Overview of RES-H/RES-C Support Options

D4 of WP2 from the RES-H Policy project

A report prepared as part of the IEE project
"Policy development for improving RES-H/C penetration in European Member States
(RES-H Policy)"

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The RES-H Policy project

The project "Policy development for improving RES-H/C penetration in European Member States (RES-H Policy)" aims at assisting Member State governments in preparing for the implementation of the forthcoming Directive on Renewables as far as aspects related to renewable heating and cooling (RES-H/C) are concerned. Member States are supported in setting up national sector specific 2020/2030 RES-H/C targets. Moreover the project initiates participatory National Policy Processes in which selected policy options to support RES-H/C are qualitatively and quantitatively assessed. Based on this assessment the project develops tailor made policy options and recommendations as to how to best design a support framework for increased RES-H/C penetration in national heating and cooling markets.

The target countries/regions of the project comprise Austria, Greece, Lithuania, The Netherlands, Poland and UK – countries that represent a variety in regard of the framework conditions for RES-H/C. On the European level the projects assesses options for coordinating and harmonising national policy approaches. This results in common design criteria for a general EU framework for RES-H/C policies and an overview of costs and benefits of different harmonised strategies.

This report

This report aims to give an overview of possible options for policy instruments to support the development of RES-H and RES-C technologies within EU Member States. It draws upon experience in regard of applied instruments to support other renewable technologies, whilst considering how instruments might apply specifically to RES-H and RES-C and the particular characteristics of the different technologies this includes.

1 Executive Summary

The ambitious targets for the growth of renewable energy within the European Union by 2020 make the rapid growth of renewable energy sources of heating and cooling (RES-H/C) a political and practical necessity. This document sets out the key policy options currently identified as being available to support the enhanced development and deployment of RES-H/C technologies.

The policy experience with renewable energy sources of electricity (RES-E) provides a number of lessons that can be applied in ensuring the more efficient adoption of RES-H/C and it is important to learn from these lessons, while also taking into account the unique characteristics of the markets for heating and cooling and for the delivery of both.

Meeting EU and Member State goals for adoption of RES-H/C will require the use of multiple technologies applied in context appropriate ways. Fundamental to the efficient growth of RES-H/C will be the development of a holistic policy environment addressing all elements of policy. The different levels of technological maturity represented by the RES-H/C technologies will mean they require different policy instruments if they are to progress through from the demonstration phases to commerciality. Even where a single technology is concerned, efficiency will be best served not by the application of a single policy instrument but with a selection of complementary instruments applied to overcome the range of financial and non-financial barriers that RES-H/C face. Policy instruments which best suit the early stages of technological development will need to be supplanted by other more appropriate instruments as a technology matures.

It is also likely that some policy instruments will be better suited to the policy and regulatory milieu of some Member States than others, and this must also be considered in adopting policy instruments.

The cost to the consumer or taxpayer of supporting development of RES-H/C must remain a fundamental element of choosing policy instruments and it is important to question the assumptions that have been made about all instruments, most notably in the light of the RES-E policy experience.

Adoption of policy to support RES-H/C must also be considered in the wider societal context and the wider policy context. Provision of renewable heating and cooling has been given little consideration in terms of its relationship with current markets and their regulation and there is potential both for conflict and for the adoption of regulatory frameworks which can enhance RES-H/C deployment. There is also significant potential for the greater use of heat energy currently regarded as waste from thermal electrical generation and other industrial purposes and care must be taken to ensure that RES-H/C policy and regulation does not conflict with the potential for enhanced exploitation in that area. Overlap in the areas of energy efficiency policy, policy relating to the reduction of fuel poverty and to policy concerning RES-E and biofuels must also be taken into account in developing a holistic framework for the support of RES-H/C.

2 Introduction

The increased use of renewable energy has been a key element of energy policy at the European level and at the level of Member States for at least two decades. Its increased uptake has been identified as being a key technology in efforts to reduce emissions linked to climate change, and having an important role to play in improving European energy security of supply, in stimulating innovation and technological development and in providing new opportunities for employment.

These benefits are available in regard of renewable energy sources of electricity, heating, cooling and transport fuel. Despite this, the historical focus of much of renewable energy policy in most Member States over the last two decades has largely been on the development of renewable energy sources of electricity (RES-E), with some more recent efforts to develop policy mechanisms to support increased use of renewable transport fuels in recent years. The development and application of policy instruments to support renewable energy sources of heating (RES-H) and cooling (RES-C) are considerably less advanced in many Member States despite the large portion of energy that is expended in meeting societal needs in each of these sectors and the considerable potential that exists for meeting a substantial fraction of this demand from renewable sources. While, for example, Sweden, Austria, Germany and Denmark and others have long established policy in supporting RES-H, the level of complexity of instruments has not progressed as far as with RES-E. Globally, heating and cooling account for an estimated 40% of total energy demand (with heating far the more significant of the two) while in Europe, heating accounts for 48% of total energy demand (EREC 2006). This is significantly in excess of demand associated with either electricity or transport. Despite this, considerably less experience has been gained in regard of applying the range of available support mechanisms, indeed the public debate over support is also much less advanced and there is comparatively little discussion as to the relative advantages and disadvantages of particular policy instruments.

While cooling does not represent as significant a fraction of consumer demand as heating across Europe, in some Southern European Member States consumer demand for cooling is higher than for space and water heating due to climate conditions. Cooling loads do represent an expanding area of energy use within in more northern parts of Europe and may increasingly do so as temperatures increase with climate change and with increased welfare. They represent an area where a shift to more sustainable sources could yield benefits similar to other renewable energy sources.

This report sets out some of the different policy instrument options available to support increased deployment of RES-H and RES-C technologies. The current European policy context is set out to ground the report. Each policy option and its essential components is then described along with how they have been or might be applied in practice, including any significant variations on the central mechanism that might be adopted and the implications of these variations. Each option is discussed in terms of its advantages and disadvantages, drawing on experience with its application to support other renewable energy sources, most notably, RES-E, though in support of RES-H or RES-C where applicable. The application of each mechanism to RES-H and RES-C is then discussed as appropriate, taking into consideration the particular constraints and characteristics inherent to those technologies. The key elements which differentiate RES-H/C from RES-E are discussed in section 5 to clarify both why simple transfer of policy mechanisms from RES-E to RES-H/C is not as straightforward as it might be and to assist in picking out what lessons might be learned from the RES-E experience while emphasising which lessons might be more difficult in cross application.

3 The European Policy context for RES-H/C Policy: The 2009 Renewables Directive and the European Energy Performance of Buildings Directive

3.1 The new directive on the promotion of the use of energy from renewable sources

Although the European Commission and its Member States have a long-term commitment to the general development of renewable energy sources, support has tended to focus primarily on renewable energy sources of electricity (RES-E). Although the Commission included a specific sectoral target for RES-H in its 1997 renewable energy White Paper, this has not been transferred into European legislation (as has been the case with RES-E and latterly with renewable transport fuels) for a long time.

However, on December 11th the European institutions agreed upon a new directive on the promotion of renewables. The directive that is covering the use of renewables in the electricity, heating/cooling and transport sectors can be regarded as milestone to improve the policy and regulatory frameworks in the Member States as far as the market penetration of renewables in the heating and cooling markets is concerned. This chapter summarises the directive's key regulations that are explicitly addressing the RES-H/C sector and especially the support framework aiming at strengthening the deployment of RES-H/C technologies.[1]

- **National overall targets and measures for the use of energy from renewable sources(article 3)**

  For the purpose of reaching an overall 20% target in 2020 each Member State is obliged to ensure that in 2020 the share of energy from renewable sources in gross final energy consumption of energy equals or exceeds a national overall target that is set out by the Annex of the directive. The national targets that have a binding character have been determined according to a flat rate and GDP-related approach. As the targets are of a relative nature (related to the gross final energy consumption) Member States can obviously follow two different strategies to reach their target, a) to increase the absolute production rates of renewables and b) to reduce the final energy consumption by efficiency measures (e.g. improving the efficiency standards of buildings). Target compliance is based on statistical data. In addition to the 2020 target Member States need to design their support framework as to meet an indicative target trajectory that is also defined by the directive (Part B of Annex I). It is rather apparent that most Member States will only reach

[1] It must be noted that this chapter refers to the provisional consolidated trilogue version of the Renewables Directive from December 2008 that at the point of writing this report still had to go through a legal linguistic check before being finally adopted by the Council.

their targets by introducing measures by which the support framework for RES-H/C will seriously be improved.

