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Energy Productivity: A Review of Scottish Government Activities and International Practices

Authors: Benjamin Evar, Heather Lovell[1], University of Edinburgh

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[1] Contributing author to all sections except sections 2 and 6.

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Executive Summary

This report analyses government policies and programmes, and industry case studies to provide insights into how energy productivity can be promoted in the industrial and commercial sectors.

The findings are based on:

- A review of policies and measures implemented by the Scottish Government and other countries.
- A set of case studies on energy productivity gains and further potential for selected industries.

The purpose of the report is to:

- review legislation and programmes in Scotland;
- review practices around the world that could potentially serve as inspiration; and
- review the scope of changes already made in Scotland (and the UK where policies are relevant) and the potential for additional improvements in energy productivity.

Energy productivity is defined here as *a ratio of a measurable economic output relative to a measurable energy input*. The key conceptual difference between energy productivity and energy efficiency is in the specific focus on energy savings in the latter, as opposed to any *productivity enhancements* that arise from changes to energy input in the former.

Key findings include:

- Between 2003 and 2012 Scottish energy productivity increased 19%.

- Over the past four decades productivity relative to labour and energy use has risen significantly in industry, commercial activities and services across the UK, as in many other countries. This is due to technological advances, the economic benefit from reduced energy use, *and* explicit policies to encourage efficiency or productivity.

- Despite the 'rebound effect (falling prices lead to consumption increasing) the net effect of energy efficiency improvements in OECD countries has been to reduce the growth in energy demand.

- Current data collection practices associated with energy measurements are generally not fit to account for wider causes of energy productivity improvements.

- Including non-energy benefits (NEBS) along with direct energy savings in analyses of industrial energy efficiency improvements has been shown to double cost-effectiveness.

This report summarises a variety of governance[2] measures where policies and primary legislation, regulations, codes, financial incentives, grants and institutional arrangements have been used to encourage energy productivity. The term 'energy productivity' is not in widespread use within our case study countries (Austria, Germany, United States and Denmark), and public-sector initiatives are therefore often branded as 'energy efficiency' without considering full-chain effects explicitly.

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[2] There are numerous definitions of 'governance' in use across distinct literatures. This report uses the term in its widest sense following e.g. 6 (2005) in considering mechanisms of control (generally regulations), inducement (taxes and subsidies), influence (of individuals, organisations, arguments and ideas) and coping (reactions and strategies for survival).

Key insights from this research are as follows:

- Few governments have developed coherent national energy productivity programmes. This seems to be a missed opportunity to both promote and increase energy productivity.
- Methodologies for energy productivity data collection, reporting and benchmarking are poorly developed in most countries, and at EU level. The Scottish Government could lead the way by drawing on experience in energy assessment and management programmes and develop methodologies for assessing energy productivity, in collaboration with energy managers in industry, NGOs, utilities and energy service companies (ESCOs).
- The Scottish Government has implemented a variety of measures that relate to energy productivity across several categories. These could be combined in an explicit national energy productivity programme to compare and streamline potentially overlapping and related policies and regulations, and to promote and increase energy productivity across industrial and commercial sectors.
- Where initiatives such as energy productivity regulations and financing are being developed, this should be done on the back of strategic recommendations, discussions with industry about long-term investments, and evidence of best practice from around the world.
- Energy productivity financing could most usefully target technology upgrades with the potential to introduce productivity gains elsewhere (e.g. improved maintenance costs and indoor climates, waste-to-fuel options, and increased use of CHP systems).
- Total energy productivity (direct energy savings, and NEBS) is a strong basis for evaluating – and communicating – improved performance.
- Key sectors to consider in Scotland include the commercial built environment, opportunities in district heating, commercial and council energy grids generally.

1. Introduction

Structure of the report

This report presents insights from a review of a selection of policies related to energy productivity in Scotland, a comparison with activities across a small number of case study countries, and a close look at industrial and commercial sectors relevant to Scotland. It concludes with reflections on what additional measures may be appropriate in the Scottish context. The research was conducted in two stages[3], starting with a review of a few international case studies in energy productivity and continuing with a detailed look at the Scottish policy and regulatory context.

The final report is structured as follows:

- Section 2 presents a review of EU, UK and Scottish Government policies and related initiatives on energy productivity in the commercial and industrial sectors;
- Section 3 looks at how energy productivity is part of energy policy across a set of case study countries
- Section 4 presents three international case studies from the industrial and commercial sectors with relevance for Scotland
- Section 5 presents key considerations for government officials working with measures that relate to energy productivity in Scotland
- Section 6 presents an assessment framework for government officials working with energy productivity policies and measures
- Section 7 presents key insights

A definition of energy productivity

This research firstly defines energy productivity as **a ratio of a measurable economic output relative to a measurable energy input. This may also be expressed dynamically as a change in one measure relative to a change in the other over time.**

Following this definition, the denominator – change in kilowatt-hours, joules or therms – allows a simple accounting of various activities within a single figure. The change in economic output in the numerator may be one of several measures, but should relate to how a firm, sector or government conceptualises output activities, be that in widgets or GDP.

Box 1 includes two examples of common ratios of energy productivity. At first glance these ratios are simply the inverse of energy efficiency. However, energy productivity measures not only changes from direct energy input, but also indirect ones. Highly relevant activities to consider including in a complete measure of energy productivity include so called 'double dividend' opportunities for a company or society at large – in other words incentives or investments that increase productivity and profit margins while reducing undesirable outputs such as pollution or illness.

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[3] The first stage of this project was carried out in partnership with Heather Lovell to whom we are grateful for her contribution to this research.

Box 1: Example ratios for expressing energy productivity

Macro-economic energy productivity = **ΔGDP/ΔkWh**

Sector / firm energy productivity = **ΔUnit Output/ΔkWh**

The key conceptual difference between energy efficiency and energy productivity is therefore in a specific focus on energy savings in the first instance, as opposed to a focus on any productivity enhancements that arise from activities related to changes in energy use.

Energy efficiency indicators and initiatives ordinarily assess facility upgrades and technology innovations on their direct energy saving merits. The term energy productivity as defined here instead considers any initiatives that lead to improvements in output following changes to energy input. Examples include changes to lighting systems, air conditioning technology, building insulation, and industrial emissions, which often involve indirect energy and cost savings that arise from reduced environmental penalties, better in-door climates, and new use patterns. *Energy productivity strategies and assessments aim to capture the variety of changes that arise from energy saving initiatives and give rise to productivity gains, also referred to as non-energy benefits (NEBS)*. For a schematic explanation of NEBS see **Figure 1** below.

Total energy productivity gains can therefore be expressed as the sum of productivity gains from direct energy saving initiatives plus any associated NEBS[4]. In an analysis of 70 case studies across industrial activities[5], the inclusion of NEBS in modelling assessments doubled the cost-effective potential for energy improvements, compared to assessments that only looked at direct energy savings. Other studies have shown the benefits of including NEBS in analyses of savings, payback and productivity at industrial facilities[6]. However, there is also evidence to suggest that industry often overlooks the productivity gains that arise from simple but effective measures such as conventional technology upgrades[7].

One benefit to energy managers of thinking about improvements in terms of energy productivity is that this widens the scope of relevant industry initiatives and public sector activities. *Governments may likewise consider whether energy productivity offers a good basis for engaging with businesses on terms that relate public sector initiatives, private sector output and energy use*.

[4] Boyd and Pang (2000)
[5] Worrell *et al.* (2003)
[6] Lilly and Pearson (1999), Pye and McKane (1999)
[7] Worrell *et al.* (2003)

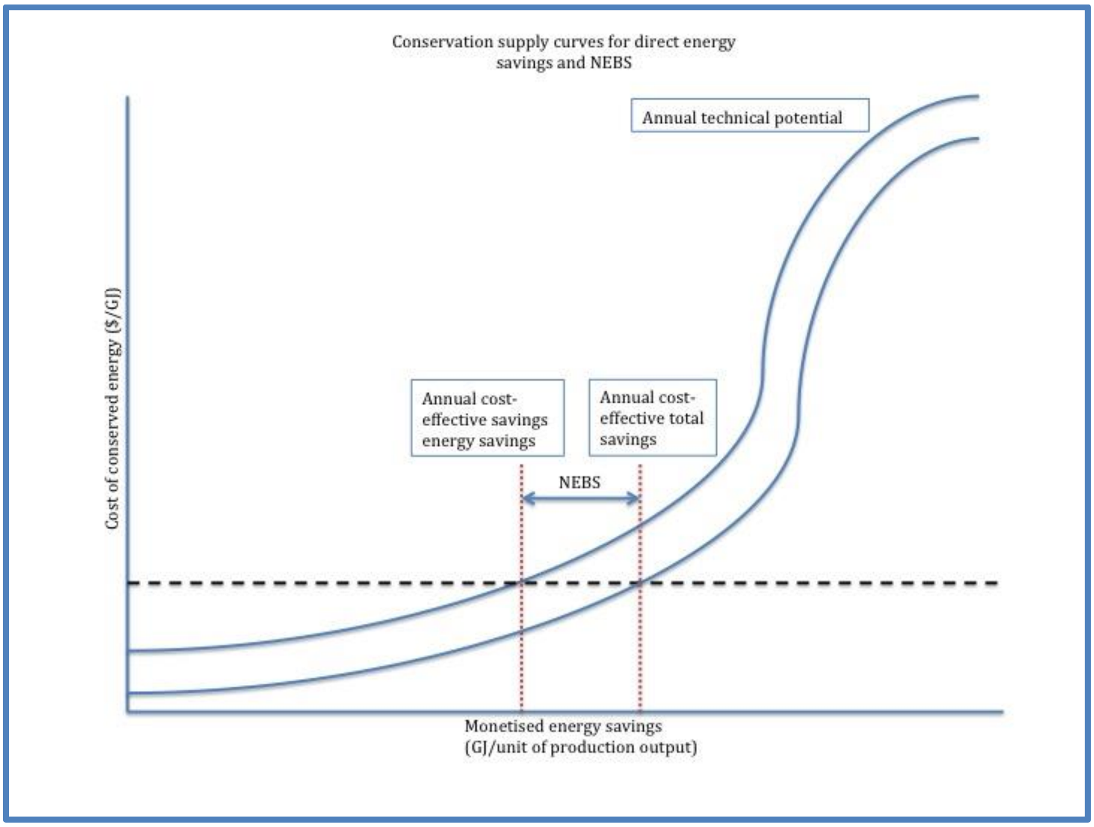

Figure 1: Conservation supply curve for direct and non-energy benefit savings (NEBS) from adopting new technologies and processes. The top curve accounts only for direct energy savings, while the bottom includes savings from NEBS. By including NEBS in the analysis, a greater amount of monetised energy savings are achieved relative to the same cost of conserved energy. Source: Adapted for the general case from Worrell *et al.* (2003).

Box 2: Productivity gains from energy efficiency initiatives in the US

While conventional wisdom may suggest that the availability of global fossil fuel supplies has eroded energy saving incentives, several countries have witnessed substantial increases in energy productivity in the recent past. Over the past 40 years the US economy has grown by almost 300% while energy consumption has increased by less than 50%.[8] The US federal governance system has furthermore allowed states such as California and Massachusetts to set policy and emerge as leaders in areas such as appliance standards, electricity generation and heating.[9] While there is considerable uncertainty associated with the attribution of causal relationships between energy productivity improvements and government policies and regulations[10], it is clear that the contribution of efficiency measures towards energy productivity in the US has exceeded the combined effect of all new energy supply resources since 1970[11] and that current low natural gas prices and rising international and energy and labour costs, have created a competitive advantage for US manufacturing.[12] This argues for the important role of energy efficiency measures in increasing economic productivity.

[8] US energy consumption peaked in 2007 and has been on a downward trend since, with consumption in 2012 below 1999 levels (NRDC 2013).
[9] Alliance to Save Energy (2013a)
[10] The NRDC estimates that 25-75% of productivity gains in the US have been achieved as a result of efficiency investments.
[11] NRDC (2013)
[12] Aden *et al.* (2013)

Methodology and scope

This report focuses on policies and initiatives that relate specifically to activities in the industrial sector. Policies aimed at changing energy use patterns in the domestic and public sectors are only commented on to the extent that there is a likely impact on how energy related services and products from industry will be delivered in the market.

Material has been collected and analysed through policy and regulatory documents available online and interviews with key stakeholders from public bodies and NGOs in Scotland and beyond. Analysis in later sections of the report is supported by theoretical insights from multidisciplinary literature on energy consumption, public policy and sustainability studies.

2. Energy Policy in the EU, UK and Scotland

This section presents a brief overview of energy use patterns in Scotland and a review of policies and initiatives in the EU, UK and Scotland that relate to energy productivity.

The Scottish and UK contexts

Why look at commercial and industrial sector energy productivity? Data from the past four decades shows that productivity relative to labour and energy use has risen significantly in industry, commercial activities and services across the UK. The same pattern has been witnessed in many other countries. Even where explicit policies to encourage efficiency or productivity have not been developed this has been the case, simply because of the economic benefits that derive from curbing energy use and improving process technologies.

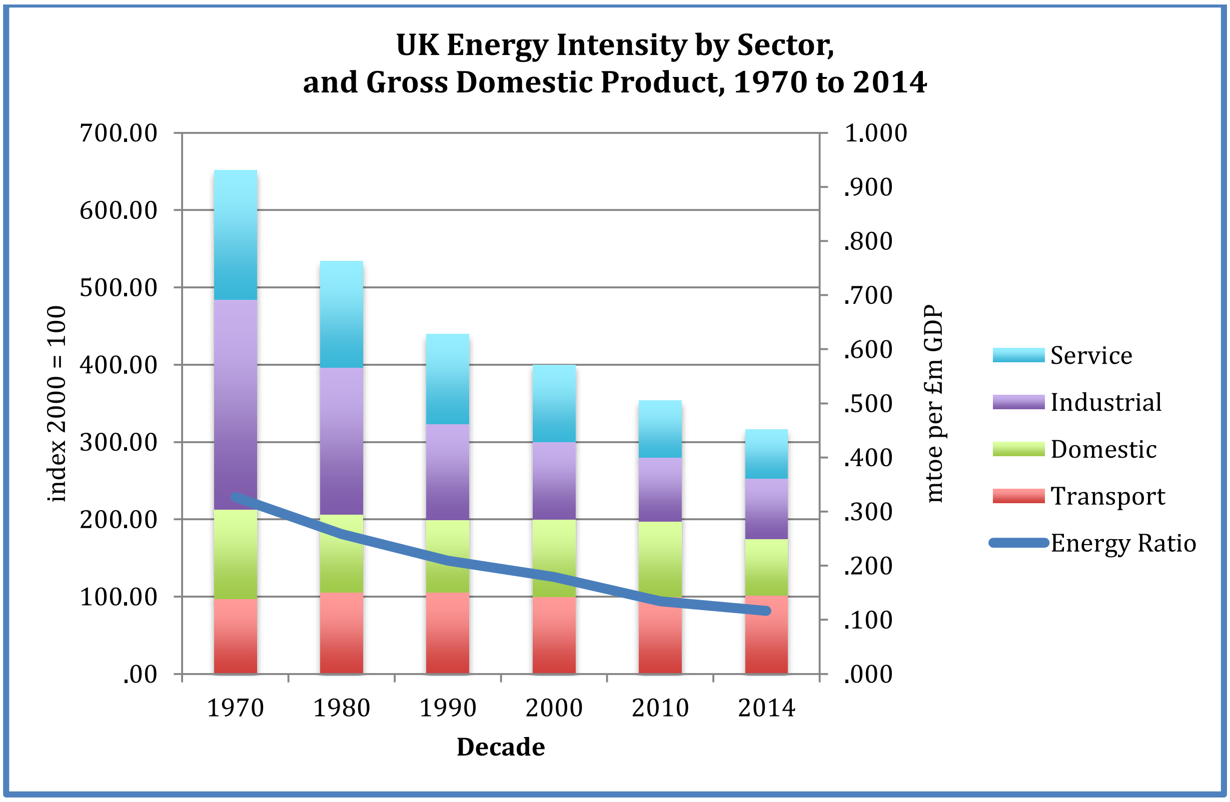

Figure 2: UK Energy Intensity by Sector, and Gross Domestic Product, 1970 to 2014. Energy intensity fell significantly over the period, particularly in services and the industrial sector. Energy ratio is defined as total inland consumption of primary energy (tonne of oil equivalent) per £1 million Gross Domestic Product.
Source: DECC (2015)

