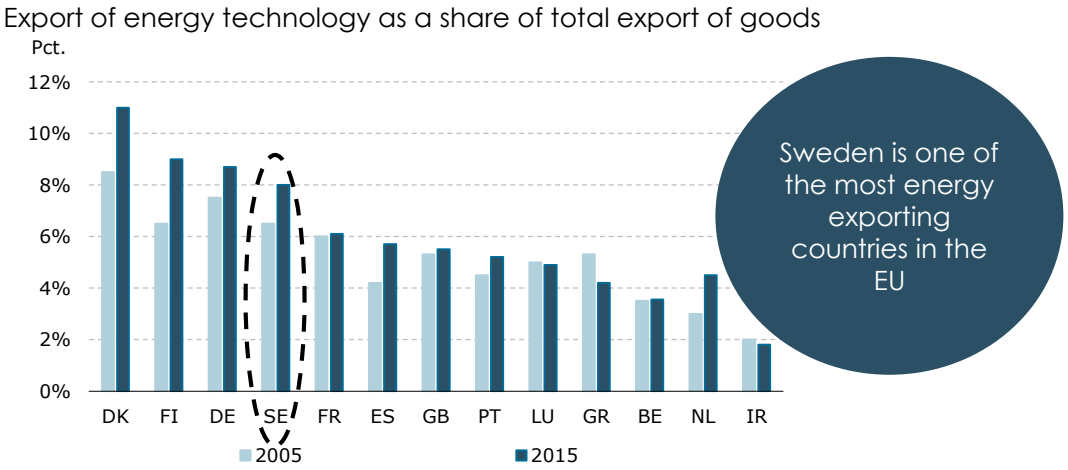
1. Implementing asymmetrically ambitious requirements compared to other countries reduces the likelihood of other countries demanding Swedish products and services

2. This is especially the case, if the ambitious energy standards are based on strict component requirements and not energy performance for the building as a whole

CO_2 reduction pathway consistent with the 2˚C objective



Export of energy technology



Source: Top figure: Copenhagen Economics (2016b).
Bottom figure: Danish Energy Agency, Danish Energy Association and DI Energi (2016).

Swedish innovation can only be exported if other countries demand the solutions – Swedish energy standards play vital role for this to happen

INNOVATION WILL ONLY CREATE EXPORT POTENTIAL IF OTHER COUNTRIES DEMAND SWEDISH SOLUTIONS

New energy standards give rise to innovation creating value in the Swedish market. Whether the innovation also will materialise in higher exports for Swedish companies depends on two factors:

1. How likely are other countries to demand the products?
2. Can the products be exported?

First, in order for a product to have value in international markets, the product must address a certain foreign need. If the product only solves a Swedish need, which is not defined or shared abroad, the export potential is limited. On the other had, Swedish companies developing products needed to comply with energy standards in other countries will obtain a competitive advantage.

Second, some products and services related to low energy buildings are exportable, others are not. If it is not possible to export a certain product to begin with, it will not be an advantage for Swedish business – in terms of exports – to 'be motivated to' make that innovation.

NEW ENERGY STANDARDS SHOULD NOT BE TOO AMBITIOUS, NOR FOCUS ON STRICT COMPONENT REQUIREMENTS

In order to provide the best conditions for Swedish export potentials, new energy standards should not be too ambitious compared to other countries and should not include strict component requirements as the resulting solutions may not be needed in other countries.

Instead, focusing on energy performance for the building as a whole may support export potentials as this gives room for flexible solutions and is more likely to comply with energy standards implemented in other countries (see figure).

Likelihood that Swedish innovation is valuable abroad

	Likelihood that other countries will follow suit	Suitable for export
Architects	+ Solutions demanded if functional requirements are implemented	+ The solutions can be exported but in limited scale: Primarily among the largest companies
Engineers	+ Solutions demanded if functional requirements are implemented	+ The solutions can be exported but in limited scale: Primarily among the largest companies
Material producers	- Low chance that solutions are demanded under component requirements + High chance that solutions are demanded under functional requirements	+ + Very suitable for export
Entrepreneurs and practical construction	+ Solutions demanded if mainly functional requirements are implemented	- Practical construction is typically not suitable for export + Large entrepreneurs are often more suitable

Source: Copenhagen Economics (2014).

References

BPIE (2015) *Nearly Zero Energy Buildings Definitions Across Europe*

BPIE (2017) *Is the primary energy factor the right indicator for determining the energy performance of buildings?*

Cialani, C and Perman, K. (2014) *Policy instruments to improve energy efficiency in buildings*

Copenhagen Economics (2014) *Betydning af lavenergiklasserne for byggebranchen*

Copenhagen Economics (2016) *Multiple benefits of energy renovations of the Swedish building stock*

Copenhagen Economics (2016) *The Future of Fossil Fuels*

Danish Energy Agency, Danish Energy Association and DI Energi (2016) *Eksport af energiteknologi 2015*

International Energy Agency (2017), *World Energy Outlook 2017*

IVL (2014) *Quantification of population exposure to NO2, PM2.5 and PM10 and estimated health impacts in Sweden 2010*

Kruyt et al., (2009) *Indicators for energy security and own analysis*

Nässén, J., Sprei, F. and Holmberg, J. (2008) *Stagnating energy efficiency in the Swedish building sector—Economic and organisational explanations*

OECD (2016) *Effective Carbon Rates - Pricing CO_2 through Taxes and Emissions Trading Systems*

Swedish Energy Agency (2017) *Scenarier över Sveriges energisystem 2050*

Zalejska-Jonsson, A., Lind, H. and Hintze, S (2012) *Low-energy versus conventional residential buildings cost and profit*

CONTACT

Martin Bo Westh Hansen, Managing Economist
Sixten Rygner Holm, Economist

Copenhagen Economics
Langebrogade 1
DK-1411 Copenhagen K