- **Renewable Energy Action Plans (article 4)**

  Each Member State will be obliged to adopt and submit a renewable energy action plan. These plans shall set out a break down of Member States' national overall targets to the sector specific shares of RES-E, RES-H/C and RES-T in 2020. With the plans Member State governments are also obliged to report on their planned measures to achieve their target. The national action plans that will be based on a standardised template provided by the Commission are due by 30 June 2010 at the latest.

- **Calculation of the share of energy from renewable sources (articles 5 and 17-19)**

  The gross final consumption of RES-H/C in a Member State shall be calculated as the quantity of renewable district heating and cooling plus the consumption of other energy from renewable sources in industry, households, services, agriculture, forestry and fisheries for heating, cooling and process purposes.

  - In multi-fuel plants only the renewable part of the heating and cooling output is eligible to contribute to the target.
  - In the case of heat pumps – the directive differentiates between aerothermal, geothermal and hydrothermal heat energy – Annex VII of the directive provides a methodology that tries to ensure that only this share of the captured energy output shall be taken into account that exceeds the primary energy input that is necessary to operate the heat pump. Thermal energy captured by passive energy systems (e.g. windows, transparent insulation systems, shading systems) is not eligible for counting to the targets.
  - Bioliquids for heating/cooling purposes (e.g. palmoil) is only eligible for target accounting if they comply with sustainability criteria that are set out in the directive.

- **Support framework (articles 6-11)**

  The directive keeps the subsidiarity of the Member States' support framework for RES-H/C. However, some flexibility in target contributions is introduced by allowing Member States to achieve their targets through non-domestic RES projects. For RES-H/C the flexibility mechanisms encompass statistical transfers, joint projects and joint support schemes between Member States. The regulations are designed to avoid double counting of RES production with regard to target accounting.

  A joint support scheme for RES-H/C is given in the case that two or more Member States decide (on a voluntary basis) to join or partly coordinate their national support schemes. In such cases, a certain amount of RES-H/C produced in the territory of one participating Member State may count towards the national overall target of another participating Member State. However, such a shift of target contributions must be accompanied by a distribution rule that specifies how the amounts of RES-H/C are allocated between the participating Member States. In addition the allocation must be reflected by a statistical transfer between the countries involved.

- **Administrative procedures, regulations and codes (article 13)**

  The directive obliges Member States to set up streamlined, objective, transparent and non-discriminatory administrative procedures aligned to the particularities of each individual RES-H/C technology. In order to reinforce the deployment of RES-H/C in buildings Member States shall by 2015 at the latest, where appropriate, include in their building regulations and codes a requirement to use a minimum share of RES in new buildings and in existing buildings that are subject to major renovation. However, the directive does not fix EU-wide minimum levels for the required share. Moreover Member States shall ensure that the public body fulfils an exemplary role in the use of RES-H/C. However it is not specified which minimum requirements a Member State shall apply in order to meet this target. Finally, Member States shall clearly define any technical specifications which must be met by RES-H/C equipment and systems in order to benefit from support schemes.

- **Guarantees of origin of RES-H/C (article 15)**

  Member States may (but are not obliged to) arrange for guarantees for origin (GO) to be issued in response to a request from producers of RES-H/C. No more than one GO shall be issued in respect of each unit of energy produced. The GO does not have any function in terms of target accounting. Thus any transfer of GOs between Member States does not have any effect on the decision of Member States to use any form of flexibility mechanism in view of proving target compliance or on the calculation of the gross final consumption of RES-H/C.

- **Sustainability criteria for biofuels and other bioliquids (articles 17-19)**

  The directive sets out sustainability criteria including underlying verification/certification requirements for biofuels (applicable for the transport sector) and bioliquids. The latter has an impact on the use of liquid biomass (e.g. palm oil) for heating and cooling purposes. The sustainability criteria are relevant for the eligibility of bioliquids to target accounting and financial support schemes. RES-H/C produced from bioliquids that do not meet the sustainability criteria are not eligible to contribute to a Member State's target. In addition a Member State government is not allowed to support the use of such unsustainably grown and produced bioliquids. For solid and gaseous biomass for heating/cooling purposes the Commission is required to report on the need of respective sustainability requirements. The report that is due by the end of 2009 shall be accompanied by proposals for a respective sustainability scheme (e.g. including minimum standards for a sustainable forest management).

3.2 The recasting of the European Building Directive (EPDB)

As a major share of RES-H/C is used for space heating and cooling as well as warm water generation, policies to enhance the deployment of RES-H/C are strongly linked to the building sector. The latter (including residential and commercial buildings) is the largest user of energy and CO_2 emitter in the EU and is responsible for about 40% of the EU's total final energy consumption and CO_2 emissions.

On the European policy level the building sector is mainly addressed by the directive 2002/91/EC on the energy performance of buildings (EPBD). The EPBD compels Member States to implement energy performance requirements that are based on a transparent methodology for new and large existing buildings that undergo major renovation.[2] Among others the methodology shall take into account the positive influence of active solar systems and other heating and electricity systems based on renewable energy sources. For large new buildings (useful floor area > 1000m^2) building owners are obliged to take into consideration whether the installation of alternative heating systems is technically, environmentally and economically feasible. Explicitly listed are decentralised energy supply systems based on renewable energy, CHP, district or block heating or cooling and under certain conditions heat pumps.

In November 2001 the European Commission came up with a proposal for the recasting of the EPDB aimed at strengthening its provisions to exploit more of the existing cost efficient energy savings potential in the building sector. As regards RES-H/C the Commission proposes to extend the obligation to consider alternative energy systems for new buildings to all new buildings irrespective the useful floor area. In order to ensure that the assessment of the technical, environmental and economical feasibility of the alternative systems is really carried out Member States shall make certain that the assessment is documented in a transparent manner in the application for the building permit or the final approval of construction works of the building.

On 3 February 2009 the ITRE Committee of the European Parliament published a draft report commenting on and proposing additional amendments to the Commission's proposal for a recast of the EPDB. The major proposal concerning the RES-H/C sector comprise

- an obligation of the Commission to bring forward (by 30 June 2010) a proposal as to how to define the term 'technical, environmental and economic feasibility', referred to in the directive

[2] The EPDB defines major renovations as cases where the total cost of the renovation related to the building envelope and/or the technical building systems such as heating, hot water supply, air-conditioning, ventilation and lighting is higher than 25% of the value of the building, excluding the value of the land upon which the building is situated, or those where more than 25% of the building envelope undergoes renovation.

- an extension of the requirement to assess the technical, environmental and economical feasibility of installing alternative energy supply systems (including RES-H/C) for existing buildings which undergo any major renovation
- an obligation on Member States to report to the Commission by 30 June 2011as to which requirements the respective country has put in place in order to ensure the minimum levels of RES-H in new and existing buildings undergoing major renovation, as required under the RES directive and the respective articles of the EPDB
- an obligation on Member States to take the necessary measures to train more installers and to ensure training to a higher level of competence for the installation and integration of the energy efficient and renewable technology required.

4 Goals of Policy for Renewable Heating and Cooling

The general aims of renewable energy policy are straightforward; to assist in reducing emissions damaging to the natural environment; to enhance energy security of supply; to stimulate innovation and technological development and to stimulate new employment opportunities. These general aims can be broken down to give more specific goals, and clarified to better represent the particular needs of the body initiating policy. One important lesson of the experience with renewable energy policy so far has been the need to develop and apply policy instruments aiming to achieve a particular outcome. This can apply at the highest level, for example the adoption of strategy to encourage either more dynamic or more static efficiency increases, for example, by setting specific deployment goals or engendering a more general policy aiming to stimulate overarching technological improvement and cost reduction. Since there are strong variations in the scale and output of technologies, in the needs of different stakeholder groups, in the relative maturity of different technologies and in various other factors then it is important to consider the appropriateness of different policy options within the context of specifically defined goals.