Figure 2 above shows the change in intensity in the UK since 1970, a pattern that can also be seen for Scotland in more recent years where detailed data is available. In the past decade substantial productivity gains have been achieved within Scotland's commercial and industrial sectors while absolute energy consumption has simultaneously been reduced. *Between 2003-2012, Scottish energy productivity increased 19%*[13] (see **figure 3** below). This trend suggests that industrial activities separate from the domestic and transport sectors became increasingly energy efficient. This data analysis is noteworthy because it reaches

[13] Measured as GVA indexed to year 2009 relative to kWh consumption. The Scottish Government generally relies on the GVA measure while the UK uses the GDP measure.

further than previous statistical compilations on energy productivity[14], which have been less granular and only considered changes at the level of the entire economy.[15]

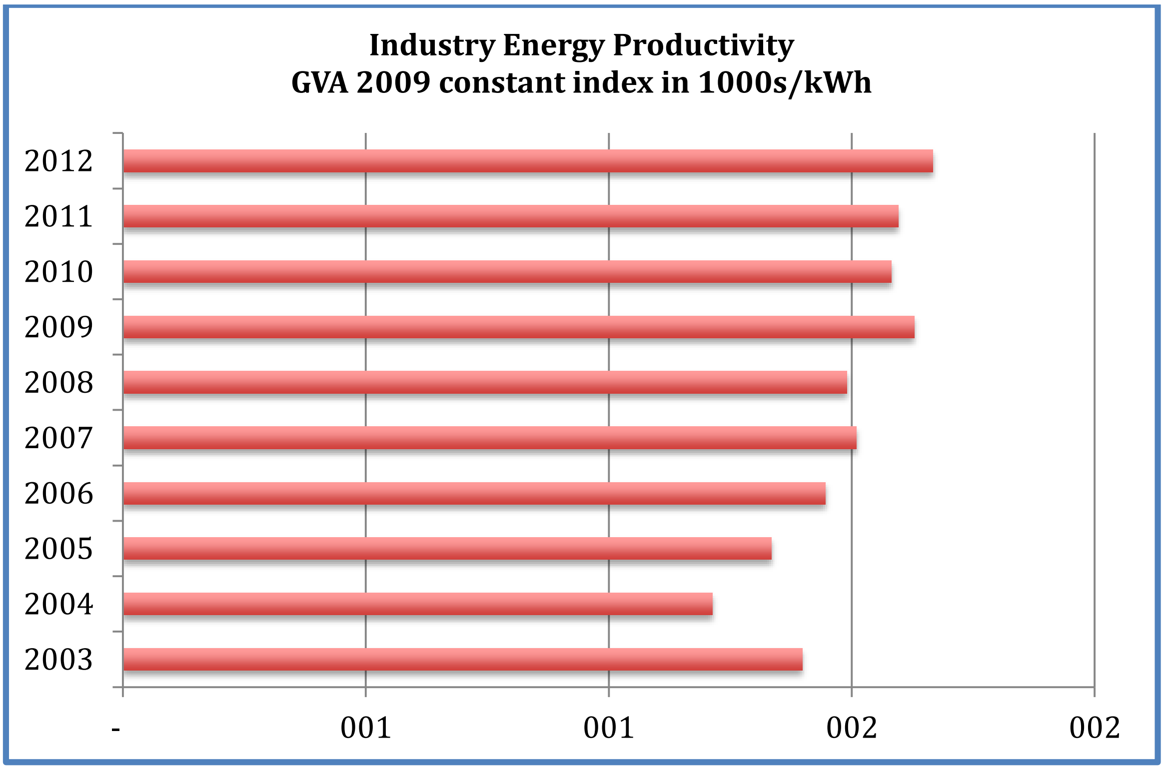

Figure 3: Scottish Industry Energy Productivity at constant 2009 weighted GVA index (index as reported in Scottish National Accounts) per kilowatt-hour, 2003-2012. The difference in the index between years 2003 (1.40) and 2012 (1.67) is 19%. Sources: Created from data in BERR (2008); DECC (2014b); SG (2013d)

We undertook a comparison of sector output across typically energy-intensive manufacturing activities in Scotland to identify industrial and commercial activities that might be prioritised under energy productivity initiatives. The activities chosen for consideration were agriculture; cement, lime and plaster; and paper products. The commercial built environment was furthermore selected, as this area has received a great deal of attention in recent energy efficiency analyses and policies internationally, and is a key part of Scotland's Energy Efficiency Action Plan.

Not all energy-intensive industries have witnessed the same growth in recent years. While output in agriculture and cement remained fairly constant, and paper contracted, throughout the period 1998-2009, construction witnessed dramatic increases of more than 200% each. There is good reason for prioritising such high growth industries for special attention. At the same time, governments may want to pay special attention to sectors that have witnessed rising energy costs and international competition in recent years, such as paper, and enable them to redesign manufacturing activities to become more energy efficient and by extension more competitive, using an energy productivity framework.

[14] Scottish Government (2013c)

[15] Data on changes in energy consumption within individual standard industrial classification (SIC) codes could not be obtained for this report. It therefore remains unclear whether macro-economic developments, structural reforms or productivity changes specific to individual activities, have been at the root of this trend.

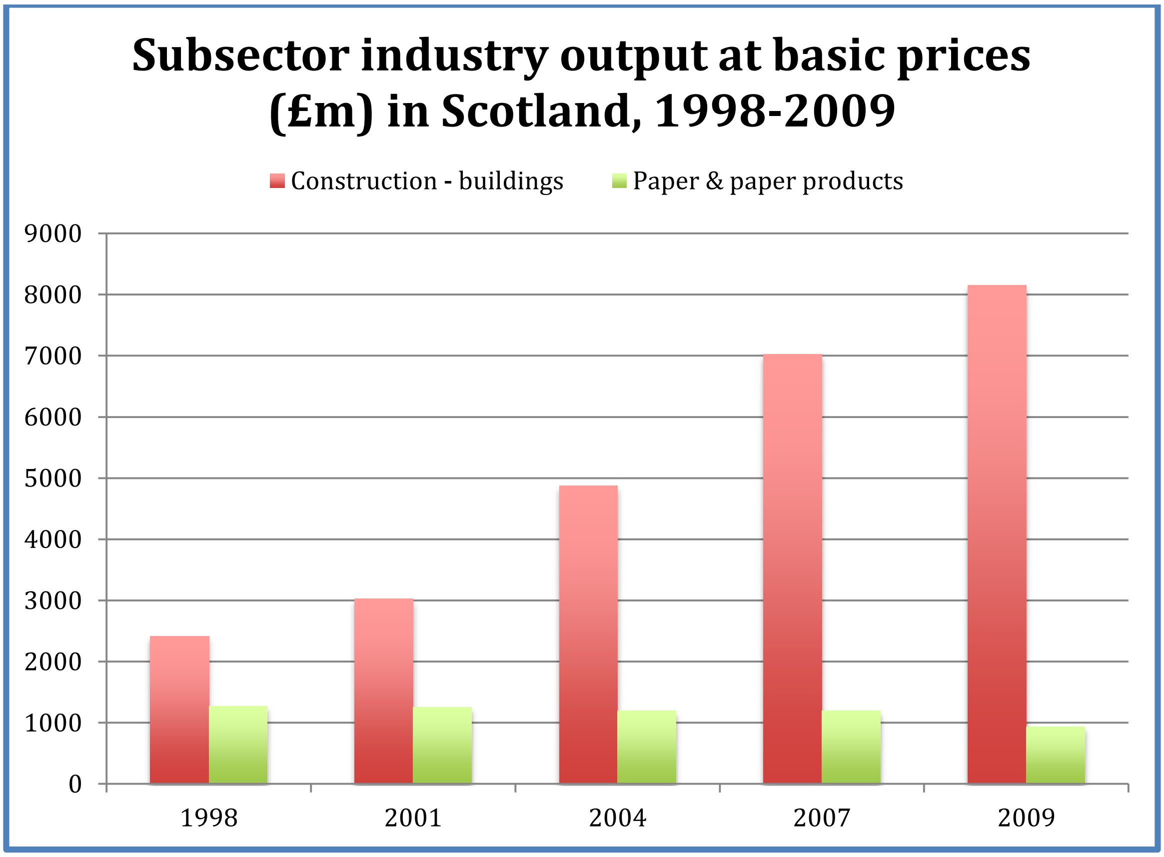

Figure 4: Subsector industry output at basic prices(£m) in Scotland, 1998-2009
Source: Created from data in SG (2013d)

While the Scottish Government does not have an explicit policy or programme on energy productivity, many relevant initiatives can be addressed under related policies and regulations, notably energy efficiency and renewable energy generation. In 2010, the Scottish Government pledged to reduce energy consumption across all economic sectors by 12% in 2020 relative to an averaged baseline for 2005-2007, in line with the EU 20% target. Associated targets included the increase of renewable energy to meet 100% of Scotland's gross annual electricity consumption; 11% of non-electrical heat demand from renewable sources; the development of a discrete district heating policy; energy standards for buildings developed in 2010[16]; and a 43% carbon emission reduction for non-domestic buildings from 2014 onwards relative to a 2004 baseline. These initiatives are designed to grow a green economy and reap productivity gains while reducing energy consumption and greenhouse gas emissions (GHG), and thus are at their core about energy productivity, even if not explicitly labelled as such. More detail on these policies can be found in the next section of this chapter.

Programme options

The variety of initiatives discussed in this report can be grouped according to categories such as those listed in table 1 below. Initiatives often overlap across types, however it is clear that activities listed in the following section fall into general types that can be compared with those in other countries. The category

[16] These new standards for buildings were developed in line with recommendations presented in the 2007 Sullivan Report, *A Low Carbon Building Standards Strategy for Scotland*, which aims towards net zero carbon buildings by 2016/17.

headings in table 1 have been used to group and compare international energy productivity policies and programmes throughout the report.

Codes and standards	Minimum compliance standards for specific technologies and processes, such as GHG emissions, heating and energy conversion.
Performance/resource standards	Minimum performance standards mandate usage as a function of a specific value, e.g. occupancy levels, units of production, or emissions – by point of construction or time of sale in case of retrofits.
Taxation and subsidies	Levied and paid out on activities that meet specific goals such as minimum standards or double dividends.
Public service obligations (PSO)	Mandating that utilities fund energy efficiency improvements annually through demand-side management.
Energy efficiency resource standards (EERS)	Like a PSO, an EERS is a long-term policy that establishes specific annual energy saving targets. The target may however fall on any stakeholder, public as well as private. Targets are tightened annually.
Voluntary standards, ratings and disclosures	Common for buildings but also include carbon emissions disclosures for manufacturing and industry association targets.
Education and information	Engaging with developers, users, tenants, manufacturers etc. through government- or utility-sponsored channels to help assess energy and cost savings and to understand investment barriers.
Technical assistance and training	Developing specialised skills programmes and providing building managers with follow-up training.
System public benefit charges	Collected by utilities, revenues flow into funds operated by the state, towards earmarked purposes.
Special appropriations and grants	Government support for innovative new schemes and technologies. Particularly applicable to stakeholders that have relatively poor access to financing such as many SMEs.
Financing options	See table 3 for a detailed list of options applicable to the commercial built environment.

Table 1: Government policy options towards increased energy productivity
Source: Alliance to Save Energy (2013b); IEA (2010); Granade *et al.* (2009); Downs *et al.* (2013)

EU level policy and programmes[17]

At the highest level, regulatory initiatives with potential to influence energy productivity in Scotland are guided by EU Directives such as the Energy Efficiency Directive (EED). A few of these initiatives are summarised below.

- **The Energy Efficiency Directive (EED) –** aims to increase energy efficiency 20% by 2020. This target was adopted by EU Member States in June 2014. The EED covers all end-use sectors except for transport. EU member states have an obligation to fulfil several requirements including the preparation of a buildings renovation strategy, development of National Energy Efficiency Action Plans, and regular reporting on targets to the Commission.
- **The Energy Performance of Buildings Directive (EPBD) –** introduced in 2002, this brings forward energy labeling for domestic and non-domestic properties when built, sold or rented. Energy Performance Certificates (EPCs) were introduced for different types of buildings, and Display Energy Certificates (DECs) specifically for large non-domestic buildings in the public sector were introduced in the UK in 2008 (see UK policy notes below).
- **The Energy Service Directive –** covers the retail sale, supply and distribution points of grid-based electricity and natural gas, as well as district heating, heating oil, coal, etc. Among the aims of the Directive are the creation of a market for energy saving and efficiency measures; an indicative target for a 9% energy efficiency increase between 2008 and 2016; and requirements for public sector efficiency improvements and information provision.
- **The Ecodesign and Energy Labelling Directives –** regulates minimum energy efficiency and labelling standards for end-users, which is anticipated to expand to include industrial equipment[18].
- **The EU ETS –** mandates most large energy-intensive companies to reduce or offset part of the CO_2 emissions associated with energy consumption.

UK level policy and programmes

At UK level the Climate Change Act 2008 mandates an 80% reduction in greenhouse gas emissions by 2050 compared with 1990 levels[19]. In line with EU Directives, the UK has committed to increasing its share of final energy consumption from renewable sources to 15% by 2020[20] and reducing final energy consumption by 18% between 2007 and 2020 compared with business-as usual-projections.

The list here presents selected UK government policies and initiatives that are relevant to energy productivity in industry directly and indirectly – through regulations and the support of transformations, and by changing final demand. Such activities have defined a course towards low carbon transformation in UK energy policy, which the Department of Energy and Climate Change believes helped reduce energy consumption for much of the past decade.[21]

Overarching policies	High-level government programmes that address multiple aims and leverage several activities and financing options.

[17] This list is correct as at 21 August 2015
[18] Viagand og Maagøe (2013)
[19] CCC (2008)
[20] European Parliament (2009)
[21] The following is a selection of policies and measures that relate to industry and other non-domestic activities, rather than a comprehensive list of all energy policies in the UK. Details and further references can generally be found in DECC (2014a) unless another source has been noted.

- **UK Electricity Market Reform (EMR) –** the UK Government estimates that two of the most significant price mechanisms under the EMR, the Capacity Markets and Contracts for Difference, alone will account for more than £3 billion of expenditure payments from generation and demand-side-response by 2020. **The Capacity Market** allows suppliers to be remunerated according to the capacity they supply rather than just the energy delivered. This provides investors with some security of a reasonable return on their capital through regular proving rather than price spikes. An opening auction was held in 2014 for deliveries in 2018, with a price of £20 per kW, for an initial 50 GW, i.e. a total of £1 billion of capacity payments in the delivery year. **Contracts for Difference (CfD)** have been introduced to replace Renewable Obligation Certificates (ROCs). Where ROCs have provided suppliers with a fixed payment on top of the price in a wholesale market, the CfD pays the difference between a strike price and a market reference price. CfDs were first initiated in the spring of 2015 and reviewed by the UK Government's Competition and Markets Authority, which noted that current legislation may open the door to non-competitive allocations in the future, thus potentially distorting the efficiency of the system.[22]
- **CHP support mechanisms** – there are several support mechanisms available for Combined Heat and Power (CHP) under UK Government policies. **The CHP Focus Programme** provides information on overall benefits and the assessment of economic viability. The **CHP Quality Assurance Programme** ensures that only high quality plans are eligible for support under a range of schemes enforced in England and Wales. CHP has a limited exemption from The **Carbon Price Floor (CPF)**, depending on the use of the energy being generated. A limited exemption is also made under the **CRC scheme**. CHP schemes receive 100% tax relief under the **Enhanced Capital Allowance (ECA)** scheme introduced in 2001 and are additionally eligible for **preferential business rates**. And finally, the **Renewables Obligation, the Feed-In Tarff (FIT)** and the **Renewable Heat Incentive (RHI)** all provide support for renewable CHP installations. The RHI has functioned as a subsidy on non-domestic heating from renewable sources active since 2014. The RHI is projected to have a worth of £90 million over four years and to be expanded to the domestic sector as well. The policy is projected to reduce emissions in Scotland by as much as 914 $ktCO2_e$ from 2027 onwards[23].