4.1 RES-H technologies and characteristics

There are a diverse range of renewable energy technologies and applications that can act as sources of heat and cooling. Policies aiming to stimulate the full breadth of renewable heat applications will need to take this into account.

RES-H/C technologies include, but are not limited to;

- Wood fuel heating systems: using logs or chipped wood or wood pellets. Applicable at all scales from single home to commercial process heat user.
- Wood fuel heating systems: using logs or chipped wood or wood pellets. Applicable at all scales from single home to commercial process heat user.
- Solar water heating: for domestic use for both space heating and to meet hot water demand, in larger systems and pre-heating for industrial processes.
- Anaerobic digestion of animal waste: where animal waste from livestock farms is used to produce gas.
- Biogas production from energy crops.
- Geothermal heat use: This can vary from higher temperature exploitation as occurs in Iceland (though this quality of resource is not common elsewhere in Europe) and elsewhere for electrical generation through medium temperature and down to relatively low temperatures applications.
- Heat pumps: Employing differences between temperatures above and below ground for heating or cooling purposes. This includes heat pumps which exploit "aerothermal energy" (energy stored in form of heat in the ambient air), "geothermal energy" (energy stored in form of heat beneath the surface of solid

earth; e.g. ground coupled heat pumps, groundwater heat pumps) and "hydrothermal energy" (energy stored in form of heat in surface water; e.g. surface water heat pumps).

- Substitution of fossil fuels with biomass in multiple heating applications (biomass co-firing).
- The use of passive solar design has the potential to allow for increases in sustainability of heat provision but is not classified by all as a renewable technology and does not fall within the definition expected to be used within the new renewables directive.

The technologies cover a diverse range of scales and of levels of technological maturity.

It is important to note that the characteristics of these technologies are often quite different. Those listed display significant variation that will impact on the ability of particular policy instruments to impact on the incentivisation of their use. Significant uptake of some technologies will require stimulation of more or less complex supply chains. Some of the technologies are small-scale applications only, while others vary from domestic scale applications through to industrial application. These variations have the potential to have significant impacts on the optimal design of policy instruments aiming to support increased RES-H deployment, with different scales of technology likely to be served more appositely by the application of different policy instruments.

The scale of some RES-H technologies links to an issue which was not really a problem in regard of RES-E policy and its application. Metering of electrical output or consumption is standard for all grid-connected generators and suppliers. Heat metering is non-standard and uncommon in many Member States and brings additional expense for both training and installation and this may complicate the application of support, particularly at the smaller end of the technological scale. A further linked problem is that many RES-H and RES-C applications are best suited for use in the building where the heat or cooling load occurs. This makes heat metering redundant and complicates the application of financial support via application of instruments which rely on volumes of energy generated. Support may thus require some mechanism which allows simplification of measuring output or which does not rely on volume of output.

Similarly, subsidisation of small-scale sources of renewables can become costly in terms of the levels of transactional and administrative costs associated with the unit costs of providing the subsidy. Since installation of some heat technologies will produce only a small amount of energy annually, for example, a domestic solar thermal unit might produce in the region of 1-3 MWh_{th} per year, then the value of this must be taken into account in implementing policy to ensure that associated costs do not render the subsidy economically inefficient to apply.

RES-C can also vary in scale, from residential systems rated at a few kW through light industrial and commercial systems and up to industrial applications and district cooling scale systems potentially rated above 1MW. Typical technologies include seasonal storage of cold water in aquifers during winter for summer use and cooling via absorption or adsorption driven by solar thermal energy (IEA 2007; SOLEM Consulting 2008).

A key lesson arising from experience with RES-E policy is that the level of technological maturity of a technology will also play an important part in determining whether a particular policy instrument is appropriate for the effective stimulation of the technology. Foxon *et al* (2005) present evidence for this, as well as categorising the various RES technologies according to their levels of maturity, effectively making it clear that if all technologies are to be advanced in terms of maturity that it will be necessary to apply different instruments to different technologies, and additionally that technologies will need to have different instruments applied to them as their level of maturity shifts over time (that is, in simple terms, with deployment). The IEA (2007) and Seyboth *et al* (2008) typologically assess RES-H and RES-C technologies along similar lines to place each in the continuum of technological maturity.

The concept of maturity can relate to two types of technology indicators: technological maturity and commercial maturity. The phase of *technological* development may vary between proof of concept (infant technology) versus to a stage where no (important) technical improvements are to be expected (technologically mature technology). To characterise the *commercial* maturity, the relevant parameter is the difference in energy production costs using the renewable technology compared to the conventional technology. The resulting ‘cost gap’ may be high (for options that aren’t competitive), low, nil (for options having the same cost of energy as their respective conventional reference technologies) or negative (renewables that are cheaper than the conventional option). It should be noted that as reference prices may vary over time, the commercial maturity is not only dependent on development of the technology itself, but at the same time conventional fuel price development is exogenously influencing its level. Each technology can be characterised using the above-mentioned dimensions. A technology may have different stages of maturity for either the technological or the commercial dimension. The table below indicatively shows both parameters for the RES-H/C technologies. Most technologies are characterised by a range, as different types exist, but also because the reference technology varies in its cost of energy. In addition, the performance of RES-H/C technologies differs widely as a function of climate conditions: comparing Greece to Finland for example, there are differences in solar irradiation, length of the heating season, and average ambient temperatures resulting in a wide performance range and consequently the maturity stage is widened. Next to these aspects, the total energy system in which the technology is embedded is also important, as is the energy-quality and user pattern. This applies for example to heat pumps, which can be integrated in a sensible manner, but misconception concerning their installation may result in even higher primary energy consumption than in the reference case.

Table 1: Indicative overview of technical and commercial maturity

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As indicated above, the level of maturity of a technology plays an important role in determining whether a particular policy instrument is appropriate for its effective and efficient stimulation. It is apparent from the RES-E policy experience that some instruments fit best to a certain technology, taking into account its levels of both technological and commercial maturity. A key aim of the RES-H Policy project is to comment on which instruments might best fit the development of RES-H/C technologies

5 Lessons Learned from Policy to Support RES-E

Support for the deployment of renewable energy sources of electricity (RES-E) and their attendant technological stimulation and industrial growth represents decades of practical experience in the development and application of renewable energy policy instruments. This experience has allowed a number of conclusions to be drawn concerning the apposite application of policy instruments in regard of stimulating technological innovation, deployment of renewable energy technology and capture of opportunities for new industries and attendant social and economic benefits. While it is important to bear in mind the limitations of this experience in supporting RES-E when considering how best to support both RES-H and RES-C technologies given their diverging characteristics, there has been considerable generation of knowledge which can offer benefits and the literature in this area has been expanding in recent years. Many lessons have emerged which will apply and mistakes have become apparent, often at considerable expense, which can be avoided in application to both RES-H and RES-C.

5.1 Key Lessons of the RES-E policy experience

5.1.1 Creating stable conditions

Adopting multiple mutually reinforcing policy instruments which together create stable market conditions and thus allow stable demand enables continuous development, encourages investment and contributes significantly to establishing the wider framework necessary to long-term development of renewable energy industries. Some of the most desirable characteristics of the policies necessary to create these conditions can be summed up in three key words: ‘powerful, predictable and persistent’ (Jacobsson and Bergek 2002). While these descriptions where originally used to describe the characteristics of policies aiming to drive industrial development of renewable energy, they are also appropriate to general support for creating a stable market environment and driving steady growth in deployment. To clarify the terms; policies need to be powerful in that the support they offer should be substantial enough to impact sufficiently on the economics of the relevant technology that a demand can be enabled. They need to be persistent in that they must apply for a sufficiently long period to stimulate growth and they need to be predictable so that investors can make informed decisions about future development, develop meaningful business plans and more easily access finance via demonstration of these to financial institutions.

Adopting a policy instrument or multiple such instruments which achieve these conditions allows minimisation of risk for those investing in the sector and helps to address some of the financing issues which can blight growth of renewable energy, specifically the high cost of capital and the issue of access to capital for technologies which have yet to prove themselves in a territory.