Codes and standards	Minimum compliance standards for specific technologies and processes, such as GHG emissions, heating and energy conversion.

- **Energy Service Companies / Energy Performance Contracting** – in order to comply with EU law and promote the development of energy related SMEs the UK Government has published a model contract with guidelines for contractors, a Best Practices Guide to Energy Performance Contracting, and separate guides for financing energy efficiency in the public and private sectors.
- **Smart Metering –** in 2010 the UK Government proposed the installation of 53 million smart electricity and gas meters in domestic and non-domestic properties by 2020. A Code of Practice has been developed by the UK Government to guide the types of meters and site installations. In Scotland alone, this policy is expected to reduce annual emissions 46 $ktCO_2e$ by 2027.[24] As of summer 2015 6% of this target for total installed units had been reached.[25]

Performance/resource standards	Minimum performance standards mandate usage as a function of a specific value, e.g. occupancy levels, units of production, or

[22] Competition and Markets Authority (2015)
[23] Scottish Government (2013e)
[24] Scottish Government (2013e)
[25] Lynam (2015)

	emissions – by point of construction or time of sale in case of retrofits.

- **Building Regulations** – in England, average reductions of 6% in CO_2 emissions are now required for new homes and 9% for new non-domestic buildings compared to 2010 regulations. Scottish regulations are even more stringent, see details below. DECC estimates that improvements to Part L of the Building Regulations (England) saved 13TWh by 2012 and are projected to save 14TWh by 2016 in non-domestic buildings. This accounts for over 40% of all savings from energy efficiency programmes and policies in the private and public sectors, roughly equal to the proportion of the UK's carbon emissions associated with the entire building stock.
- **Energy Performance Certificates (EPCs)** – introduced as part of the EU Energy Performance of Buildings Directive, EPCs present energy efficiency ratings of both commercial and domestic buildings on a scale from A/A+ to G. The EPC also contains recommendations on a range of measures to improve building energy efficiency and must be made available whenever a property is constructed, rented out or sold.[26] Similar programs in other EU member states (Denmark and Germany) have helped establish energy service companies (ESCOs), some of which are independent branches of established energy utility companies.
- **Display Energy Certificates (DECs)** – as opposed to EPCs, DECs provide information on actual energy use, rather than a theoretical energy rating. From 2008, buildings occupied by a public authority with more than 1000 m^2 of usable floor space and which are frequently visited by the public were required to have a DEC. The threshold was reduce to 250 m^2 July 2015.

Energy efficiency resource standards (EERS)	Like a PSO, an EERS is a long-term policy that establishes specific annual energy saving targets. The target may however fall on any stakeholder, public as well as private. Targets are tightened annually.

- **CRC Energy Efficiency Scheme (CRC)** – a mandatory scheme introduced in 2010, aimed at improving energy efficiency and cutting emissions in large, non-energy intensive, public and private sector energy users. The CRC includes around 2000 participants in the public and private sector across the UK (around 130 in Scotland) and aims to encourage organisations to prioritise investment in energy efficiency and to cut carbon emissions through carbon pricing, mandatory monitoring and reporting of energy consumption, and the publication of participants' emissions data. The policy is expected to reduce emissions in Scotland by as much as 154 $ktCO_2e$ from 2027 onwards and will be reviewed in 2016.[27]
- **Energy Savings Opportunity Scheme (ESOS) –** implemented in 2015, ESOS requires large UK companies to undertake energy efficiency audits every four years. This covers undertakings that are not otherwise covered under regulation pertaining to the Green Deal or Energy Display Certificates. ESOS requires that companies present practicable ways to save energy and cut costs, supported by verifiable data, cost/benefit analyses and a life-cycle analysis perspective. Initial analysis suggested that ESOS had the potential to deliver nearly £2 billion of net benefits and reduce energy bills by £300 million in its first year.[28]

[26] Energy Saving Trust (2015b)
[27] Scottish (Government 2013e)
[28] Carbon Trust (2015)

Taxation and subsidies	Levied and paid out on activities that meet specific goals such as minimum standards or double dividends.

- **Climate Change Agreements (CCAs)** – CCAs provide energy-intensive industries with annual tax discounts in return for meeting energy efficiency targets. Targets are set using evidence submitted by industry on abatement potential. CCAs cover around 9,000 facilities (often within the companies targeted by CRC and EU ETS, with the CRC targeting non-CCA and non-EU ETS energy use). The policy is to be reviewed in 2015.
- **The Climate Change Levy (CCL)** – introduced in 2001, this is a tax on the supply of specified energy products used as fuels (for lighting, heating and power) by business consumers.
- **The Enhanced Capital Allowance (ECA) Scheme –** provides businesses with enhanced tax relief for investments in equipment that meets published energy-saving criteria.
- **The Carbon Price Floor (CPF)** – a policy that ensures a minimum price for carbon emissions from electricity generation. The UK-only element of the carbon price floor will be capped at £18 per tCO_2 from 2016-17 to 2019-20.[29]
- **Feed-in Tariff (FIT) –** introduced in 2010, the FIT has so far paid a rate per unit of electricity generated with solar, wind, hydro and micro CHP plants. Tariffs have been awarded depending on eligibility and Energy Performance Certificate rating.[30] In December 2015 DECC announced a pause to the FIT scheme and the introduction of deployment caps.[31]

Voluntary standards, ratings and disclosures	Common for buildings but also include carbon emissions disclosures for manufacturing and industry association targets.

- **Mandatory greenhouse gas (GHG) reporting** – introduced in 2013, the programme places a requirement on companies to report their emissions and associated energy use, and to report such figures in annual reports to function as tool for investors to assess the long-term performance of public companies.
- **Green Government Commitments** – the UK's approach to reduce emissions associated with energy use in Government buildings 25% by March 2015 relative to a 2010 baseline. By the Government period 2013-14, 20% emissions reductions had been achieved, totalling savings of £75m in reduced energy consumption.[32] A follow-on goal by the Government states that an estimated 516.6 GWh of energy may be saved between 2014 and 2020, 163.6 GWh of which have been targeted to follow the EU Directive. In other words, there is potentially scope for public sector energy savings to far exceed targeted amounts.

Special appropriations and grants	Government support for innovative new schemes and technologies. Particularly applicable to stakeholders that have relatively poor access to financing such as many SMEs.

- **The UK Green Investment Bank (GIB)** – established by the Government in October 2012, the GIB is the world's first bank dedicated to placing capital in to areas of the economy that have the potential for increasing environmental sustainability, specifically energy efficiency, off-shore wind and waste. With government funding of £3.8 billion, the GIB invests in infrastructure projects that have insufficient support from private markets and always invests alongside and on terms similar to the private sector. By

[29] HM Revenue and Customs (2015)
[30] Energy Saving Trust (2015a)
[31] Ofgem (2016)
[32] HM Government (2015)

April 2015, the GIB had spent £1.8bn to mobilise a total of £6.9bn of private sector capital in support of 46 projects.[33]

- **Salix Finance Ltd** – a grant-funded finance scheme that provides interest free loans for energy efficiency projects in the public sector. By 2015 Salix had funded projects with an estimated lifetime financial savings of £1.4. The fund continues to support activities such as district heating pilot schemes (see below).
- **The Small Business Research Initiative –** developed by the Technology Strategy Board in 2012, the Initiative has introduced a £10 million *Invest in Innovative Refurb* competition in England and Wales. The programme aims to tackle barriers associated with small and emerging markets, such as limited roll-outs of new products, lack of faith in energy benefits of energy investments and poor collaboration between market stakeholders that lead to perverse incentives (a common problem where landlords and renters have mixed incentives related to efficient energy management).
- **Energy Entrepreneurs Fund (EEF) –** run by DECC the EEF supports the development and demonstration of new technologies and processes in energy efficiency and building technologies, as well as power generation and energy storage. A total of £35 million has been made available since its launch in 2012.

Technical assistance and training	Developing specialised skills programmes and providing building managers with follow-up training.

- **The Energy Saving Trust – The Energy Saving Trust** – (in Scotland replaced by Resource Efficient Scotland, see below) has worked with over 2.500 organisations to manage and reduce their energy use between 2007 and 2011.
- **The Carbon Trust** – (in Scotland replaced by Resource Efficient Scotland) until 2012 funded by the UK Government. That year energy savings were estimated to have reached 398 GWh with cost savings of nearly £4.3 million[34]. The Carbon Trust is now a self-funded entity that continues to offer its energy standard to businesses, requiring the measurement, reduction and management of energy use.
- **Build Up Skills UK** – This programme focuses on identifying and alleviating the skills gap related to the installation and maintenance of building energy efficiency technologies. The project is led by the Sector Skills Council and aims to establish a long-term training infrastructure.
- **Accreditation of energy professionals** – the National Occupational Standards (NOS) for Energy Assessors guides the certification of those carrying out Energy Performance Certificates and Display Energy Certificates. The Institute for Energy Management and the Energy Institute peer-review registers also ensure a comparable skills basis for energy auditors.
- **Certification of building installations** – is done separately for the UK and Scotland, and special requirements are in place for air conditioning units and installations under the Green Deal.
- **The Technology Innovation Needs Assessment (TINA)** – a programme aimed at innovation in the non-domestic buildings sector, estimated to result in savings of 86 $MtCO_2$ and £13 billion by 2050 across the UK as well as export opportunities of around £1.7 billion to the UK GDP.

Education and information	Engaging with developers, users, tenants, manufacturers etc. through government- or utility-sponsored channels to help assess energy and cost savings and to understand investment barriers.

[33] GIB (2015)
[34] Scottish Government, 2013

- **Energy Technologies Institute (ETI) –** the ETI runs a 5-year Smart Systems and Heat Programme, which investigates heat demand drivers and the potential for technical innovations in the field.
- **Energy pricing (government involvement) –** in a 2015 review of energy pricing tendencies in the UK, the Competition and Markets Authority (2015) noted that several factors may be inhibiting competitive and efficient pricing for micro businesses. These include higher prices paid by microbusinesses relative to SMEs; tendency to keep non-domestic prices hidden, thus weakening the negotiating power of microbusinesses; minimal use of brokers to obtain competitive prices; and a tendency to stay with existing suppliers. Government led education and information campaigns may have a role to play here.

Scotland level policies and programmes

Scottish policies and initiatives to a large extent build on the energy and climate change context of the EU and UK. In 2010, the Scottish Government pledged to reduce energy consumption across all economic sectors 12% by 2020 relative to an averaged baseline for 2005-2007, in line with the EU 20% target. Scotland has also introduced its own climate change and renewable electricity targets, which mandate deeper GHG reductions than the UK, namely 42% by 2020 and 80% by 2050 compared with a 1990 baseline.[35] With respect to renewables, Scotland has introduced ambitious targets with a current goal of 100% electricity demand to be met by renewables in 2020.[36]

For the built environment, a carbon emissions reduction ambition of 43% has been established for non-domestic buildings from 2014 onwards relative to a 2004 baseline,[37] and several skills training programmes have been initiated including the Low Carbon Skills Fund. While Scotland does not have an explicit policy or programme on energy productivity, the activities listed below show that there has been commitment on multiple levels to increase efficiency and productivity across the industrial and commercial sectors[38]:

Overarching policies	High-level government programmes that address multiple aims and leverage several activities and financing options.

- **The Climate Change (Scotland) Act 2009 –** sets targets for the reduction of all major GHGs of 42% by 2020 and 80% by 2050, compared to a 1990 baseline. Data published in 2015 show that Scotland is currently not on track to meet annual emissions reduction targets.[39]
- **Electricity Generation Policy Statement (EGPS) –** formulated in 2012, the EGPS sets out four overall aims: security of supply; affordability to consumers; decarbonisation 2030, with an average carbon intensity of 50 gCO2/kWh; and maximising economic benefits and competitive advantages for Scotland with a community focus.[40]
- **The Energy Efficiency Action Plan for Scotland (EEAP) –** published in October 2010, this plan developed a 12% efficiency target for final energy consumption across 10 priority areas, which cover all sectors of the economy, up to 2020 against a 2005-2007 baseline. The plan established minimum levels of ambition for all sectors and was implemented alongside existing policy targets for greenhouse gas emissions reductions. The plan notes the importance of securing financing and developing skills across

[35] Scottish Parliament (2009)
[36] Scottish Government (2011)
[37] Scottish Government (2013b)
[38] The following is a selection of policies and measures that relate to non-domestic activities and the industry sector, rather than a comprehensive list of all energy policies in Scotland. More detail and further references can be found in Scottish Government (2013b), unless another source has been noted in the list.
[39] CCC (2015)
[40] Scottish Government (2013b)

society such that resources for ensuring efficiency and increasing productivity are available. Progress reports have since been published annually.[41]

- **The Carbon Management Plan** – commits public bodies in Scotland to reduce emissions 30% between 2010 and 2020. Associated energy savings are estimated at 27.5 GWh. The Scottish Futures Trust estimates that investments in the public sector totalling £350 million could yield savings of £900 million.
- **Heating –** heating needs make up half of energy consumption in the UK and contribute a third of all greenhouse gas emissions. Although there are around 200 district heating schemes operating in the UK, these only supply 2% of all heat going into commercial, domestic and public sector buildings. Pilots are support by funds such as **Salix** (see details in list below) and the Government has put forward policy on the matter. In June 2015 the Scottish Government released its **Heat Policy Statement**, which sets out its future policy direction for heat demand, generation, distribution and storage. The cornerstone of this policy will be **Scotland's Energy Efficiency Programme** (SEEP), to be launched in 2017/18. SEEP will provide an offer of support to all buildings in Scotland – domestic and non-domestic – to improve their energy efficiency rating. The Heat Policy Statement also includes: an ambition to deliver of 1.5 TWh of heat by 2020 to households, businesses, industry and the public sector using district heating, and includes an extension of financial support mechanisms; the **District Heating Loan Fund**, which makes more than £10 million available for heat policy support; the **Outline Heat Vision**, a policy published in January 2014 to support the development of low-carbon heat generation and the goal of a near-zero carbon heat sector by mid-century; the **Heat Mapping Programme for Scotland** carried out in cooperation with Local Authorities to produce a national heat map;[42] and the **Heat Network Partnership**, which provides support to district heating projects at all stages from planning to procurement and implementation. The Partnership aims to support the involvement of industry with local authorities in the development of a systematic approach to project implementation.

Performance/resource standards	Minimum performance standards mandate usage as a function of a specific value, e.g. occupancy levels, units of production, or emissions – by point of construction or time of sale in case of retrofits.

- **Building Regulations** – in Scotland, homes built to the new 2015 standards will deliver a 21% reduction in CO_2 emissions relative to 2010 levels, while non-domestic buildings will deliver a 43% reduction. This translates into annual abatement of approximately 14-16 ktCO_2.[43] The publication of the **Sullivan Report** in 2007 called for a 'net zero carbon' standard in new buildings from 2016 onwards. Following the economic downturn this recommendation was revised to fall in line with the **EU's Energy Performance of Buildings Directive** requirements of a 'nearly zero energy' standard for new non-domestic public buildings from 2019. The cumulative emissions reductions from new buildings standards introduced as part of the Sullivan Report in and EU Directives are projected to reach 1.2 MtCO_2e by 2027.[44]

Taxation and subsidies	Levied and paid out on activities that meet specific goals such as minimum standards or double dividends.