A linked, though slightly different lesson emphasises the importance of minimising changes in instruments once they have been adopted. There have been repeated instances of instruments been adopted and later being subject to change or to wholesale replacement due to unsatisfactory performance. This has tended to lead to reduced stability, the undermining of investor confidence and the slowing or even temporary halting of deployment. Perhaps the leading example of a policy instrument being wholly replaced with considerable disruption is the attempt by the Danish government to switch from a tariff to a quota mechanism for RES-E in 2000. The switch generated considerable uncertainty, causing domestic demand for wind turbines to drop drastically (Meyer and Koefoed 2003). The UK’s quota mechanism, the Renewables Obligation, adopted in 2002 has required a number of reviews and subsequent amendments, the combined affect of which has been to raise uncertainty and to drive up costs.

This point also emphasises the need to get policy strategies right in the first instance. Failure to do so means costly inefficiencies with the possibility that these will extend considerably over time. Poor strategy choices might include a failure to properly consider potential negative outcomes, failure to consider and address wider issues such as regulatory frameworks and failure to avoid perverse incentives which drive undesired market behaviours.

5.1.2 Addressing regulation

Despite funding to support deployment of increased levels of RES-E in some Member States since the 1980s the wider extent of some of the barriers to renewable growth did not become apparent until more experience was gained in operation of large volumes of capacity; this included a number of regulatory barriers. While some regulatory barriers, perhaps most notably access to distribution grids for renewable electricity sources, were obviously apparent from an early stage and in many cases have now been dealt with, other regulatory problems were less apparent and continue to limit development. These include regulations which favoured centralised generation, regulations which failed to monetise all the benefits of renewable energy distributed energy sources and others. The regulatory system associated with electricity supply, along with technical elements of the supply system, was designed to support the operation of the centralised generation paradigm. It became increasingly apparent in the last decade that this regulatory framework offered a less useful fit for smaller-scale generators, more distributed around the grid, perhaps operating more intermittently, and with other operational characteristics varying from traditional large-scale generators.

It seems likely that large-scale provision of RES-H/C will require significant changes in regulation concerning energy markets, including the potential introduction of new regulators, of new regulatory powers for existing regulators and new bodies of regulation. There is a need to avoid any regulation which will raise costs to consumers unnecessarily, but that there may be some need to review, and if necessary, revise existing regulation to ensure that it does not entail barriers to the adoption of new technologies as well as to devise new regulations which both reduce barriers to RES-H/C while avoiding the creation of new ones. This seems likely to require significant legislative changes, and potentially, substantial changes in the approach of regulation to they way in which heat markets are currently overseen. Woodman and Baker (2008) discuss some of the issues relevant to regulatory oversight of decentralised energy delivery, with specific reference to some of the issues likely to impact on RES-H, including issues such as the protection of investment, the protection of consumer interests and the need to stimulate competitiveness while also protecting the environment.

5.1.3 Holistic consideration of policy

It has already been noted that different RES-H/C technologies are at different stages of development. The same remains true of RES-E technologies and has been for some time. It has become apparent from the RES-E experience that a single policy will not suit technologies at different stages of maturation, rather policy instruments need to be crafted to address the specific needs of the technology which are to be advanced. The key problem with doing so is that it will tend to imply the selection of technologies for support, or ‘picking winners’, which can be unacceptable to some stakeholders.

Moreover the transformation of markets in view of long-term climate goals and in terms of a sustainable, future-viable development requires a large measure of "learning investments", e.g. new technologies must be developed, and existing but not yet economic technologies must be retained, in order to be able to access a sufficiently large technology portfolio in the long term. Single instruments which lead to a market behaviour that tends to concentrate on only few technologies (e.g. those that are most mature) and to align with short-term demands on investment returns are to a large extent blind to such long-term requirements (Bürger, Klinski *et al* 2008).

The leading example is probably the application of quota mechanisms, adopted to allow the market to decide, the market has always tended to choose the technology or technologies already closest to market at the moment of the introduction of the instrument, effectively making them the default winners. This may have some advantages in meeting targets for renewable installation by lowest societal costs but may be less effective at engendering long-term price reductions across a basket of technologies. Despite any advantages, there are numerous examples of quota mechanisms having to be supplemented in order to provide any support to less mature technologies.

5.1.4 Minimisation of public cost

Haas *et al* (2004) suggest that, along with a number of other goals, the major goal for policy should be the minimisation of public cost. While it may seem obvious that this would be significant, its importance makes it worth reiterating, along with the corollary that other factors – some of them difficult or impossible to monetise – also need to be considered. Highlighting this serves to frame the key debate as to the comparative merits of the main mechanism for supporting RES-H/C technologies as they approach becoming commercial. This will tend to be the most expensive stage as a shallower learning curve sees less returns against deployment, requiring greater deployment.

However, there is some disagreement over how minimisation of cost might best be achieved. The adoption of quota mechanisms, as for example, in the UK, tends to imply a short term approach to minimising cost, wherein targets are set and the aim is to minimise costs in achieving them. Other perspectives allow for a longer term approach, where reducing the long-term cost of the technology provides the greatest benefit. Menanteau and Finon (2003) present evidence that some instruments may promote greater dynamic efficiency – essentially they are able to deliver cheaper technologies in the long-term, while other instruments may have superior static efficiency, that is they can better address hitting short term targets for capacity increases. However, as is noted later in this text, the growing evidence that quota mechanisms do not deliver greater short-term efficiency may undermine the short-term approach entirely.

5.1.5 Who pays?

Different choices of instrument applied to support the development of renewable energy technologies from the research and demonstration phase all the way through to commercial maturity will result in costs borne by different stakeholder groups. It is possible to frame a number of arguments as to whether to favour instruments which allot costs on the basis of those stakeholder groups which cause these costs to be necessary. There is a strong argument that the polluter pays principle should apply in determining which stakeholders bear the costs of any instrument adopted to support the growth of renewables energy on the basis that support is primarily intended to mitigate and replace the use of fossil fuels. While the most economically efficient way to apply the polluter pays principle would be the introduction of measures to internalise all environmental externalities, this is often not politically acceptable (Owen 2006).

The distinction as to which stakeholders meet the costs of supporting renewables will be clarified for each instrument discussed, contextualised as either advantage or disadvantage, and with commentary as to acceptability where possible.

5.2 Limitations on the lessons of the RES-E policy experience: the differing nature of electrical and heat energy delivery and trading

5.2.1 Delivery

The delivery of electricity in industrialised countries is systematically straightforward. It is generated, transformed to an appropriate voltage and dispatched via transmission and distribution networks and various further transformations to reach consumers. Input of electricity to the grid and extraction from the grid are metered. This provides a simple way to measure production by all generators, consumption by all consumers and provides a mechanism whereby consumers receive essentially the same product (albeit at different voltages for smaller and larger users) on demand. Mechanisms employed to address policy goals linked to renewable energy sources of electricity have been developed to fit this model.

Delivery of heat energy to consumers is a more complex and considerably more heterogeneous process however. Heat can be delivered directly to homes via district heating at either small or large scale, with a variety of fuel stuffs acting as the energy source; it can be generated in the home via networked delivery of gas or with bottled gas located near the heat load, it can via a range of other fuel stuffs delivered to the location where the heat energy is required. A substantial fraction of heat demand in some Member States is met via the use of networked electricity at the point of consumption, including for industrial heating purposes and for domestic space and water heating and cooking.

Demand for cooling can be met via district cooling systems, again powered by various different energy sources, or can be delivered at site by systems generally powered by electricity.

The added complexity associated with delivery of cooling and especially of heat energy and related fuel stuffs, and the absence of a central delivery mechanism may make application of some mechanisms more complex, more difficult to administer and as a result potentially more expensive. This will not apply with regard to all mechanisms but consideration must be given to this in assessing the usefulness of mechanisms in the context of RES-H/C. Support mechanisms which require significant levels of administration for example, are likely to be impacted negatively, and there may be other impacts.

5.2.2 Trading

The existing network mechanism for electrical delivery also allows for relatively straightforward trading in that it tabulates all production and consumption, subject to an overarching albeit territorially individual regulatory regime, allowing additional and more complex regulatory elements – renewable energy support mechanisms for example – to be overlaid. The market for heat energy is less well defined; its heterogeneous nature means that different elements are subject to different sets of regulation, are subject to different oversight bodies and may be individually subject to various different taxes, including taxes linked to their environmental disbenefits. All of these factors may potentially conflict with or present barriers to the adoption of particular policy instrument options for the support of renewable energy. Such potential problems are discussed in the context of the different support policy instrument options in section 5.2.