- **Financing Low-Carbon Home Construction –** although directed at improving energy efficiency in domestic housing, these programmes have direct implications for employment and investment levels in the energy sector: the **Home Energy Efficiency Programmes for Scotland (HEEPS)** delivered nearly 89,000 energy efficiency measures between 2013 and 2014 and aims to raise funds totalling £200

[41] CCC (2015)
[42] Available at: http://www.gov.scot/Topics/Business-Industry/Energy/Energy-sources/19185/Heat/HeatMap
[43] Scottish Government (2013b)
[44] Scottish Government (2013f)

million annually.[45] The primary targets have been upgrades to the housing stock of people living in fuel poverty. It is expected that £120 million of this funding will be allotted via the UK's public service obligation scheme, the ECO scheme (see section above). Another policy aimed at improvements in home energy use is the **Warm Homes Fund**, established in 2012 with private and public financing. The fund aims to invest £50 million into renewable heating projects such as biomass and wind turbines. Additionally, landlords can apply for funding under the **Energy Saving Scotland Small Business Loans Scheme** to install energy efficiency measures while the **Landlords' Energy Saving Allowance (LESA)** provides up to £1,500 as a tax allowance claim on energy efficiency measures.[46]

Special appropriations and grants	Government support for innovative new schemes and technologies. Particularly applicable to stakeholders that have relatively poor access to financing such as many SMEs.

- **The Climate Challenge Fund** – provides funding for community groups that are tackling climate change through community led projects. By 2015, nearly £70 million had been awarded across several hundred individual awards since its establishment in 2008.[47]
- **Scottish Investment Bank –** supports private sector SME growth by providing access to different investment pools, some of which partner with private sector venture funds, on a co-investment and shared risk basis.[48]
- **The Renewable Energy Investment Fund (REIF) –** makes £103 million available for community renewable energy and district heating projects at the stage of testing and commercial rollout, in the form of loans and equity on fully commercial terms. This will supplement the more than £13 billion of private sector investment in Scottish renewables that have been made available since 2010.[49] The fund runs until March 2016.[50]
- **Low Carbon Infrastructure Transition Programme (LCITP) –** a £76 million scheme that aims to provide support for low carbon infrastructure projects.
- **Central Energy Efficiency Fund (CEEF) –** provides £20 million of funding for public bodies split between the 32 Scottish Local Authorities, NHS Scotland, and Scottish Water to implement efficiency and renewable measures.

Technical assistance and training	Developing specialised skills programmes and providing building managers with follow-up training.

- **Resource Efficient Scotland** – RES aims to help public, private and third sectors reduce costs by implementing resource efficient changes in the management of energy, water, raw materials and waste. The Resource Efficient Scotland programme offers free advice and technical support as well as the sharing of sector-specific best practice and new technologies. The programme was launched in April 2013 and integrates the various non-domestic energy and material resource efficiency services previously provided in Scotland by Zero Waste Scotland, Carbon Trust and Energy Saving Trust (these organisations continue to operate in the remainder of the UK). RES aims to support at least 12,000 SMEs annually through site visits and audits, and is drawing up decarbonisation roadmaps for individual

[47] Scottish Government (2013b)
[48] Scottish Government (2013b)
[49] Scottish Government (2015a)
[50] Scottish Government (2013b), Scottish Enterprise (2015)

sectors. The high level target is to save organisations in Scotland at least £21 million annually, including energy efficiency savings of 45 GWh.

- **The Low Carbon Skills Fund –** provides training and financial support for up to 100 employees per company in areas such as waste management, energy efficiency and renewable energy option.[51]
- **Scottish Futures Trust (SFT) Low Carbon workstream –** SFT activities have included investments in street lighting, which could save local authorities up to 15% of their electricity bills, ca. £130 million. The SFT has assessed that an investment of around £300 million in low carbon measures could lead to cost reductions of more than £1 billion.[52]

An international Review of Energy Productivity Policies and Initiatives: Findings from Four Case Study Countries

Comparing initiatives across countries

Scottish energy productivity governance initiatives should ideally be designed drawing on best practice examples from around the world. This report uses examples primarily from four countries – Austria, Denmark, Germany, and the US – to present best practice options across the commercial and industrial sectors. Some of the examples discussed here may not be applicable to Scotland as they are the products of particular political and institutional arrangements. On the other hand, international comparisons provide a helpful basis for reassessing existing approaches and redefining aims. This section presents the overall findings while detailed descriptions are available in annex 4.

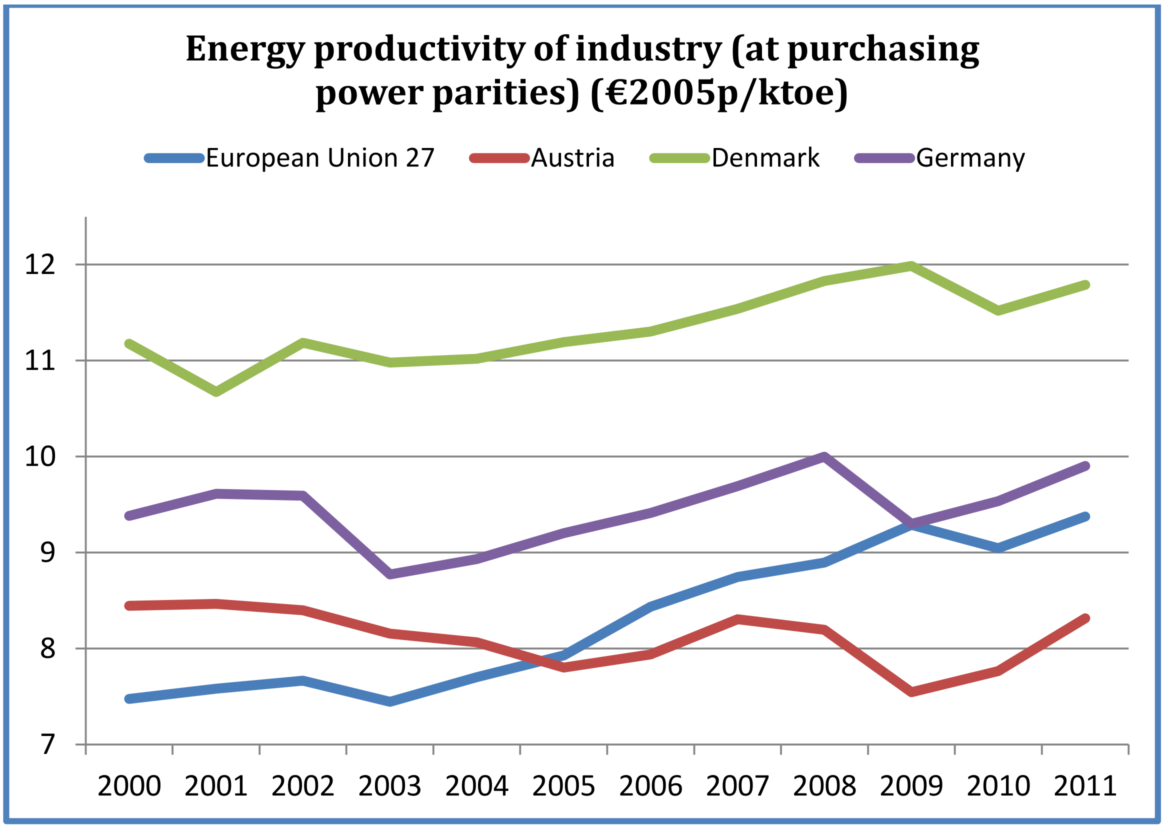

Figure 5: Energy productivity of industry across EU countries, in 2005 € at purchasing power parities per 1000t of oil equivalent. Source: Adapted from data available from Odyssee (2013).

[51] Scottish Government (2013b)
[52] Scottish Government (2013b)

Figure 5 above shows energy productivity across EU countries: there is a trend of increasing energy productivity since 2000. The picture is different across some of the case study countries, with Denmark maintaining a consistently favourable position compared with Germany and Austria. Austria and Germany have furthermore witnessed stagnation during some years with an overall trend of little change since 2000. While improvements were made across individual sectors and activities, governments should also consider aggregate impacts on industrial output relative to energy.

Table 2 below summarises key energy efficiency and energy productivity measures in place in the case study countries. As can be seen, the measures are varied and use different metrics and ratios. A wide number of measures have been adopted with different aims in mind, making like-to-like comparisons difficult. Note that with the exception of Germany, none of these targets are explicitly aimed at energy productivity.

Country	**Economy wide targets**			**Sectoral Targets**
	Indicator	Target	Timeframe	
Austria	Final energy demand	9% absolute reduction	2001-2005 (base)-2016	Economy-wide
	Energy intensity (primary)	20% reduction	2020	Economy-wide
	Energy use - existing construction	Thermal renovation of buildings constructed 1950-1980	2020	Buildings
	Energy use - New construction	50% of new buildings	2004-	Buildings
	Renewables - final energy demand	34% of total	2020	Energy
Denmark	Final energy demand	1.5% absolute reduction per annum	2008-	Economy-wide
	Gross energy demand	2% absolute reduction	2006-2011	Economy-wide
	Gross energy demand	4% absolute reduction	2006-2020	Economy-wide
	Annual energy savings	100% increase	2010	

	Annual energy savings	50% increase	2013	Utilities
	Annual energy savings	75% increase	2017-2020	
	Energy use - New construction	Require less energy than passive homes	2015	Buildings
Germany	Energy Intensity	20% reduction	2008 (base)-2020	Energy, buildings, transportation
	Electricity consumption	20% reduction	2008 (base)-2020	
	Energy productivity	2.1% increase per annum	2050	
	Energy productivity	Double	1990 (base)-2020	
	Building renovations	Double from 1% to 2%	2008 (base)-2020	Buildings
	Heating	20% reduction	2008 (base)-2020	
	Government buildings	Near carbon zero	2012	
United States	Energy intensity	25% reduction in energy intensity of GDP (relative to 2005)	2030	Economy-wide
	Energy intensity	25% voluntary reduction in energy intensity by industry partners	10 years from start	

Table 2: Energy targets across case study countries.
Sources: ABB (2011); Alliance to Save Energy (2013a); Buchan (2012); Schlomann *et al.* (2012); IEPD (2014b).

Austria

Austria has presented some relatively strong energy efficiency measures for the buildings sector in particular, but has lagged compared to other EU leaders in its initiatives for the appliances and transport sectors. The latter has witnessed a rise in final energy consumption of more than 75% between 1990 and 2010. The energy consumption of industry over the same period rose by nearly 44%.[53] Industry efficiency generally did not improve over this period, with a significant decrease from 2007 onwards. Renewable

[53] Jellinek (2012)

energy played a prominent role over this period accounting for 31% of gross domestic consumption, with biomass and hydropower taking the lead.[54]

Austria has been both ambitious and successful at reducing energy consumption and CO_2 emissions associated with the built environment, but lacks mandates that go beyond EU requirements.[55] Given that the industry sector accounts for 36% of final energy consumption and 48% of electricity,[56] there is scope for more stringent policy intervention in the sector.

Germany

Germany is notable for having an explicit target of doubling energy productivity between 1990 and 2020 (see table 2 above). Energy productivity rose by an average of 1.7% per year between 1990 and 2010. Energy efficiency also rose by 1.4% between 1991 and 2008[57]. Between 1991 and 2010 energy efficiency for the economy as a whole increased 24%.[58] Associated achievements between 1990 and 2008 include a 5% reduction in primary energy consumption and a 27% reduction in GHGs. Much of this change has been attributed to the reunification of East and West Germany and subsequent modernisation of East Germany's industries – industrial energy efficiency increased by 24% during the 1990s alone. Since then improvements across energy-intensive industries such as steel, chemicals and paper have been inconsistent. Since 2009 the trend has even reversed towards increasing intensities.

Germany has spearheaded the introduction of renewables and is known for providing energy consumption advice.[59] However, voluntary installation retrofit schemes, lack of incentives for commercial improvements and missing behavioural incentives such as labelling mandates all mean that there is scope for additional energy efficiency and productivity improvements.

Denmark

Energy delivery has historically been expensive in Denmark and the country has therefore long actively pursued energy efficiency and increased productivity. Since 1980 the Danish economy has grown by nearly 80% while energy consumption has remained nearly constant.[60] Much of this has followed from increased use of combined heat and power (CHP). From 1980 to 2009 the share of district heating from CHP plants rose from 39% to 80%, while the share of electricity cogenerated with heat rose from 18% to almost 53%.[61] Between 1990 and 2010 energy efficiency of final energy consumption increased by 20%, an average improvement of 1.1% annually. The change in industry has been even greater, with a 24% rise in energy efficiency over the same period, equivalent to 1.4% annual improvement. Policy packages are in place, which promote cost-effective and market-oriented energy efficiency solutions.[62]

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[54] Jellinek (2012)
[55] Schüle et al. (2013)
[56] ABB (2011)
[57] Buchan (2012)
[58] Schlomann et al. (2012)
[59] See Annex 4 for more information.
[60] Energistyrelsen (2009).
[61] Energistyrelsen (2009).
[62] Energistyrelsen (2012).

Danish municipalities and regions have entered into a voluntary agreement to manage and reduce electricity, heat and water consumption.[63] However, as this is on a voluntary basis, many do not comply or only carry out reports sporadically.[64] While Denmark has strong mandates on energy efficiency including a public service obligation (PSO) for utilities to reduce energy consumption with end-users, the presence of some data restrictions, lack of compliance for the built environment, difficulty involving SMEs in energy efficient initiatives, and a bias in industry towards short (2-3 year) payback periods holds the extent of possible measures back.

United States

Over the past decade a number of ambitious steps have been taken in the US at state and federal level to incentivise increased energy efficiency and productivity. Massachusetts, California and New York have retained top positions in annual rankings[65], following success with EERS initiatives, support for CHP and energy savings in state buildings. Technical assistance for energy audits and support for the adoption of CHP are two options that are widely available at state level, as are tax-incentives for the installation of more efficient equipment, grants and low-interest loans.[66]

Activities in the US are varied, states have significant freedom in developing their own initiatives, and regional standards even exist for appliances based on temperature differences. Focus on EERSs in leading states provides a sound policy prescription. The presence of many voluntary schemes at federal and state levels may provide important complementary options. However, these have been found to be more successful when combined with financial incentives, technical assistance, and threat of taxation.[67]

[63] Energistyrelsen (2015)
[64] Inetrviewee.
[65] Downs *et al.* (2013)
[66] Bradbury and Aden (2012)
[67] Geller (2006)

3. International Industrial and Commercial Sector Case Studies

This section presents some in depth case studies of industries worldwide where energy productivity has improved in recent years as a result of changes in high-level policy and regulatory actions.

The commercial building sector

Buildings in the commercial sector account for a significant amount of energy consumption and CO_2 emissions globally. A variety of mandatory and voluntary initiatives have been introduced to achieve greater efficiencies around the world. This section highlights several governance options with a focus on financing initiatives, and explains the case for productivity gains.

McKinsey has estimated that 87% of the efficiency potential in the commercial sector exists in buildings.[68] Buildings account for over 40% of energy consumption in the US[69] as well as the EU, which aims to reduce consumption within this area 20% by 2020.[70] At the level of primary legislation in the EU this aim is addressed through the Energy Performance of Buildings Directive (EPBD).[71] Among other objectives, the EPBD aims for 'nearly zero' energy consumption in buildings by 2020; it sets detailed procedures for issuing energy performance certificates (EPB); and it stipulates controls for such EPBs.[72]

Beyond direct energy savings, there is a significant scope for indirect savings associated with increased productivity in buildings. A large international study[73] found that the vast majority of workers in office buildings were dissatisfied with indoor air quality and thermal comfort. These results fall far behind acceptable levels under international quality standards for the built environment.[74] Aggressive standards are being spearheaded by the US Green Building Council's LEED rating for energy efficient buildings, the most popular voluntary rating system globally, with around 10 billion square feet of construction being carried out.[75] LEED-rated buildings face fewer regulatory hurdles, lease up faster[76], provide higher satisfaction levels for thermal comfort and indoor air quality, and workers have been found to be as much as 5% more productive than those occupying non-green buildings.[77] A large US study[78] found that additional costs associated with LEED and ENERGY STAR rated construction was offset by associated energy reductions that led to higher market values, over and above the cost premium. Another US study similarly found that buildings with these ratings are profitable in the long run compared to buildings without.[79]

In addition to voluntary standards, individual EU member states and US states have introduced differentiated policies and mandates for the regulation of the commercial built environment. Germany has issued several pieces of legislation to tighten building codes over the past 30 years and achieved an average reduction in energy consumption of 75%. In comparison, Sweden achieved some noteworthy improvements in energy efficient home construction throughout the 1970s and 1980s, but stagnated

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[68] Granade *et al.* (2009)
[69] Alliance to Save Energy (2013b)
[70] EU COM (2011)
[71] EUCOM (2010)
[72] Note that the Energy Efficiency Directive also includes articles on activities relevant to renovations in the built environment, notably Articles 4 and 5.
[73] Huizenga *et al.* (2006)
[74] ASHRAE standards
[75] Interviewee.
[76] Interviewee.
[77] Abbaszadeh *et al.* (2006)
[78] Eichholtz *et al.* (2010)
[79] Miller *et al.* (2010)

during the 1990s when technical requirements regarding energy use were relaxed.[80] Denmark has the world's strictest mandatory performance standards for the built environment and provides developers with the option of meeting stricter standards coming into force in 2015 and 2020. Between 10-20% of developers currently choose to meet these higher standards, partly because some municipalities enforce stricter codes.[81] In the US, energy intensity in commercial buildings declined nearly 25% during the 1980s primarily following improved thermal efficiencies, but then rose on the back of increased electricity consumption associated with computers and telecommunications. Overall energy consumption per unit of floor space declined 21% for commercial buildings[82] in spite of a 45% increase in electricity use per square foot between 1983 and 2005.[83] This followed an increase in energy efficiency investments in the commercial built environment from around $1 billion to $3 billion between 2008 and 2011.[84] Utilities supplied the vast amount of these funds (42%), followed by ESCOs (29%), and federal stimulus spending (22%).[85]

Continued growth in absolute energy consumption in some countries including the US[86], along with the long-lasting nature of use patterns formed during construction, are important reasons to focus on efforts to increase energy efficiency and ultimately productivity associated with new and existing buildings. The US federal government lags compared with individual states in mandating compliance and incentivising energy efficient building codes. In terms of incentives, Property Assessed Clean Energy (PACE) financing schemes are emerging in some states. These aim to remove split incentives from multifamily homes (often part of large property portfolios) and concerns over long investment payback periods, while providing low-rate financing (see table 3 for more details). An emerging regulatory option is the requirement to rate energy use in buildings at the point of sale.[87]

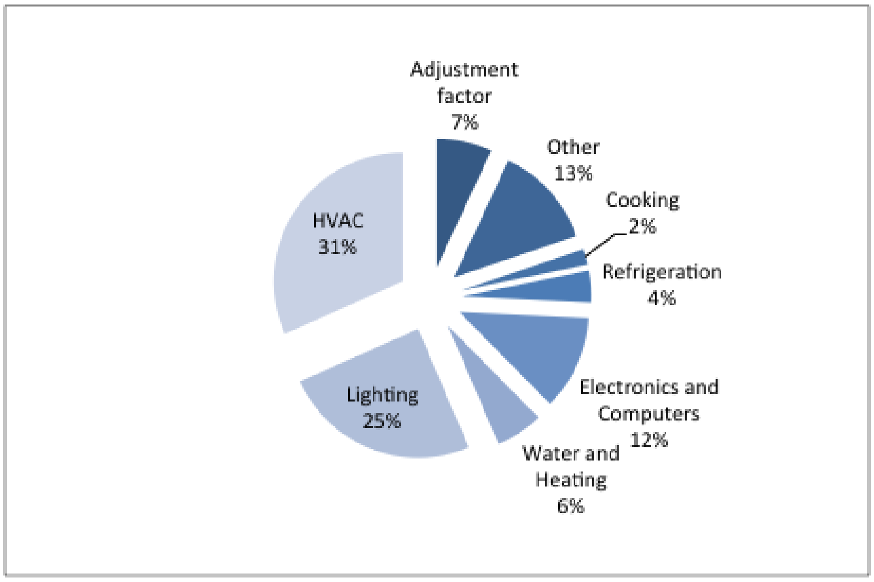

Figure 6: Energy use in US commercial buildings by end-use, 2006. Source: NAS *et al.* (2010)

[80] Schade *et al.* (2013)
[81] Low Carbon Transition Unit (2013).
[82] Alliance to Save Energy (2013b)
[83] Belzer (2007)
[84] Wallace and Forster (2012)
[85] Hesser (2012)
[86] Alliance to Save Energy (2013b)
[87] Interviewee.

Figure 6 above shows the breakdown of energy use in US commercial buildings by end-use. The data is generalised for all commercial building types, but it is clear that opportunities of very different sizes are available. While electricity consumption increased significantly with the introduction of more electronics into the workplace in the 1990s, heating ventilation and air conditioning (HVAC), and lighting still account for by far the greatest proportion of energy consumption. While the adoption of energy efficiency measures across several end-use activities has increased significantly over the past 20 years[88], regulations that account for behavioural preferences in workplaces, e.g. for lighting and heating, may thus have a large role to play in reducing end-use intensities. As an example, one ESCO interviewee noted that 30-50% of energy savings in their portfolio had come from behavioural changes. Other interviewees explained that commercial building owners will generally only consider a short investment payback horizon (less than four years), rather than the lifetime of investments associated with upgrades. This leads to a whole class of technology upgrades being left out of consideration. For appliances this can often lead to higher operational and maintenance costs. This is where soft loans and grants for companies with few cash reserves have been pointed to as an important source of change.[89]

Table 3 below lists a variety of instruments that have been used in the US to promote energy efficiency in commercial buildings. Different types of barriers may however hold back the successful introduction of some strategies if they are not properly designed. These include[90]:

- *agency issues:* Financial incentives for a building owner or tenant to invest are unclear, unless investments lead to significantly lower maintenance or lease costs;
- *elevated hurdle rate:* Where the payback period for investments is more than 4 years, owners may find it difficult to find a loan. Alternatively, investment cases have not taken into account productivity gains and made erroneous assessments;
- *capital constraints:* Owners may not wish to increased debt or may want to prioritise revenue-raising investments. Financiers may face difficulty in allocating collateral for loans aimed at efficiency improvements;
- *lack of awareness:* Facility managers may not have accurate data on energy use or the monetary savings associated with efficiency improvements; and
- *missing systemic approaches:* A survey of architects and engineers in Germany and Sweden involved in energy analysis of the built environment showed that voluntary standards alone led to very limited results.[91]

Political and social considerations will thus sway which methods are likely to be chosen. For example, the Scottish Government has made clear that fuel/energy poor households are a high priority when designing energy infrastructure near cities. This means that the financing for development and use of these infrastructures needs to take account of limited access to capital and low levels of disposable incomes amongst final households. The Scottish Government has therefore built on the UK's ECO programme with

[88] NAS *et al.* (2010)

[89] Interviewee.
[90] Granade *et al.* (2009); interviewees; Schade *et al.* (2013).
[91] Schade *et al.* (2013)

the HEEPS initiative, the Warm Homes Fund, as well as activities related to district heating in Glasgow. Similar activities will be considered as part of the SEEP, which will come into effect in 2017/18.

Energy Savings Performance Contracting (ESPC)
Typically a comprehensive energy efficiency project implemented by an ESCO, which may also help with financing. Subsequently monitored and upgraded over time. ESCOs guarantee savings from projects and pay the difference in case of a shortfall, thus minimizing project risk. Funding is a mix of private debt and equity from utilities, public loans, bonds, etc., usually for facilities owned by public institutions with good credit, and some large commercial operators.
Energy Services Agreements
Third parties negotiate, arrange capital, develop projects and manage installations. The client agrees to a percentage deduction from or fixed rate payment for e.g. each kWh avoided. For the life of the agreement, the provider may own the installation and all associated grants raised, returning cash flow to outside investors. The service is thereby an off-balance sheet transaction rather than accounted for as assets and liabilities to the client. Tax incentives (such as accelerated depreciation) are retained by investors rather than clients. Many commercial building owners in the US however prefer to self-finance projects. Funding pools and securitized debt markets could increase availability to SMEs.
State/Municipal Loan Programs
Provided at federal, state or local levels where utilities join cities and councils. Often program offerings and loans will be provided by a single source with technical support provided by agencies and ministries. Loans may be consolidated across multiple programmes and sold to the secondary market.
Sustainable Energy Utilities (SEU)
Administers financing programmes, offers technical assistance, and provides financial incentives towards efficiency measures and renewable energy installations. Initial costs may be funded by an increase in utility charges. May be combined with offers from ESCOs to raise funds from credits granted for energy efficiency or renewable installations. In 2007, the Delaware SEU used the state's AA rating to issue a tax-exempt bond, which resolved the normal credit barrier using a highly rated entity. Also used in Washington D.C.
Preferential Terms for Green Buildings
Integrated design processes in green buildings lead to lower risk of building system failures, reducing the risk of uninsured events and work shut downs. Such buildings also have higher work productivity and health benefits to users. Similar to the literature on energy productivity benefits, there is scant recognition of these attributes by investors.
Utility On-bill Financing
A utility covers upfront costs of an upgrade and users repay the loan through a charge on the monthly bill - either tied to the customer or the building meter. Examples have been

implemented in Connecticut, New Hampshire, Massachusetts and Rhode Island, with a combination of zero or low interest loans, public grants and incentives for early repayment. Utilities may however be reluctant to provide loans and to collect on these.
Property Assessed Clean Energy (PACE) - Commercial
Local governments fund energy improvements on multi-family, commercial and industrial properties with long-term loans, secured by a right to take over the property in case of a default (a lien), and paid back via a charge on the property tax bill. Funded via bond issues or grants. One benefit is the lien facilities' relatively low interest with long repayment periods. There have been significant administrative expenses tied to schemes. However interviewees for this study have noted that they see great potential for a further development of PACE arrangements based on experiences in California.

Table 3: Financing options for energy efficiency initiatives in commercial buildings. Examples draw on studies from the US. Sources: Kats *et al.* (2011); interviewees.

The US energy efficiency service sector will increase its workforce between 220,000 and 380,000 personnel between 2008 and 2020, equivalent to a two to four-fold increase[92]. It will be hampered by several challenges including lack of experience, lack of standard certification across specialty training, retirement of older workforce, poor integration with construction industry at large, and unstable funding towards workforce development. An interviewee explained that benchmarking buildings was often very difficult because of poor data or restrictions on disclosure. A related issue is the quality and type of data disclosure. A comparison of energy use in over 200 buildings[93] concluded that mandatory upfront certification based on the 'design intent' of a building was a poor indicator of actual consumption. An alternative is Display Energy Certificates, based on metered energy usage. The Scottish Government could consider mandating data disclosure based on 'in use' performance and using this as a basis for ratings. While the EPBD does not mandate in-use data collection as a basis for ratings, it may be necessary to make such information visible in order for ratings to reflect real consumption and for regulations to enact savings.[94] Following the definitions used in this report, in-use data shifts assessments from efficiency towards productivity by examining how work patterns affect actual loads.[95]

Another challenge exists around thinking of energy savings in buildings as a systemic activity, connected to early design decisions and subsequent energy delivery. One interviewee explained that architects and designers would in most cases be unaware of where a building's energy is delivered from, while utilities rarely pay attention to peak energy use patterns in buildings. Connecting utilities' DSM programmes to building developers' activities was therefore identified as a major area of future work. Another interviewee had found success in regulatory processes that involved 'negotiated rule-making'. Regulators would meet with industry and NGOs for days to develop standards for appliances or other equipment. This was particularly useful when technologies were developed and open discussions made participants aware of key issues for regulation.

[92] Goldman *et al.* (2010)
[93] Jones Lang Lasalle (2012)
[94] Interviewee.
[95] How different usage affects work patterns is a separate issue that could be addressed in connected data collection practices.

The paper products sector

The equipment supply chain for paper production is global and dominated by a few large players based in Germany, the US and Scandinavia. Smaller and more specific equipment suppliers exist in the UK. The market for paper production has been shrinking in the UK in recent years – Scotland's International Paper site near Aberdeen closed in 2009. Average primary energy consumption relative to output in the UK paper industry improved 12% between 2002 and 2008[96] - between 1.5 and 2.5% per year – with variations across product type. Despite such productivity gains, rising competition from emerging economies has meant that the industry in OECD countries continues to face difficulties.

Energy-saving initiatives in the UK paper industry have been incentivised primarily by carbon abatement legislation that mandates emissions reductions over the coming years, specifically under the EU ETS and the UK's voluntary Climate Change Agreements.[97] A study of the large Swedish paper industry found that energy demand had become an increasingly important priority to stakeholders in recent years, a finding that is generalizable given the maturity of the global industry. [98] The same study concluded that ESCO services were not preferred where energy delivery was highly integrated with core manufacturing operations. As some ESCO interviewees have noted, this indicates a bias towards energy management advice when industry perceives that significant gains have already been made. The industry has mostly opted to comply with this legislation by reducing energy consumption and associated emissions through process optimisations, rather than increasing their share of renewable energy. This has boosted energy productivity by 14% in Austria and 100% in Denmark (see figure 7 below).

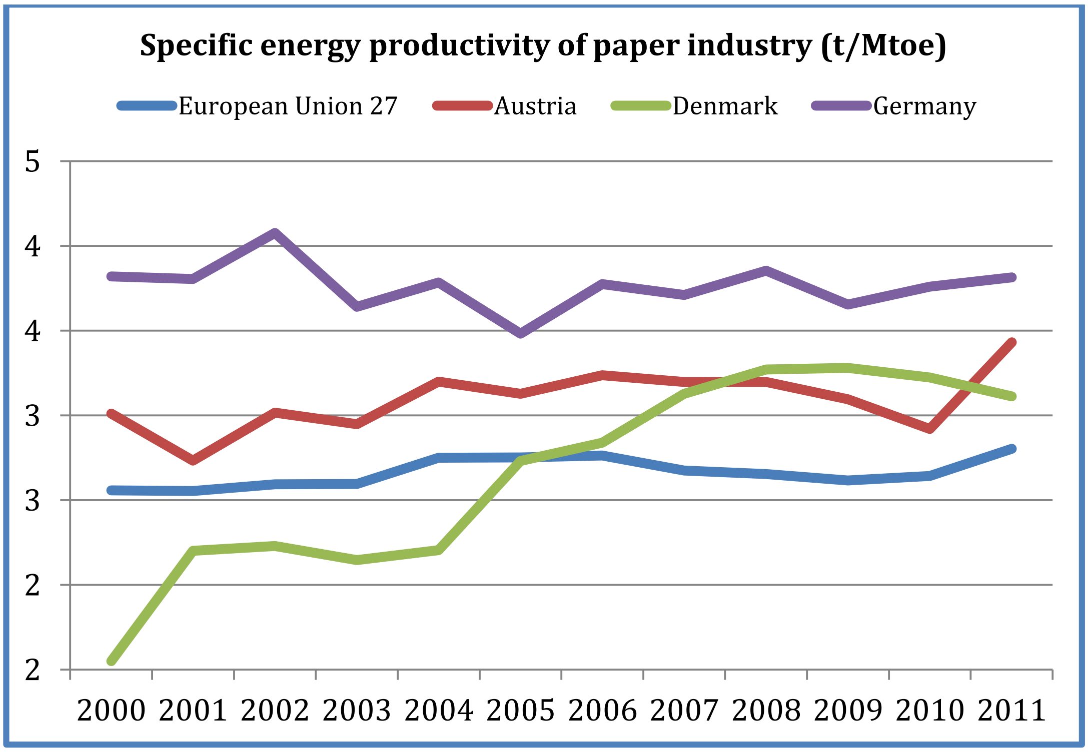

Figure 7: Specific energy productivity of paper industry, in tons of output per millions tons of oil equivalent
Source: Adapted from data available from Odyssee (2013)

[96] From 4,476 kWh/t in 2002 to 3,940 kWh/t in 2008 (the Carbon Trust 2011)
[97] the Environment Agency (2013).
[98] Thollander and Ottosson (2011).

Use of new and best-available technologies has steadily increased energy efficiency in the sector over the years, largely because of a focus on cost reduction within the industry rather than compliance with regulations. At the same time an increased global market for pulp supply[99] coupled with a lower demand for paper products has squeezed margins for European and US players, with China surpassing the US in 2008 as the largest paper products manufacturing country.[100] This increases the urgency of additional cost reductions on energy.