The fragmented nature of the market for heat may also imply greater difficulty in driving wholesale change. The much larger number of individual stakeholders and their far less homogeneous nature may make influencing behavioural change far more complex and difficult. The need for many householders, building owners, commercial enterprises and others to be prepared to take on change will be far greater than is the case with electrical delivery.

6 RES-H/C Support Mechanisms

A wide variety of different types of mechanisms have the potential to support the expansion of RES-H/C. These can be classified in different ways, since the aim here is to detail the variety of mechanisms a straightforward typology will be applied, with the mechanisms split into three overarching categories:

- financial or fiscal mechanisms[3]; that is, mechanisms which provide some financial stimulus to increase the economic viability of the technology with the aim of creating a market for the technology
- non-financial mechanisms; this is a wide-ranging grouping of mechanisms, including obligations on particular stakeholders to purchase or sell technology, promotion measures to support awareness and to assist with infrastructure and mechanisms which exist to address specific barriers to renewable energy deployment.

Within these categories, the basic form of each mechanism will be described, along with its general aims and objectives, and consideration of the stage of technological development when the particular mechanism might be most appropriately applied. Where applicable, mechanisms which have considerable scope for variations in their operation and application will have these variations described, most notable where these create the potential for different outcomes in regard of their application to RES-H/C. The likely advantages and disadvantages will then be described based on experience of their application to RES-E but also taking into account the particular characteristics of RES-H and RES-C as appropriate. Experience in the RES-E policy sector has also demonstrated that there is potential for some mechanisms to operate simultaneously to complement each other, positive and negative experiences of such application this will be discussed and addressed in the text and then from a wider perspective at the end of the chapter.

6.1 Financial mechanisms with potential to support RES-H/C

6.1.1 Grants/Investment subsidies

Direct financial subsidies for the purchase of RES-H systems are the most widely adopted financial mechanism in the EU for the support of RES-H (Bürger, Klinski *et al* 2008; IEA 2007). They have been made available to support different RES-H technologies across a range of Member States, including Austria, Greece, Germany, the Netherlands, Poland and the UK. The basic aim of adoption of grants is to defray the high

[3] The key feature of fiscal instruments is that the state itself manages the funding flows below the legislative level (i.e. is responsible for execution) or commissions other agencies to do so on its behalf.

initial cost of purchasing systems and render the technology more attractive to consumers. Grants tend to be easy to administrate and are attractive to governments wishing to stimulate initial interest in expansion of demand for particular technologies where they can be easily targeted. Grants are funded directly from the public purse, justified on the grounds that they provide an initial stimulus for technologies that it is in the public interest to support. Since they are generally applied in relatively early stages of deployment the total costs can be limited, should this provision be extended to later stages of the commercial maturity process then costs are likely to rise significantly which may undermine political support.

There are a number of possible variations in the application of grants. They can be made available to developers or owners installing their own RES-H or RES-C systems or directly to manufacturers, though the latter is less common as it can lead both to competition issues and to the undermining of quality. This section will focus on operator facing grants. Attaching conditions to grants such that they are only available to support approved or certified models can act to assist in maintaining quality though care should be taken to ensure the approval/certification process should be both transparent and easily accessible to new entrants (i.e. without undue financial or other barriers). Sawin (2006) suggests five key elements and variations on the application of grants:

1. capacity installed subsidies (e.g. €/ installed MW)
2. subsidies as a fixed percentage of total costs, with the fixed percentage specific to named technologies
3. a fixed upper limit per installation
4. the availability of rebates rather than direct subsidy, again based on a specific percentage of the cost of the installation
5. refunding of a fixed amount of money per unit of capacity installed (i.e. effectively breaking the link between actual costs and the level of the subsidy.)

Grant schemes will typically specify the total amount of funding available with grants awarded on a first come, first served basis. Availability of funds may also be limited on a per technology basis, to specific stakeholders or within shorter sections of the total available time frame (I.e. a specific amount per month over the course of the schemes availability). These options may be combined. Grants may be made conditional on some operational target, for example, a minimum metered energy output over a specified time or a period of installed operation.

6.1.1.1 Advantages and disadvantages of grants

Grants should be straightforward to administrate, with limited interaction between the operating body and the recipient required. In practice, the upfront application of grants and the general lack of operational oversight of subsidised developments mean there is no guarantee of levels of deployment of renewable energy stimulated by grants. An IEA comparison of grant subsidies for solar thermal in different Member States showed considerable variation in energy generated per unit of investment.

Foxon *et al* suggest they are an appropriate method for stimulation of renewable technologies in the R&D, Demonstration and Pre-commercial phases of technological maturity. Grants are not generally applied as the key mechanism to stimulate large-scale renewable energy developments, though there are examples of there being used in addition to other mechanisms for less mature large-scale applications in addition to other mechanisms.

Another advantage linked to grant schemes are comparably low transaction costs, especially where public administrative bodies that manage the grant programme are familiar with running such schemes. An example is the existing German handling procedures for the Market Incentive Programme, which is a grant scheme with a financial volume between 200 and 400 Mio EUR per year that is mainly addressing small scale RES-H applications. Here only about 100 people process well over 150000 funding applications every year.

Furthermore grant schemes are on principle popular with the recipients. Contrary to support received via tax breaks or soft loans (that might correspond to a similar level of financial support as the grant) a grant means a direct transfer of money to the recipient. From the psychological perspective and at least for small scale investors this might be perceived as being advantageous.

Finally, grant schemes can be designed as to provide incentives for structural goals such as technology diversification or – if desired – the expansion of district heating systems. Support for specific technologies or applications can be adjusted through setting the grant level to its deemed importance.

The main disadvantage of grant schemes is that they burden the state or communal budgets and are therefore dependent upon the current political agenda. As a result it might be rather difficult to apply grant schemes as the main instrument to foster the deployment of RES-H/C to the extent that is necessary in view of the overall RES targets set by the new RES Directive. Moreover the dependency on public budgets might lead to a stop-and-go development in the RES-H/C market sector. This is mainly due to the risk of frequently changing support conditions (e.g. support level per m^2 solar collector area) that might result from the limited availability of the total amount of funding. A foresighted, economically efficient planning of production and investments is made very difficult by the resulting demand fluctuations. It is relatively difficult to provide stable subsidy conditions that are stable over a longer time when based on investment grants.

It is likely there is considerable potential to continue to apply grants to stimulate increased market demand for RES-H and RES-C technologies, most notably in regard of smaller-scale applications and of less mature technologies. There is potential in some Member States to bring together disparate existing grants to improve efficiency of administration and this may similarly offer some potential for a degree of harmonisation of policy at the EU level or at least between a limited subset of Member States.

6.1.1.2 Application of grants to RES-H/C

Grants may be offered directly from a government department or via a separate body given responsibility and funded by government. The key element of applying grants is to try to achieve a system which awards grants efficiently and effectively. An efficiently run system is likely to require some form of standardisation to ensure that funds are directed only into technologies that are of sufficient quality to warrant support as described in section 6.2.4. Further checks to ensure public value may include checks on whether the technology continues to be used a certain period after the use of the technology, though this necessarily involves added cost, and responsibility for this task may become an issue as regards more short lived grant programmes. Also key to achieving efficiency is to set the level of grants such that the maximum volume of deployment occurs against the funds set aside for the grant programme. Setting grants too high effectively results in overpayment to some schemes, and less deployment achieved per unit cost to the taxpayer. It may also lead to early overspend of funds resulting in a stop-start impact on demand development. Setting grants too low will result in ineffective stimulation of technology, with attendant delays in the growth of the technology and concomitant improvements in cost reduction.

6.1.2 Public procurement

Generally overseen by government or by a government directed agency, a programme of public procurement encourages or compels the adoption of new technology in public buildings. The policy aims to stimulate market demand for eligible technologies and is generally aimed at moving technologies through from the demonstration phase and through the pre-commercial phase. It has been applied in a number of different Member States to support various environmental technologies including a number of different RE technologies, including in support of heat pumps in Sweden (IEA 2007).