The paper production sector is relatively energy-intensive. It is the fourth greatest consumer of energy in the US[101] and has the second highest electricity intensity behind primary metals. The WRI estimates that Midwest manufacturers could save $120 million by investing in the lowest performing factories to meet industry average efficiency levels, and that energy use could be reduced 25% if mills adopted proven energy efficiency technologies and practices.[102]

Such gains are however held back by several barriers. The capital-intensive nature of manufacturing equipment and a bias towards equipment with long payback periods, leads to investment disincentives. Lack of standardisation erodes the potential for engineering efficiencies and components designs.[103] Knowledge of cost-effective energy saving equipment may be scant, management may believe that additional gains are out of scope, and those with the technical know-how may not be in a position of authority.

[99] Germany, Finland and Sweden account for nearly 50% of paper production in Europe and are also home to key machine manufacturers and service suppliers. Paper however resembles a commodity market and the increasing share supply from emerging economies such as of China and Latin America therefore erode existing stakeholders' shares.
[100] Aden *et al.* (2013)
[101] IETD (2014)
[102] Aden *et al.* (2013). It is furthermore projected that a total of $240 million could be saved if all mills in the region achieved an ENERGY STAR rating in the top 25% of comparable facilities. This may also result in greater CO_2 emissions reductions than would be achieved by switching end-use energy from coal or oil to natural gas.
[103] CEPI (2013)

Box 3: The Flambeau River Papers mill in Park Falls, Wisconsin

Following a 2006 closure of the Flambeau River Papers plant, new energy efficient initiatives were placed at the centre of a business strategy to reopen and boost productivity. In 2007 the DOE performed an energy savings assessment and the company implemented fuel switching and efficiency strategies that suited the facility. Even with rising electricity costs, these efforts contributed to a 10% annual cost savings and an 11% increase in production at the plant between 2005 and 2011. By 2010 aggregated savings amounted to $10 million, from efficiency investments with an average payback period of just over 5 years, reducing electricity requirements by 15% per ton of manufactured paper. The gains arose from extensive modifications to one paper machine, reusing heat that would otherwise have been vented, and wastewater treatment (reducing environmental compliance costs). These initiatives are technically applicable to mills throughout the sector and the plant has plans for an additional $10 million of investment in the near future.

Technical, informational and financial (loan) barriers were overcome with support from the federal DOE and a state-level programme funded partly through utility companies' demand side management (DSM) activities. The company was thereby induced to consider longer payback periods for individual energy efficiency investments, bundled under an aggregate investment horizon.

In the US most regulatory involvement with the manufacturing sector is conducted on a voluntary basis. Examples include a technology roadmap published by the Forest products industry and the DOE, and a newly proposed National Network for Manufacturing Innovation programme organised by the DOE with $1 billion of funding to support public-private partnerships across several industrial sectors. The WRI and the Carbon Trust have listed several available best-practice paper sector technologies that can be adopted now to reduce energy consumption substantially. Simply adopting CHP equipment for 75% of energy inputs could reduce consumption by 38%[104] while adoption of best available technologies in the manufacturing process could reduce consumption by 28%.[105] In the Netherlands a Strategic Innovation Agenda has been established for the paper industry as part of an aim to halve energy consumption for industrial products by 2020. Activities and objectives under these initiatives and others[106] include the following recommendations:

- expansion of industry data collection programmes and use of benchmarking assessment tools;
- minimum energy performance standards for new equipment;
- efficiency targets established at industry, department, company and process levels;
- standardisation of equipment;
- greater involvement of ESCOs in securing energy savings;
- reduced energy consumption of dryers, which often use more than 70% of all heat;[107]

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[104] Carbon Trust (2011) and Aden *et al.* (2013)
[105] Jacobs and IPST (2006)
[106] Carbon Trust (2011); CEPI (2013); Jacobs and IPST (2006).

- increased use of CHP and renewables alongside other DSM activities;
- increasing biomass supply and value extraction (bio-refinery);
- increasing the recovery and recycling of waste products;
- establishing new supply chain connections to meet consumer demands; *and*
- replacing water as a carrier, thereby substantially reducing energy consumption.

4. Key considerations for energy productivity initiatives in Scotland

This section presents key considerations from a range of economic and policy related literature to inform thinking about implementing energy productivity initiatives.

Energy and economic growth

There is a long tradition in economics of asking policy relevant questions by considering the change in the input factors of labour, capital and technology in growth models and empirical data. Technological change has variously been conceived as an endogenous and an exogenous factor in growth models[108] while increases in energy input and energy efficiency have largely been seen as means to increase the productivity of these factors. In other words, means to increase the 'total factor productivity' of the economy.[109]

Energy's traditional role in economic theory and modelling is thus seen as a contextual factor that changes the degree of fundamental inputs (labour, capital, technology), rather than as a fundamental input factor in its own right. This may have a role in explaining why there is still considerable scope for improving the ways that energy is delivered, used and discarded. Alternative economic modelling based on engineering has instead portrayed energy as a prime factor involved with economic growth[110], setting labour and capital inputs as secondary factors.[111] While any direct causal relationship between the type of available energy and economic growth remains unclear[112,113], energy productivity suggest that energy delivery and use should occupy a more central role in economic theory and by extension in the long-term macro-economic planning of governments.

At the micro-economic level, limited empirical information on changes to efficiency in production processes indicates that increasing the amount of energy available at the point of production or work leads to positive changes in output – i.e. energy productivity works at the micro-economic level.[114] *Policymakers interested in understanding the relationship between provision, availability and use of energy as well as technical improvements, may consider commissioning studies that consider changes to productivity at firm and sectoral levels, working closely with the companies and production processes involved.*

108 Jones and Manuelli (1997)
109 Sorrell (2009)

111 Ayres and Warr (2005), Beaudreau (2005)
112 Payne 2010
113 Economists who have considered the effects of a growing 'green' economy on employment figures have noted that care should be taken to rely on specific data from localities of interest rather than generalised figures and models of growth (Lambert and Silva 2012). Time horizons also impact any forecasted effects in labour markets. Separating short-, medium- and long-term effects in specific studies can therefore help determine the direct and indirect effects of policy changes (Fankhauser et al. 2008; Ho et al. 2008).
114 Lilly and Pearson (1999), Pye and McKane (1999), Worrell *et al.* (2003)

Box 4: The role of life-cycle assessments (LCA) in industrial energy productivity

The definition of boundaries when assessing energy consumption for complex industrial processes is critical in determining where and how productivity may be increased. If data collection and assessment focuses only on a production plant, any energy consumption involved in upstream processing and transportation of raw materials will be neglected. Likewise, downstream use patterns, waste streams and reuse options will not enter into calculations.[115]

LCA assessments instead consider the total energy consumption involved in industrial processes and may be helpful in identifying avenues of co-processing such as waste-to-energy. While data collection for LCA studies may be more cumbersome than for individual operations, such an approach will supports the macro-economic focus on sectoral energy productivity by identifying potential co-benefits.

The rebound effect

Critical to the success of initiatives focused on energy use and productivity is the role of the 'rebound effect'. An umbrella term for direct and indirect changes to energy use patterns, the rebound effect is associated with improvements in energy efficiency. Standard economic theory suggests that as the price of a good falls, consumption increases. However, research on price elasticity[116] – the degree to which a change in price leads to a change in consumption – has shown that improvements in household appliance energy efficiency may lead to increases in energy consumption elsewhere. In other words, an indirect rebound effect has been observed in households where the final cost of energy falls. There is however cause for caution before rushing to conclusions about the likely effects of rebound effects across sectors of the economy, with some researchers suggesting that we need to define the underlying theory better before rushing to obtain empirical results.[117]

Practically speaking, research focused on the US[118] has found that the direct effect of increased energy efficiency in household appliances on consumer behaviour was very small and for other sectors varied greatly. Other research has found that most of the direct effects of energy savings for consumers and businesses have remained even after some behaviour changes. *The net effect of energy efficiency improvements in OECD countries has been to reduce the growth in energy demand*.[119]

The discussion above leads to two important points for policymakers working at the intersection of economics and energy within specific sectors and the economy as a whole:

- total energy efficiency dynamics within specific sectors are at least as important as individual process improvements, particularly because of the potential to trigger a net increase in energy consumption, commonly referred to as 'Jevons' Paradox'[120]; and
- on a macro-economic level the challenge is to devise policies and initiatives that support economic growth while not increasing raw energy inputs – or any inputs deemed socially undesirable.

[115] Tanaka (2008)
[116] Khazzoom (1980, 1987)
[117] Turner (2012)
[118] Greening, Greene and Difiglio (2000)
[119] Geller and Attali (2005)
[120] Sorrell (2009)

Following Lipsey et al.[121], Sorrell[122] recommends that policies should distinguish between improvements to general-purpose and dedicated technologies, as the history of energy improvements suggests that the former are associated with large increases to net energy consumption, or Jevons' Paradox. A key lesson for policymakers is thus to acknowledge that the availability and efficient use of energy greatly affects economic decision-making at firm, sector and macro-economic levels, to the point that demand for raw energy inputs may rise. *The positive challenge is to ensure that energy efficiency policies are coupled with initiatives that support the growth of desirable energy inputs over the long-term, and to develop initiatives for dedicated technologies rather than general-purpose technologies.*

Planning across time horizons and regions

A policy concern related to the rebound effect is that technological improvements, which reduce the cost of environmental control in the medium-term, may increase the cost of long-term control if the absolute growth of energy consumption is not controlled.[123] Given a long-term goal of near-zero carbon emissions, initiatives that aim to improve the efficiency of coal- and gas-fired power plants in the short-term may therefore increase the costs of long-term decarbonisation, if they are not coupled with broader policies. The implications of this at the level of the firm and sector is that short-term goals may be pursued when long-term government policy objectives remain unclear, thereby making decarbonisation costlier for society in the long-term.

Box 5. Complementarity of energy productivity policies

A key question for this report is whether Scotland's relatively ambitious energy and climate targets have been helpful in setting a more ambitious agenda for industry to decarbonise and reduce energy consumption. Generally, if regional targets lead to higher marginal abatement costs compared with national targets, they could be argued to be ineffectual, because they draw resources away from meeting lower cost abatement in the rest of the nation. If on the other hand, in the specific case of Scotland, the marginal abatement costs are lower compared with the rest of the UK, then Scotland would be expected to achieve greater percentage reductions, simply because of a regional competitive advantage. Modelling work by Anandarajah and McDowall[124] has found that meeting Scottish renewable energy targets in 2020 would add to the costs of meeting the UK's overall obligations. While this result rests on several modelling assumptions, in particular it does not account for differences in wind resource, it does raise an important question about energy productivity: *how do efforts in Scotland complement wider UK policies and initiatives?*

[121] (2005)
[122] (2009)
[123] Baker et al. (2008)
[124] (2012)

5. Towards an Assessment Framework for Energy Productivity Policy

This section presents a strategic framework, useful in designing and implementing policies and measures related to energy productivity in Scotland and beyond.

Assessing government policies and initiatives

A strategic framework based on considerations listed in the previous sections will be a useful starting point for policy makers tasked with drawing up plans for measures that relate to energy productivity. Given the many options available, it is critical to draw boundaries around top priorities for detailed assessment and continuously compare whether new and existing policies overlap. We have adapted the framework below from several sources to fit this purpose.

Strategic considerations

Diagnose	Where and how do sectors use energy?
Forecast	What energy futures do we need to plan for and which do we want within individual sectors?
Search	What governance activities exist that will support greater energy productivity?
Choose	What is our society's and different sectors' integrated strategy on energy production and consumption?

Assessment considerations

Rebound Effects	Develop technology-specific initiatives, producer and consumer incentives, and subsidies.
Greenhouse gases (and generally the management of waste streams)	Consider the effects of taxes, cap-and-trade and the regulation of unwanted effects of production.
RD&D	Look at whether technical RD&D is encouraged with tax breaks, subsidies, and instruments such as feed-in-tariffs.
Imperfect capital markets	Consider helping companies face risks and costs associated with changing production by using guarantees, revenues from feed-in-tariffs, a carbon price floor, and bank loans to infrastructure.
Networks	Consider how more efficient changes can be developed by improving network services such as electricity grids, transport links, broadband, recycling requirements and community-based insulation.

Labour Markets	Collect data from specific industries and companies to measure direct vs indirect as well as short- vs long-term effects of government initiatives.
Production Processes	Collect data to assess effects of initiatives on variables such as elasticity of supply, process improvements, improvements in working environments and waste minimisation.
Co-benefits	Measure spill-over effects and non-energy benefits (NEBS) in working environments, health, process control; regulate technologies deemed to be at odds with policy goals.

Governance-economy interactions

Commitment	How do we want government to drive changes with other stakeholders such as industry?
Adequacy	Are the proposed measures adequate in meeting the targets?
Stability	Will the effect of the chosen governance mechanisms remain stable over time? Will the problem change character?
Evolution	How do we adapt to changing economic activities, and energy delivery options and costs?

Table 4: Strategic and assessment specific framework for energy productivity governance
Source: Developed from a review of Stern (2013), Sorrell (2009), Bowen and Kuralbayeva (2015), Bradley *et al.* (2013), IEA (2010), Mills and Rosenfeld (1994).

Taking the time to decide on how the problem at hand should be framed, and what overall aims the strategy should pursue, may pay off in the long run. For the purposes of this report, this will involve weighing the desire towards long-term government involvement across several categories of industrial activities and what the associated aims of increasing energy productivity are. For example, subsidies and high-skills training programmes may pay off in several years' time, but demand significant up-front investments. Is the prospect of a more specialised labour force important enough to accept losses for several years beforehand?

Questioning assumptions and the supposedly familiar is central to good intelligence collection. From a high-level governance perspective, this report suggests not only collecting data on waning industries, but also relative winners, to assess whether these are in fact productive relative to energy use. Existing methodologies should come up for revision regularly, whether they exist explicitly or are followed tacitly. Comprehensive assessments of direct and indirect gains from new initiatives are crucial in determining the total productivity arising from specific options. One example is the convention of relying on upfront assessments of energy consumption in the built environment rather than generating in-use data as a basis for benchmarking and identifying poor performers for special consideration. This would save ESCOs and consultants considerable time and direct resources towards areas of greatest gain. Following the material discussed in this report, this generally means rethinking how data is collected and payback periods are calculated; who has access to energy consumption data within companies and beyond; and how governments should think about fostering relations between stakeholders and related activities to increase co-benefits. A continuing dialogue with relevant stakeholders in industry around areas of evolving concern will likewise ensure that existing measures do not become out-dated.

Finally, committing to the strategy, regularly monitoring developments, assessing the fit with changes in economic activity and adapting to changes in economic activity and energy dynamics is crucial. Recent years' changes in gas prices and the increased use of information technology in some sectors are just examples that have dramatically changed how companies, sectors and governments think about profitability and energy management.

6. Conclusions

The purpose of this report has been to present an overview of government initiatives in Scotland and beyond that relate to energy productivity, and to present case studies of changes in the industrial and commercial sectors. The approach has relied on reviews of policies and regulations, interviews with key stakeholders, reviews of energy and economic statistics and reviews of documentation from specific industries and commercial activities.

This report suggests that while much has been achieved in Scotland in recent years, there is much more that could be done should energy productivity be deemed to be a governance priority. This would involve rethinking current approaches to energy efficiency, renewable energy and energy saving advice as integrated elements of a broader governance agenda on energy productivity. Energy productivity broadens the framing and thinking associated with longstanding areas of government policy in asking what associated measurable characteristics should and could be accounted for.

The governance measures and case studies presented throughout point to several distinctive areas of work that would support this aim. Below we present key conclusions based on experiences in the case studies assessed.

1. The Scottish Government has implemented a variety of measures that relate to energy productivity across several categories. These could be combined in an explicit national energy productivity programme to compare and streamline potentially overlapping and related policies and regulations, and to promote and increase energy productivity across industrial and commercial sectors;

2. Key sectors to consider in Scotland include the commercial built environment, opportunities in district heating, commercial and council energy grids generally;

3. Few governments have developed coherent national energy productivity programmes. This seems to be a missed opportunity to both promote and increase energy productivity;

4. Initiatives such as energy productivity regulations and financing should be developed on the back of strategic recommendations, discussions with industry about long-term investments, and evidence of best practice from around the world;

5. Energy productivity financing could most usefully target technology upgrades with the potential to introduce productivity gains elsewhere (e.g. improved maintenance costs and indoor climates, waste-to-fuel options, and increased use of CHP systems);

6. Total energy productivity (direct energy savings, and NEBS) is a strong basis for evaluating – and communicating – improved performance; *and*

7. Methodologies for energy productivity data collection, reporting and benchmarking are poorly developed in most countries, and at EU level. The Scottish Government could lead the way by drawing on experience in energy assessment and management programmes and develop methodologies for assessing energy productivity, in collaboration with energy managers in industry, NGOs, utilities and energy service companies (ESCOs).

Box 6: General conclusions from this review

- Energy managers in companies should be supported in their efforts to communicate to management the productivity gains associated with energy savings.
- Graphic tools such as conservation supply curves (CSC) can help communicate the cost-effectiveness of energy efficiency and conservation measures, as well as associated productivity gains (NEBS should be given particular attention).
- Methodologies for data collection, reporting and benchmarking should be developed across industrial activities with energy managers, utilities and ESCOs.
- Proposed policies and measures should be evaluated from multiple perspectives, and draw on a broad governance framework.
- Barriers to cost-effective investments should be identified within individual sectors.
- Regulations should be flexible rather than technology specific, and allow different sub-sector activities to adopt technologies appropriate to the context, e.g. by regularly updating minimum energy performance standards.
- Close cooperation between Government and regions as well as councils across Scotland ensures that measures appropriate for the local context are developed. This includes financing and uptake of citywide distributed heating grids in bigger cities such as Glasgow and Edinburgh.
- Training and mentoring schemes for engineers and related professions to become competent energy managers helps to develop an ESCO resource base.

Box 7: Conclusions relating to the Commercial Built Environment

- A methodology of stakeholder engagement, low cost measures prioritisation, municipal management, and energy manager training will improve efforts to retrofit existing buildings
- Energy storage requirements and retrofit incentives for building appliances should be designed to smooth energy demand and generation throughout the day.
- A methodology should be developed for data collection on energy use in public buildings as required under the EED, Article 5.
- Mandating data collection on in-use energy consumption will enable to identification of worst performers, support ESCO activities and make enforcement of penalties feasible.
- Mandating regular energy audits and clear energy labels, and updating forthcoming requirements well in advance of implementation will allow cost-effective forward planning by stakeholders.
- Bringing energy suppliers into dialogue with architects and energy managers will foster systemic thinking around energy use and savings in buildings.

Box 8: Conclusions relating to Production Industries

- Total energy productivity (energy savings, and NEBS) should be used as a basis for evaluating the sources of improved performance.
- LCA methodologies should be used to account for total energy use across sectors.
- Energy productivity gains should be benchmarked across technical and behavioural changes within industries.
- Mandate energy management efforts in energy-intensive industries.
- The focus of taxation may be shifted increasingly towards limitation of socially costly activities.
- Regularly update minimum energy performance standards as a basis for mandatory reductions in some sectors and voluntary support for others, e.g. SMEs.
- Target SMEs with consultancy services, favourable loans and access to ESCOs, possibly by pooling clients.
- Expand access to and requirements for CHP plants, and incentivise SMEs to generate energy on-site.
- Create favourable tax conditions for R&D expenditures and developments in targeted growth areas.

Box 9: Conclusions relating to Financing

- Financing schemes should be developed to overcome common barriers and biases that affect relations between facility owners, tenants, financing institutions and shareholder pressures.
- Methodologies for LCA productivity, data collection and use in operations may serve as a basis for developing and awarding grants, loans and incentives.
- Government financing schemes should be developed together with the private sector.

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Annex 1: Scottish Government Energy Statistics

Some Scottish Government initiatives focus on energy productivity in the industrial and commercial sectors, particularly targets for non-domestic buildings. However, there are no official measures in place to support the adoption of technologies and processes aimed specifically at increasing energy productivity. Looking at the overall trend in energy consumption within the industrial and commercial sectors, it appears that there has been a significant decrease in absolute energy consumption in recent years. Between 2005 and 2011, energy consumption fell from nearly 76,000 GWh to just under 65,000 GWh, a decrease of nearly 15%. Over the same period domestic consumption fell by an equivalent amount, while consumption in the transport sector fell by less than 5%.

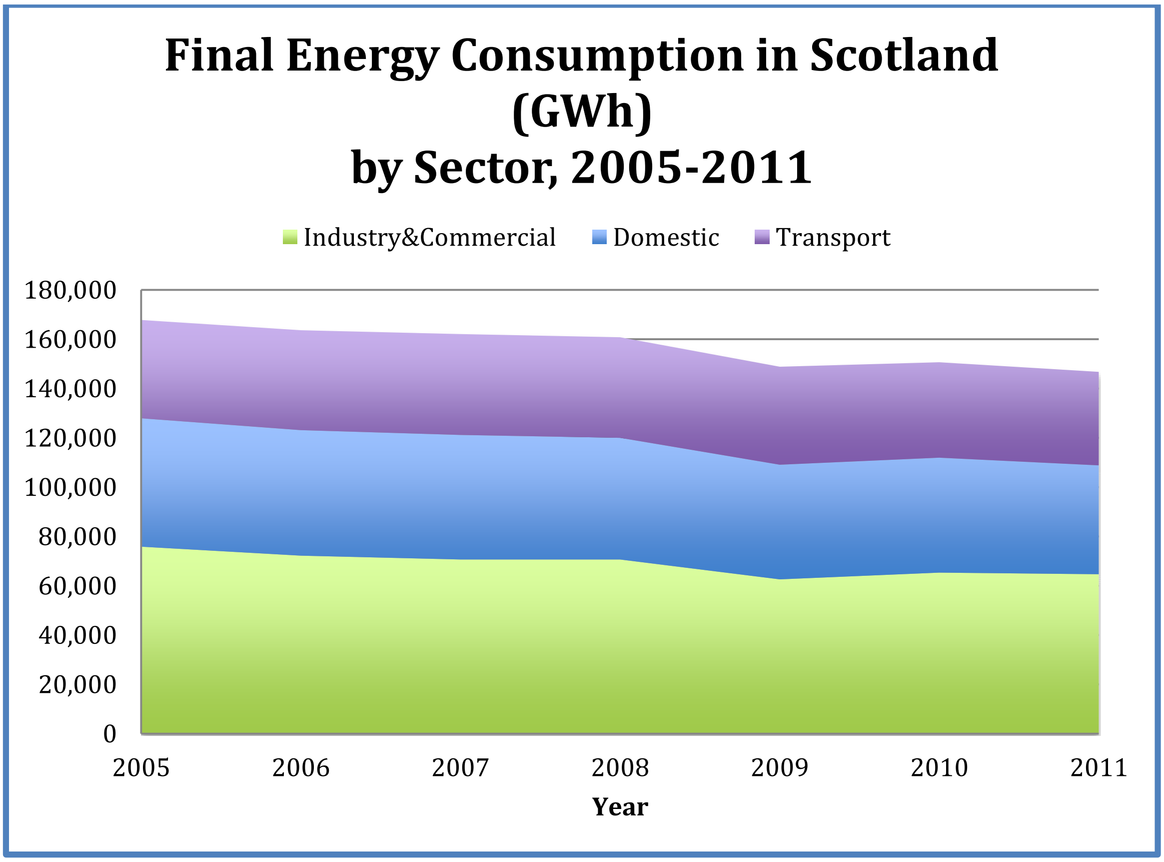

Figure 8: Final Energy Consumption in Scotland (GWh) by Sector, 2005-2011
Source: Created from data in DECC (2013)

The consumption of electricity, gas and petroleum products (oil) also changed during these years. In 2003, gas accounted over 43%, oil accounted for 29% and electricity accounted for nearly 25%. While electricity consumption remained stable up to 2011, oil products increased to nearly 39%, while gas fell to 34%. This pattern indicates a shift in the underlying economic activity.

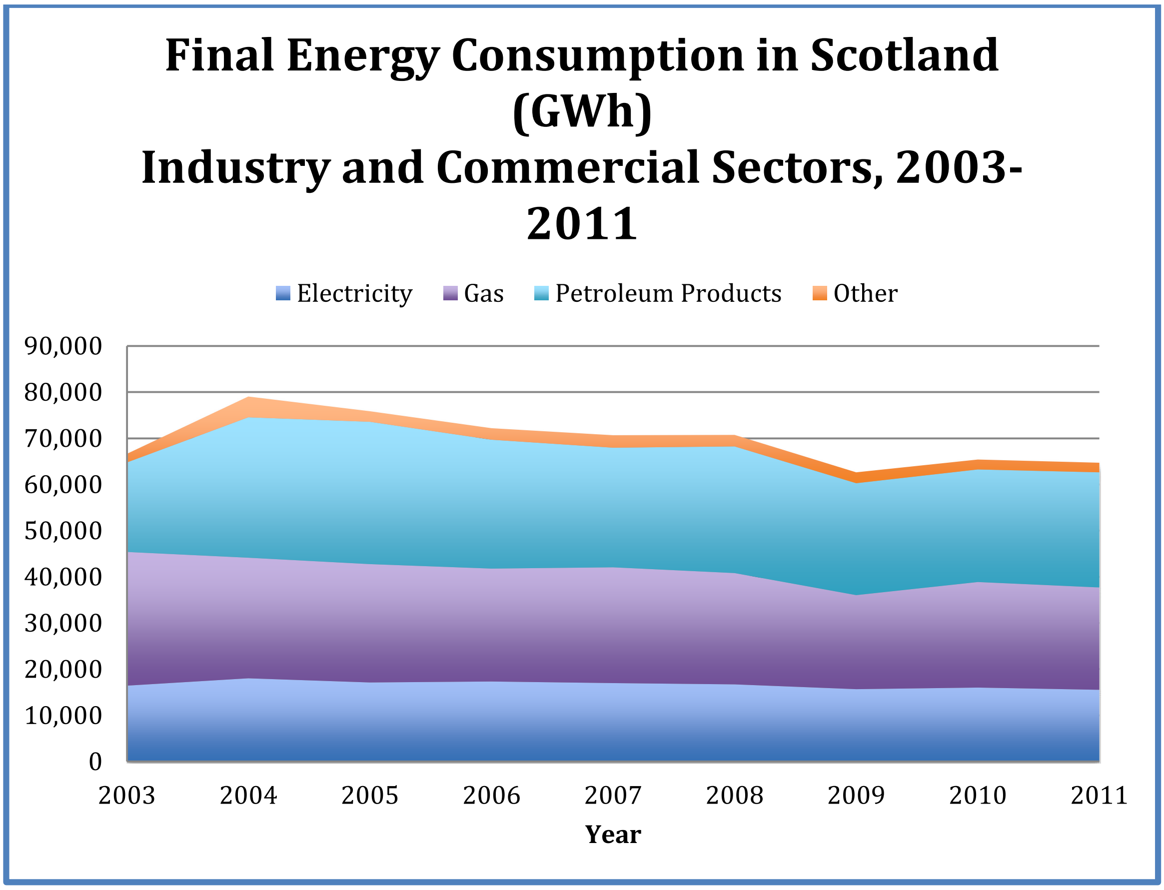

Figure 9: Energy Consumption in Scotland (GWh) Industry and Commercial Sectors, 2003-2011
Sources: Created from data in BERR (2008); DECC (2013)

Annex 2: Using Conservation Supply Curves in Assessments

Worrell *et al.* (2003) consider the relationship between the cost of an investment, any energy savings derived from it, as well as associated non-energy savings benefits (NEBS) by deriving a function for total cost of conserved energy (CCE), defined as follows:

$$\mathrm{CCE} = \frac{(\mathrm{I} * \mathrm{q} + \mathrm{M} - \mathrm{B})}{\mathrm{S}}$$

where

CCE = cost of conserved energy for a given efficiency measure in $/GJ

I = capital cost in $

q = capital recovery factor

M = annual change in O&M costs in $

B = annual total productivity benefit (NEBS)

S = annual energy savings in GJ

d = discount rate

The capital recovery factor (*q*), i.e. the rate at which an investment is recovered, takes into account the discount rate (*d*):

$$\mathrm{q} = \frac{\mathrm{d}}{1 - (1 + \mathrm{d})^{-n}}$$

Any estimation based on this equation or one that solely considers direct energy savings without taking into account NEBS, will have to assume a number of given parameters, including a constant price of energy; an acceptable discount rate; an annual decrease in O&M costs following the technology upgrade; and the magnitude of NEBS accruing from various factors including a safer and healthier working environment, time savings, etc.

Annex 3: A general theory of growth incorporating energy, information and organisation

Beaudreau (2005) presents an alternative theory of growth that centers on the role of energy as an input factor. The theory predicts that output growth increases with the rate of growth of energy consumption, and variations in second-law efficiency, defined as the efficient use of energy through *information provision* and *organisation*. Increases in energy consumption will, in general, be accompanied by increases in tools and organisation – resources for the supervision of the production process. Variations in second-law efficiency are the result of technological change, a normal input variable in standard economic modelling.

Beaudreau (1995, 1998) develops a modified production function, the KLEP (capital, labor and electric power) production function where electric power is used as a proxy for energy consumption:

$$Q = EP^{\beta 1}L^{\beta 2}K^{\beta 3}$$

Tested against data on industrial production from the U.S., West Germany and Japan, in all cases electric power consumption is by far the most important factor input.

In this alternative model, as a result of technological change, tools and organisation are able to extract additional value added from a given amount of energy. This places energy management at the centre of economic growth modelling and asks stakeholders from industry and policy to think of energy as central to optimising performance.

Annex 4: Detailed Descriptions of Governance Initiatives in the Four Case Study Countries

Austria

Austria has presented some relatively strong energy efficiency measures for the buildings sector in particular, but has lagged compared to other EU leaders in its initiatives for the appliances and transport sectors, the latter having witnessed a rise in final energy consumption of more than 75% between 1990 and 2010. The energy consumption of industry over the same period rose by nearly 44%.[125] Industry efficiency generally did not improve over this period, with a significant decrease from 2007 onwards. Renewable energy played a prominent role over this period accounting for 31% of gross domestic consumption, with biomass and hydropower taking the lead.[126]

Policies have been introduced both at the federal level and within individual provinces where regional energy agencies oversee implementation. The national klima:aktiv programme, launched in 2004, involves initiatives across several sectors with activities that include energy consulting, education, and training of building professionals, offered through the regional agencies. The aim is to increase energy efficiency and the uptake of renewables. Cooperation with 300 business partners, over 5,000 implementation partners and 2,500 competence partners has developed a national Austrian network on energy competence, which has trained more than 6,000 people. The Austrian Energy Agency estimates that by 2012 the klima:aktiv programme had facilitated the mitigation of 1.6 $MtCO_2$ annually since its introduction in 2004.[127]

Mechanisms for energy efficiency coordination and financing are furthermore supported under a climate and energy fund, established in 2007, when energy taxation was also developed.[128] Implementation of the EU Energy Service Directive has mandated a 9% reduction in energy consumption across sectors by 2016 relative to a 2001-2005 baseline, to be achieved through voluntary agreements between energy suppliers, distributors and trade associations.[129] The Austrian national energy strategy however differentiates between sectors and has formulated a 15% target increase in final energy consumption for industry between 2005 and 2020. SMEs are offered energy management services subsidised by the federal government and facilitated through agreements between the provincial governments and energy consultants, who receive additional training under the klima:aktiv programme. This includes developing energy assessment and monitoring standards, enforcing regular audits, developing new financial mechanisms, and transferring lessons from R&D into energy savings in SMEs. The service aims to achieve 50 GWh of annual energy savings across industry, and SMEs are prioritised for efficiency subsidies. Such voluntary activities had by 2012 saved an estimated 155.000 tCO_2 annually in participating companies, or between 5-10% of electrical energy in companies.[130] Agreements are in place for energy suppliers and distributors, and these are likewise not mandatory.