There are a number of possible variations on the basic form of the mechanism. To be effective, at the very least steps have to be taken to ensure that the quality of any technology funded by the mechanism is upheld. These protections can take a number of forms. Some variations on the mechanism may apply more complex procedures to drive and reward technological innovation, as was the case with the Swedish public procurement mechanism to support heat pumps.

6.1.2.1 Advantages and disadvantages of public procurement

The mechanism is a useful tool in creating an initial market pull for new technologies. It relies on being applied when the technology is sufficiently advanced to warrant being used for practical purposes. The scope of public procurement as a tool to drive deployment and maturation of renewable energy technologies is essentially limited. Public buildings represent a relatively small fraction of total building stock, and the mechanism becomes less relevant as the technology moves closer to maturity, when the scope of the market it is able to drive becomes less capable of making a substantial contribution to ongoing cost reductions.

There is some potential for the use of the mechanism is increase public awareness of the technology, and this can be assisted through efforts by local government authorities to gain public exposure for installed technology in public buildings.

There is some potential for the mechanism to expend public funds on technologies while they are still relatively expensive and which do not go on to become mature technologies. Public procurement is supported directly from the public purse and there may be limits on ongoing political support, though the limited availability of public buildings may place a natural limit on the size of funding necessary.

Improperly applied mechanisms may lead to funding of low quality technology and thus there is an imperative to combine the application of public procurement with some form of equipment and installation standards and perhaps certification.

6.1.2.2 Application of public procurement to support RES-H/C

There is no reason that public procurement mechanism should not be applied more widely to support stimulation of demand for multiple RES-H and RES-C technologies. The mechanism has been successfully applied to renewable energy, and specifically to RES-H in a number of territories, including the Swedish experience with heat pumps. Application of public procurement might require some changes in legislation in some territories, specifically where government offices are compelled to purchase the cheapest possible option but in general adoption of such an instrument should be straightforward. Care would need to be taken to ensure quality of material purchased by public bodies was of sufficient standard but this could be achieved relatively easily as described in section 6.2.4.

6.1.3 Quota mechanism

A quota mechanism, also known as a Renewable Portfolio Standard (RPS), has become one of the two key instruments used to support the deployment of large-scale near-market renewable energy sources of electricity (Rader 1996; Berry and Jaccard 2001). It is the central mechanism of choice for the support of RES-E in a number of EU Member States including the United Kingdom, Belgium and Poland (European Commission 2005; European Commission 2006; European Commission 2007. It is particularly popular in the United States, where at least half of the states have introduced the mechanism in one form or another (Wiser and Barbose 2008).

The basic form of the mechanism involves the emplacement of a legal obligation to purchase a specified amount of renewable energy. When applied to renewable electricity the obligation is generally placed on electricity supply companies. While the obligation can theoretically be placed on consumers, in practice this would generally be manifested through the supply company anyway.

The obligation can be a specified amount of energy or it can be a specified percentage of all the energy supplied by the utility in a fixed period. This can be fixed or can be set to increase over time.

Enforcement of the mechanism is generally with a fine, payable by the obligated party in respect of every unit of energy by which they fall short of their obligation during the specified period. The level at which the obligation and the fine are set are key to gauging the level of the ambition of the mechanism and to its effectiveness in developing new renewable energy generating capacity. Setting a low obligation will naturally lead to only a small increase in capacity, equally however, since companies are motivated to seek out the cheapest option setting the fine associated with non-fulfilment of the obligation at a low level will result in obligated parties being more likely to take the option to pay the fine.

All registered renewable energy generators receive certificates representing a unit of generated energy. Obligated parties demonstrate their compliance by submitting certificates to the government body given responsibility for oversight of the mechanism. Obligated parties can obtain the certificates in a number of ways, depending on what local regulation allows. These include (i) direct purchase from those renewable energy generators licensed to produce them, either with or separate from renewable electricity production, (ii) purchase from a third party, for example a certificate consolidator or other trader.

The obligation effectively creates a new market for the certificates, with supply companies willing to act as consumers where this option is cheaper than paying fines.

Central to the mechanism is the underlying idea that it acts to stimulate a market for energy from renewable sources and that it applies elements of competition to deliver increases in capacity at the lowest possible societal cost. Obligated parties have to compete to source the cheapest renewable energy, and renewable energy generators compete with each other for contracts to deliver energy. However, there is an increasing body of evidence that the mechanism does not offer the cheapest option (Ragwitz, Huber *et al* 2005; Ragwitz, Held *et al* 2006; DEFRA/BERR, 2007a; DEFRA/BERR, 2007b). It has been suggested that the mechanism acts to increase some of the financial risks for developers with the result that prices are pushed up (Mitchell, Bauknecht *et al* 2006; Butler and Neuhoff 2005). Even the UK, which has been a long-term supporter of competitive mechanisms generally, and the quota mechanism in particular, appears to have begun to acknowledge that it may not be the most economically efficient way to deliver financial support for RES-H technologies in the pre-commercial and supported commercial phases, with a number of scoping documents concluding that the tariff would be the most efficient way to deliver RES-H in the UK before the eventual adoption of a renewable heat tariff in an Energy Act in late 2008.

There are a large number of potential variations in the application of a quota mechanism in addition to the key variations of the level of the obligation and the level of the fine paid by those companies not meeting their obligation. The length of time over which the mechanism is guaranteed and the quota level is set is obviously significant, as noted in section 6.1.3, as this greatly contributes to the stability and predictability of support that experience with RES-E suggests is a key element of long-term sectoral development. The destination of the fine paid for non-fulfilment of supply obligations can be significant. In general these monies will accrue to the government or to an appointed regulatory body, quite possibly going to central government funds or being directed into other efforts to support development or deployment of renewable energy. Another potential destination for these funds is via ‘recycling’, something which can significantly change the operational characteristics of the mechanism. This occurs in the UK’s central mechanism for the support of RES-E, the Renewables Obligation, where the collected fines from those not meeting their obligation are redistributed to those meeting their obligation. This has the effect of pushing up the value of certificates, effectively increasing the amount of renewable capacity that can be stimulated economically.

Further variables include the potential for banking, i.e. whether certificates can be held over from one compliance period to the next, and borrowing, i.e. whether certificates can be borrowed for submission in a compliance period before they are generated. The first is allowed to some extent in some RES-E quota mechanisms (Mitchell and Connor 2004), the second is not known to be in place anywhere currently.

A key potential variation for quota mechanisms is the use of banding. Since competition – with the aim of achieving deployment at the minimum cost to the consumer or taxpayer – is central to the application of the mechanism, the basic form of the quota mechanism sees all eligible renewable energy technologies compete against each other. More complex variations allow ‘banding’, this can operate in a number of ways. One form of banding would specify different quotas for different technologies, for example, instead of specifying say 5% of all energy provided by supply companies must come from renewables, the target would be broken down to specify that amounts of energy or fractions of total energy supply would have to come from chosen technologies, for example 3% wind, 1,5% biomass, 0,25% wave, 0,25% solar. Another form of banding might see less mature technologies rewarded with different numbers of certificates. The UK for example is currently planning to introduce such a system for support of RES-E.

6.1.3.1 Key advantages of quota mechanisms

The key theoretical advantage of the quota mechanism is that the competition inherent in selling energy generated from renewable sources and amongst supply companies to source renewable energy (or at least the certificates which effectively subsidise generation) should lead to the lowest possible cost to society for renewable energy. There is an increasing body of evidence that this theoretical advantage does not necessarily manifest in practice (Haas, Eichhammer *et al* 2004; Butler and Neuhoff 2005; Mitchell, Bauknecht *et al* 2006; Lipp 2007; Ragwitz, Huber *et al* 2005; Ragwitz, Held *et al* 2006; DEFRA/BERR, 2007a; DEFRA/BERR, 2007b; IEA 2008). This is obviously of some significance, since this can be regarded as the key justification for the mechanism. There are further problems with this. Since the mechanism delivers at the marginal cost, most plants will receive a price above their real costs and thus there will be an excess cost within the system.

Linked to this competitive element, the mechanism may appeal to the adopting government on the grounds that its use sees the market acts to choose the technologies which are successful supported within the market, effectively relieving the government of the responsibility for choosing winners and losers and the attendant political risk of supporting technologies that come to nothing.