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[125] Jellinek (2012)
[126] Jellinek (2012)
[127] Jellinek (2012)
[128] ABB (2011)
[129] Jellinek (2012)
[130] Jellinek (2012)

A study commissioned by the EU Parliament found the policy package implemented in the Austrian buildings sector to be "very comprehensive", combining "almost all relevant elements", including minimum standards, financing (loans and grants for residential buildings), and economic incentives to attain performance certificates.[131] Experts interviewed for that study stated that regions had been very active in developing aggressive standards for residential buildings. The implementation of building shell and heating requirements has likewise had a high impact in reducing energy consumption. [132]Some of these aims have been achieved through grants such as an annual €2.4 billion support for residential housing.[133] To facilitate continued energy savings the klima:aktiv programme includes a voluntary building standard, and renovation projects have saved nearly 400.000 tCO_2 annually.[134]

Austria has thus been both ambitious and successful at reducing energy consumption and CO2 emissions associated with the built environment, but lacks mandates that go beyond EU requirements.[135] However, considering that the industry sector accounts for 36% of final energy consumption and 48% of electricity[136] the lack of strong mandates in this sector makes the policy package overall comparatively lax.

Germany

Germany is notable for having an explicit target of doubling energy productivity between 1990 and 2020 (see table 2). Energy productivity rose by an average of 1.7% per year between 1990 and 2010. Energy efficiency also rose by 1.4% between 1991 and 2008[137] and between 1991 and 2010 energy efficiency for the economy as a whole increased 24%.[138] Associated achievements between 1990 and 2008 include a 5% reduction in primary energy consumption and a 27% reduction in GHGs. Much of this change has been attributed to the reunification of East and West Germany and subsequent modernisation of East Germany's industries – industrial energy efficiency increased by 24% during the 1990s alone. Since then improvements across energy-intensive industries such as steel, chemicals and paper have been inconsistent. Since 2009 the trend has even reversed towards increasing intensities.

Germany first introduced an energy saving law in 1976 and since then has introduced more than 25 legal standards on energy. Heat insulation and heat appliance ordinances were first introduced in 1976and merged in 2002 into the so-called EnEV (German Energy Savings Ordinance) policy. The EnEV is mandatory for new and existing building in the commercial sector, but there is poor data on control and compliance for retrofits[139]. Since 2001, Germany's KfW Bank has supported the construction and renovation of new energy efficient buildings[140], but this does not extend to buildings in the commercial sector, where incentives have been lacking.[141] In 2011 the government furthermore promised to increase funding for the CO_2 Building Rehabilitation Programme from less than €1 billion to €1.5 billion, partly because of a shortfall in the Energy and Climate Fund financed by the EU ETS.[142] Appliance labels and their use are ubiquitous.

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[131] Schüle et al. 2013
[132] Jellinek (2012). Exact savings not noted.
[133] ABB (2011)
[134] Jellinek (2012)
[135] Schüle et al. (2013)
[136] ABB (2011)
[137] Buchan (2012)
[138] Schlomann *et al.* (2012)
[139] Interviewee.
[140] Schade *et al.* (2013)
[141] Interviewee.
[142] Buchan (2012)

This is in contrast to labelling of energy consumption for commercial buildings, which is yet to become commonly used and tenants and buyers are not automatically shown certification.[143] Building regulations have however been updated regularly and since 1977 have resulted in better performance across several sectors, including a reduction of average energy consumption 170 kWh/m^2 to less than 40 kWh/m^2.[144] Relatively few buildings in Germany are certified under international schemes such as BREEAM and LEED, while many more have been registered under equivalent German certification, the DGNB, issued by the German Sustainable Building Council.[145]

An ambitious high-level policy known as the *Energiewende* was adopted in in 2010. The policy establishes reduction targets for carbon emissions, increasing renewable energy, and improving energy efficiency – the latter specifically as a 20% reduction in primary energy consumption between 2008 and 2020, and a 10% reduction in electricity over the same period. This is beyond the EU target of a 20% reduction compared to BAU over the same period.[146] A public service obligation (PSO) for the energy industry to introduce energy efficiency initiatives with end-users has been a hotly debated topic for some years and it is expected that some headway will be made with the introduction of the EU Energy Efficiency Directive (EED).[147] SMEs are offered subsidised energy advice by ESCOs, an activity that is well developed in Germany. Energy services are also available for industry, but mainly through delivery rather than demand side management (DSM) activities.[148] Concern over bankruptcies and tenancy changes, and a bias towards short payback periods has furthermore led ESCOs to avoid longer contracts for the commercial built environment.[149]

Some perceive the aggressive uptake of renewables in Germany under the *Energiewende* policy, as contributing factor to a sharp rise in costs for industry compared with other EU countries. Coupled with the belief that many efforts to increase efficiency have already been made in recent years, meeting the 2.1% average annual target increase in energy productivity under current policies, is perceived as very difficult by industry.[150] While industry has expressed a wish for efficiency obligations to be handled solely under the EU ETS[151], according to several energy economists there is a challenge involved in realising the government's policies without placing unreasonable faith in the capacity of markets alone to deliver.[152] Exemptions from energy taxation and the renewables levy have been introduced for companies that have energy management plans, but it is unclear whether more plans have been introduced as a result of these allowances.[153]

While Germany has spearheaded the introduction of renewables and is known for providing energy consumption advice, a voluntary approach to retrofits, lack of incentives for commercial improvements and

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[143] Interviewee
[144] Friedrich *et al.* (2007); Kiss *et al.* (2010)
[145] Schade *et al.* (2013)
[146] Buchan (2012)
[147] Interviewee.
[148] Wargert (2011).
[149] Interviewee.
[150] Interviewee. Another interviewee however explained that while industry had been complaining over rising energy costs, the introduction of renewables had not contributed to this trend.
[151] Interviewee.
[152] Buchan (2012); Schlomann *et al.* (2012)
[153] Interviewee.

missing behavioural incentives such as labelling mandates, all means that there is scope for additional energy efficiency and productivity improvements.

Denmark

Energy delivery has historically been expensive in Denmark and the country has therefore long actively pursued energy efficiency and increased productivity. Since 1980 the Danish economy has grown by nearly 80% while energy consumption has remained nearly constant.[154] Much of this has followed from increase use of combined heat and power (CHP), which grew from 18% to 53% between 1980 and 2009.[155] Between 1990 and 2010 energy efficiency of final energy consumption increased by 20%, an average improvement of 1.1% annually. The change in industry has been even greater, with a 24% rise in energy efficiency over the same period, equivalent to 1.4% annual improvement. Policy packages are in place, which promote cost-effective and market-oriented energy efficiency solutions.[156] Beyond energy efficiency, Denmark aims to supply 100% of energy needs using renewable energy by 2050.[157]

Since 2006 utilities have faced a public service obligation (PSO) updated every three years and have therefore been active in working with industry and existing buildings to introduce energy efficiency measures. The energy reduction target for the period 2015-2020 is 12.2 PJ annually, a 100% from the 2010 target.[158] Utilities are allowed to identify any potential savings, within or outside their own distribution area, and amongst all types of energy consumption. This policy has proven very effective with utilities meeting 107% of their obligations in 2010 and saving end-users around €1 billion annually over the lifetime of investments, typically 7-15 years.[159] Access to financing for larger companies has generally not presented a problem, although utilities have made this option available to industry. In the case of SMEs there have been instances when the energy utilities have provided financial guarantees for energy efficiency investments.[160]

Utilities collect fairly comprehensive data on energy consumption and offer automatic meter readings for an additional charge. This data is aggregated by the national grid operator. Confidentiality issues have however meant that only a limited set of stakeholders have been granted access until now. This is now changing and better data will also become available with the introduction of a mandate for smart meters following the transposition of the EED.[161] Additional agreements with the manufacturing sector aim to promote energy efficiency using voluntary agreements to implement specific saving initiatives in around 100 companies that in return receive support for obligations under the EU ETS. Participating companies must have an energy management plan in place; must develop savings plans following a specific methodology; and must implement all initiatives with payback periods under four years that are eligible for support.[162]

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[154] Energistyrelsen (2009).
[155] Energistyrelsen (2009).
[156] Energistyrelsen (2012).
[157] Dal *et al.* (2012).
[158] Dal *et al.* (2012).
[159] Tingkaer (2011).
[160] Interviewee.
[161] Interviewee.
[162] Viegand Maagøe (2013)

Legislation related to energy consumption in buildings has been in place since 1961 and targets have been updated regularly. Typical upgrades for new build and renovations include 400 mm of roof insulation, and developers must calculate energy demand in new construction according to a specific methodology. New build must by 2015 meet a maximum energy demand of 36.7 kWh/m^2, but many developers already opt to fulfil requirements for 2020, which mandate 20 kWh/m^2 (25 kWh/m^2 for non-residential buildings).[163] Labelling of energy consumption in buildings is mandatory. Beyond this scheme, some participate in voluntary ratings such as the German DGNB standard, which is now emerging as a de facto standard for commercial buildings, partly to address popular demands for sustainable consumption. One interviewee explained that regulations were fairly clear and that stakeholders across government departments and agencies were competent at working alongside developers and consultants.

A mandate is in place for all councils to conduct monthly data collections of energy consumption. However, many do not comply or only carry out the mandate sporadically.[164] While Denmark has introduced strong mandates on energy efficiency and labelling, the presence of some data restrictions, lack of compliance for the built environment, difficulty involving SMEs in energy efficient initiatives, and a bias in industry towards short (2-3 year) payback periods holds the extent of possible measures back.

United States

Over the past decade a number of ambitious steps have been taken in the US at state and federal level to incentivise increased energy efficiency and productivity. At federal level, the Clean Air Act is the primary piece of legislation regulating air emissions from industry. In 2013 new standards were adopted to limit hazardous emissions from boilers (Maximum Achievable Control Technology, or MACT). The rule targets industry energy users' toxic emissions, with associated implications for energy use.[165] The same is true of the 2012 New Source Performance Standards, which are aimed at decreasing GHG emissions from fossil-fuel emissions in power generation, when utilities' DSM programmes lead to efficiency investments. Executive Order 13624 in 2012 mandated a 50% increase in CHP capacity by 2020 supported both by the Department of Energy's (DOE) and the Environmental Protections Agency's (EPA) focus on increased use of CHP in industrial facilities.[166] The uptake of CHP and small renewables is furthermore supported by the Business Energy Investment Tax Credit policy, which provides tax credits to companies choosing to install equipment[167], and the Combined Heat and Power Partnership, a voluntary programme under the EPA that provides technical assistance, grants and favourable regulatory treatment to partners.[168] This follows the success of the 1978 PURPA Act, which helped double the share of electricity generation from CHP and small-scale renewables relative to total supply.

The voluntary Energy Star for Industry programme, developed in 1992, requires partners to assess and reduce their energy use according to an energy management plan. Results include 60 plants meeting or exceeding their targets in 2011 by achieving a 10% reduction in energy intensity, saving 16 trillion Btu and preventing the equivalent of 1 Mt of GHG emissions.[169] The 2011 Better Buildings, Better Plants voluntary

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[163] Low Carbon Transition Unit (2013).
[164] Inetrviewee.
[165] IEPD (2014f)
[166] IEPD (2014g)
[167] IEPD (2014c)
[168] IEPD (2014d)
[169] IEPD (2014e)

programme is aimed at reducing energy use across manufacturing sectors and the built environment, and is based on a pledge by partners to reduce energy intensity by 25% over a ten-year period with annual reporting.[170]

In 2012, President Obama signed the American Energy Manufacturing Technical Corrections Act into law. The bill included a mandate to study energy-intensive manufacturing, development of a federal data collection standard, and reducing barriers (legal, regulatory and economic) towards greater efficiency in electricity markets.[171] In 2013 the DOE proposed a National Network for Manufacturing Innovation (NNMI) program with the aim of strengthening public-private partnerships across several industrial sectors, by using an 'industrial common' approach of shared physical facilities to support commercialisation of projects established by SMEs.[172] The Superior Energy Performance Program is a voluntary certification initiative that provides industrial facilities across sectors with a roadmap for achieving continual EE improvements.[173] A range of efficiency policies and regulations complement such programmes. These include technical assistance programs offered by the DOE's Advanced Manufacturing Office - including the Better Plants Program, 26 regional Industrial Assessment Centres (IAC), and 8 regional Clean Energy Application Centres (CEAC).

State level energy efficiency and productivity activities are varied. Massachusetts, California and New York have retained top positions in annual rankings[174], following success with EERS initiatives, support for CHP and energy savings in state buildings. Technical assistance for energy audits and support for the adoption of CHP are two options that are widely available at state level. So are tax-incentives for the installation of more efficient equipment, grants and low-interest loans.[175]

Activities in the US are varied, states have significant freedom in developing their own initiatives, and regional standards even exist for appliances based on temperature differences. Focus on EERSs in leading states provides a sound policy prescription. The presence of many voluntary schemes at federal and state levels may provide important complementary options. However, these have been found to be more successful when combined with financial incentives, technical assistance, and threat of taxation.[176]

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[170] IEPD (2014b)
[171] Alliance to Save Energy (2012)
[172] EOP and NSTC (2013)
[173] IEPD (2014)
[174] Downs *et al.* (2013)
[175] Bradbury and Aden (2012)
[176] Geller (2006)

Annex 5: List of Interviewees

This report was produced with data from a literature review covering the theory of energy productivity, individual country initiatives, governance mechanisms, and best practice across the relevant sectors – the commercial built environment, paper products. Additional insights were gained from interviews with the following 22 expert stakeholders:

- Stefan Buettner, Parliamentary Researcher and Advisor, The Scottish Parliament (government)
- Marissa Lippiatt, Head of Resource Efficient Scotland, Resource Efficient Scotland (third sector)
- Stephen Boyle, Programme Area Manager, Resource Efficient Scotland (third sector)
- Geoff Smyth, Head of Technology and Delivery, the Carbon Trust (consultancy)
- Susan Love, Policy Manager for Scotland, Federation of Small Businesses (third sector)
- Lars Grønbæk, Sales Director, Scanenergi (ESCO / consultancy)
- Anne Svendsen, Project Manager (buildings), Viegand Maagøe (consultancy)
- Kamilla Tingvad, Dansk Energi (industry consortium)
- Lars Reimann, Verband der Industriellen Energie- und Kraftwirtschaft (industry consortium)
- Stefan Thomas, Wuppertal Institut für Klima, Umwelt, Energie (research)
- Bob Dixon, Head of Industry Affairs – Americas Region, Building Performance & Sustainability, Siemens Infrastructure & Cities (industry)
- Harvey Sachs, Senior Fellow (buildings), American Council for an Energy-Efficient Economy (research)
- Brendan Owens, Vice President of LEED Technical Development, U.S. Green Building Council (third sector)
- John Wilson, Program Director (buildings), the Energy Foundation (third sector)
- Gunnar H. Lille, Managing Director, OG21 (third sector)
- Helle M. Fredslund, Project Manager, State of Green (third sector)
- Roar Grønhaug, Senior Advisor, ENOVA (government)
- Gavin Slater, Glasgow City Council Lead, TSB Future Cities Scotland
- Rebecca Carr, Senior Heat Policy Advisor, Scottish Government
- Victoria Barby, 2020 Climate Group
- Vivienne Cockburn, Director of Corporate Services and Low Carbon, Scottish Futures Trust
- Peter Clark, Head of Operational Affairs, Scotch Whisky Association

We thank the interviewees for their valuable input. All information was recorded in the report anonymously.

Annex 6: List of Figures, Tables, Boxes and Acronyms

List of Figures and Tables

List of Boxes

List of Acronyms

ASHRAE - American Society of Heating, Refrigeration and Air Conditioning Engineers

CHP – Combined heat and power

DGNB – German Sustainable Building Council

DOE – US Department of Energy

DSM – Demand side management

EnEV – German Energy Savings Ordinance

EPA – US Environmental Protections Agency

EPC – Energy Performance Certificate

EPBD - Energy Performance of Buildings Directive

EU ETS – European Union Emissions Trading Scheme

GDP – Gross domestic product

GHG – Greenhouse gas emissions

GNP – Gross national product

GWh – Gigawatt hour

NPD – Norwegian Petroleum Directorate

PSO – Public service obligations

SME **–** Small- and medium-sized businesses

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