Another significant advantage of a quota mechanism is that the subsidy it provides to support renewables is linked to the certificates that renewable generators receive against their energy output. While trading of electricity and of certificates often occurs together, the use of certificates effectively separates the monetisation of the environmental benefits of the renewable energy from the selling of the renewable electricity. By doing so, the mechanism acts to minimise interference with the larger electricity market. While the subsidy clearly makes the renewable energy sources more competitive and thus more likely to be purchased, the operation of the market is not compromised, specifically, the use of renewable electricity is not prioritised above electricity from other sources. This can be significant for territories with a significant political commitment to free operations of markets.

A further political advantage of quota mechanisms is that the cost attached to them is predictable. The costs of the mechanism are effectively limited by the setting of the level of the quota and by the associated fine for parties which do not meet their obligations. While it is possible to have low levels of deployment of renewable energy within the system and corresponding high levels of fines there remains an upper limit on the total cost this can lead to. This potential for financial planning can be politically attractive to governments. It must be borne in mind that the mechanism does not necessarily lead to targets being met however. The cost burden of the quota falls directly on consumers, and in general terms are thus linked to levels of energy consumption, though how this manifests on final prices to the consumer is under the purview of supply companies. To some degree this incentivises supplier behaviour for gaining competitive advantage through application of superior management, allowing consumers to switch suppliers away from companies which raise prices uncompetitively; however, the effect of this may not be that significant in terms of overall energy prices.

At the European level, the trading element of the quota mechanism suggests potential advantages relevant to increasing harmonisation of policy amongst Member States. Its wider adoption for the support of RES-E has historically been favoured by the Commission on this basis. However, support for the use of tariff mechanisms by a large number of Member States, along with decisions protecting the continued use of tariffs has meant the Commission has moved away from its original position.

6.1.3.2 Key disadvantages of quota mechanisms

Perhaps the key disadvantage of the basic form of the quota mechanism is that it forces multiple forms of renewable energy technology to compete against each other. Since different technologies are at different stages of technological maturity and have different costs associated with them this effectively means that the simple mechanism tends to support only the technologies which can deliver energy most cheaply at the point in time at which the mechanism is introduced. Technologies which are less competitive at the point of introduction of the mechanism are unlikely to be able to attract investment as it is more worthwhile for investors to favour the cheaper technology and unless further support is provided these technologies may be left stranded and fail to further develop. As a result of this issue it has been argued that the mechanism may be better suited to achieving short-term targets for RE deployment rather than addressing underlying policy goals such as long term cost reduction of the technology (Menanteau, Finon *et al* 2003) with potential implications for long term policy costs. There are a number of possible responses to the issue of stranding less mature technologies. Perhaps the most obvious response is the introduction of additional policy instruments to provide additional support to less mature technologies. While this may be useful in assisting those technologies, the introduction of additional mechanisms and the additional costs this entails would appear to be at odds with the underlying goal of the quota mechanism, minimisation of costs. When this is combined with the evidence noted in section 6.1.3.1 that the mechanism may not deliver renewable energy more cheaply then the alternatives this would appear to undermine a key reason for its adoption.

As noted above more complex variations on the quota mechanism allow some form of banding. The use of banding is specifically aimed at addressing the problem of stranding less mature technologies outside the funding mechanism. The introduction of banding acts to increase prices as it effectively introduces restrictions on utility choice of renewables, thus pushing up overall costs of meeting obligations. The two forms of banding noted above have different implications for the operational outputs of the mechanism. The banding variation wherein a government sets different targets for different technologies effectively means that government is choosing a technology to support. This removes the political advantage of allowing the market decide and opens government up to potential failures in selecting technology for public funding. The second variant on banding, awarding different numbers of certificates to different renewable energy technologies avoids this problem to some extent but also acts to decouple the availability of certificates from actual production, potentially resulting in either large numbers of certificates being awarded without corresponding generation or the converse. While the government adopting such a system may make efforts to balance the number of certificates awarded across the board to try to maintain some form of equality, this has the potential to result in regulatory uncertainty and impacts on development costs.

Some quota mechanisms in practice have required large amounts of tuning to operate effectively leading to high transactional and administrative costs for the mechanisms in comparison with tariff mechanisms, the other key instrument aiming to support renewable energy technologies in the supported commercial phase. Haas *et al* emphasise that any assessment of support mechanism must include these costs to allow meaningful comparison (Haas 2004).

As was noted in section 5.1.1, a highly desirable quality of policy mechanisms to support renewable energy is that they provide a stable environment for investment by both developers and manufacturers. To facilitate this, mechanisms need to be both predictable and persistent, as well as being a substantial enough level of subsidy to allow economic viability (Jacobsson and Bergek 2002). Quota mechanisms can provide stability through political commitment to their long term application; however, they can demonstrate some vulnerability to destabilising effects if there operational qualities require any amendment to address changing circumstances. Any required changes to regulatory conditions attached to quota mechanisms have the potential to alter the market price available for certificates, adding uncertainty to the market and thus increasing the risk faced by developers. This will tend to lead to increases in the cost of capital required for investment and an overall increase in the costs of development.

The use of the quota mechanism to support RES-E has also been associated with increased investor risk in three, and possibly four, key areas which may not apply in alternative support instruments. This increased risk leads to higher costs of investment and this has been put forward as a reason why quota mechanisms do not deliver renewables as cheaply as macroeconomic theory suggests. A number of commentators have suggested that the absence of prioritisation inherent in the mechanism means that the developer experiences increased price risk in that there is no certainty as to the price they will be able to sell their electricity (and indeed their certificates at), volume risk in regard of the uncertainty that they will be able to sell all of their output, and balancing risk in that renewable electricity generators must operate as other electricity generators and may have to deliver electricity at contracted times or face financial penalties. An argument can be made that it is legitimate for renewable generators to bear the full range of costs associated with their use, nevertheless, some instruments see renewable generators relieved of this cost and any comparative assessment of the quota mechanism with other mechanisms needs to take these factors, and their impact on renewable energy costs, into account. It should also be noted that it is possible that not all of these risks will apply within the framework of quota mechanisms applied to supporting RES-H, as discussed in the following section.

6.1.3.3 Applying a quota mechanism to support RES-H/C

While a quota mechanism could be applied to support the development of renewable energy sources of heat, inclusive or exclusive of some of the variations discussed here, the differing nature of the delivery of heat and of fuel stuffs used for heat production will again have implications impacting on how the mechanism might apply and on the advantages and disadvantages inherent in its use. There are a number of options for applying a quota to RES-H.

A basic quota model might be applied such that all suppliers of fuel for heat use have an obligation placed on them to submit certificates representing the production and use of a specified amount of heat energy, e.g. relative to their volume of heat supply in a predefined period (e.g. one calendar year). This would be closest to mimicking the situation for electricity supply, though would perhaps be more complex in the case of

RES-H/C. There are a number of complicating factors to this scenario, and other scenarios are also possible. Complicating factors for this scenario include:

- Oversight and licensing of renewable heat providers to provide the certificates necessary for the obliged parties to demonstrate compliance. While metering of electricity production occurs as standard allowing easy oversight, heat production is not metered as standard, and meters can be expensive. Introduction of meters will increase costs and this will impact particularly on small-scale heat energy production. An alternative for small-scale installations (e.g. small domestic installations) would be to use some simple calculation patterns (e.g. based on the installed capacity and an anticipated number of full load hours) to determine the number of certificates that will be issued for such a device. Furthermore, certificates could be aggregated over several years so that operators of a small RES-H/C installation would receive certificates (and thus revenues from their sale) for all their eligible RES-H/C generation only a few (e.g. two) times. Even this implies a certain level of price risk linked to variations in the price of certificates, and additionally, care would need to be taken as to when certificates become available in order to ensure flow of income against investment. Larger installations would be subject to more stringent monitoring and could be required to provide annual evidence of total RES-H/C produced.
- Similarly, while electricity is transmitted by the generator into the local grid, the absence of a central network for heat energy means that not all of the heat that can be produced will be needed by consumers; this will apply for technologies such as biomass burning CHP where technologies are capable of producing electricity and heat but where the heat demand is low e.g. during the summer season. Some compromise may be needed to ensure that certificates are not awarded for energy which is not used for any constructive purpose.
- As noted above, quota mechanisms tend to have high transactional and administrative costs. These figures will tend to rise with the number of generators and the number of obligated parties. A large number of small-scale generators will tend to mean complex licensing arrangements, and a low ratio of certificates earned against energy generated resulting in low transactional and administrative efficiencies[4]. This is likely to mean that the mechanism will be inappropriate to the support of some small-scale applications of RES-H technologies or – from the perspective of a small-scale generator – ways of simplifying the administrative process need to be implemented.

[4] As an example, the UK included small-scale renewable electricity generators in its variation of the quota mechanism from 2007. In the period 2007-08, the regulator's administrative costs linked to small generators where £650,000 against a total estimated subsidy of £400,000. This figure is not inclusive of transactional costs or of costs associated with consolidation of small numbers of certificates (Ofgem 2009).

- Section 6.1.3.1 notes that a key advantage of the quota mechanism is the absence of prioritisation that it implies for the delivery of electricity to the trading market. The absence of a central grid for heat energy will tend to mean that this advantage of the mechanism does not apply in the case of heat energy.
- Finally, practical experience with use of the quota mechanism to support RES-E has delivered increasing evidence that the mechanism may not be able to deliver the economic advantages that have been posited as the main justification for its use, namely the application of competition to allow the cheapest possible delivery of renewable energy to the consumer.

A deficiency in this final element would appear to undermine the key justification for the quota mechanism, that this may be exacerbated in application to RES-H by the other problems identified, would tend to suggest that the quota mechanism is likely to be inappropriate to support many – and perhaps all – RES-H technologies. Other options might be to apply a quota to suppliers of boilers.

6.1.4 Tariff or bonus mechanism

The tariff or bonus mechanism is essentially a financial subsidy applied per unit of energy generated to support generation from renewable energy. The term ‘tariff mechanism’ has become widely used in regard of RES-E, while ‘bonus mechanism’ has come into use more frequently, perhaps reflecting that this is the description favoured in Germany, the Member State which has led the discussion on adoption of new mechanisms specifically aiming to support heat. Tariff mechanisms have been applied widely to support RES-E in Europe where a range of EU Member States have adopted them.

In practical terms this type of mechanism must be differentiated from feed-in schemes on the one side and bonus schemes on the other. In the latter case the plant operator is required to market its electricity/heat (while receiving a bonus on top of this revenue) whereas a feed-in scheme obligates a specific actor (e.g. the grid operator) to take and pay (a fixed feed-in tariff) for the goods provided. In the case of RES-H/C only the bonus type of system seems to be feasible - at least for small scale applications - due to the lack of a homogeneous grid. Only for large scale installations connected to a grid might a feed-in scheme be applicable. As far as RES-H/C is concerned this section will only cover the bonus type of scheme.

The subsidy can be provided directly from government, with the costs met by the taxpayer or passed on to utilities via on obligation to pay for all energy production at a specified rate, this obligation can be on a geographical basis as was originally the case with RES-E support in Germany or on a socialised basis where the total costs nationally are added and then divided amongst all utilities. The latter method is more common on the basis that it provides a greater degree of justice for both utilities and consumers given that the environmental benefits of the scheme are accrued at the national level. Where the second option is chosen, the government may allow the costs accrued by individual utilities to be socialised across the broader family of utilities on the grounds that this more fairly passes on costs to consumers of energy derived from fossil fuels.

The mechanism is intended to allow renewable developers to have sufficient income to allow economically viable investment in new renewable capacity. There is some scope for variation in the application of tariffs or bonus payments. Whilst all variations on the bonus model see generators receive a fixed remuneration per unit of renewable energy generated, in addition to the base market value of the energy, the most common variation is to specify particular rates of subsidy for particular technologies, allowing differentiation on the basis of economic need. This allows governments to direct support preferentially to particular RE technologies rather than to set a single tariff rate which would effectively cut off some technologies and potentially subsidise others excessively (Bürger, Klinski *et al* 2008).

The level of the subsidy can be linked to overall energy prices, as has previously occurred in Germany and Spain in respect of RES-E. Germany no longer practices this methodology on the grounds that volatility affecting energy prices could undermine the price available to renewable energy generators, increasing investment risk and reducing the stability offered by the mechanism.

Other variations include the setting of limits on the availability of tariffs or bonus payments, this can be a time limitation, for example, making the subsidy available for a fixed number of years, or a limitation on the amount of energy that can be supported, for example, a fixed number of kWh generated. While early variants on the feed-in type of scheme as it applied to renewable electricity sometimes did not feature limits, some kind of limit is now standard. These limits act to constrain the total cost of the instrument – early versions of the tariff enacted in Denmark and Germany included no limits on the availability of respective feed-in tariffs – reducing the potential for excessive profit for developers and plant operators and discourage exploitation of lower quality renewable energy resources.

The potential for excessive profits is also addressed by a further variation adopted in the German RES-E feed-in tariff mechanism, the EEG. A key element of societal support for renewable energy technologies is the long-term reduction in their costs, with the goal of making them competitive with other energy sources and thus engendering access to cheaper energy sources in the future than would otherwise be possible. The tariff mechanism, by fixing prices, fails to pass on any reduction in the unit costs of renewable energy to the consumer. The EEG addresses this by introducing digression. This mandates a percentage reduction in the available tariff on an annual basis. RE generating capacity which has already been built remains on the same tariff until it reaches the defined limits, but a generator which come on line in the following year would have the tariff reduced by the legislated fraction, and this new level of tariff would then be available until that generator also reached the defined limit for subsidy. The level of the annual percentage reduction has been defined as far ahead as possible to aid transparency in financial planning for renewable energy developers.

While digression may help to reduce costs by forcing the market to reduce costs, and annual reductions have been calculated to take into account likely reductions in real world prices, there remains the danger that reductions in tariffs or bonus payments will be outpace real world reductions in costs and thus undermine the effectiveness of the mechanism by failing to provide sufficient stimulus to new capacity. For that reason a bonus or feed-in system should be designed as to allow for a periodic review and adaptation of the subsidy level paid to those plant operators that apply for funding following the date of publication of the adapted subsidy structure.

6.1.4.1 Key advantages of the tariff mechanism

The tariff or bonus mechanism enjoys a number of advantages. The availability of a particular price or at least bonus that is paid on top of the market price, guaranteed for each unit of energy produced and independent of the time of production has allowed developers of renewable energy sources of electricity a solid foundation for financial planning, effectively eliminating or at least reducing the key risks associated with price risk, volume risk and balancing risk. The guarantee that payment will continue for some fixed period that is present in many national variations on the mechanism also means that regulatory risk is low in many systems.

The tariff mechanism has been the mechanism adopted in those European countries which have seen the most success in stimulating significant capacities of new renewable electricity technologies, initially Denmark, then Germany, Spain and latterly other EU Member States. It has been suggested that tariff mechanisms thus offer greater proven capability for delivering large volumes of new capacity. There is increasing evidence that they may deliver this capacity at lower prices than the other mechanisms adopted specifically to support RE technologies into full commerciality, specifically that they deliver new capacity more cheaply than the quota mechanism.

Another advantage of a tariff mechanism, be it a feed-in or a bonus scheme, is the opportunity to adjust and periodically adapt the tariff/bonus level to the economic needs of the diverse technologies thus giving all different technologies the room to develop. This supports the concept of dynamic efficiency as the support scheme sets the path for delivering cheaper technologies by accessing a sufficiently large technology portfolio in the long term.

Moreover, feed-in tariff or bonus schemes set incentives to locate RES-H/C applications where they are most profitable. Thus the mechanism is capable of delivering a large degree of economic efficiency, most notably for larger scale developments. For instance in the field of solar thermal it is much more cost effective to fully cover the roofs of buildings with excellent conditions with solar collectors and to leave buildings with poorer conditions out than to spread the same collector area over a wide range of buildings with differing solar conditions (as it is e.g. the case under a use obligation).

One other area where the tariff mechanism may offer advantages is in the stimulation of new industrial opportunities. While any national or regional policy which is successful in stimulating new domestic renewable energy deployment is likely to lead to some degree of stimulation of new economic and employment opportunities in the territory, there is clear evidence that some countries have had more success in capturing large scale industrial opportunities. In Europe the Member States which have been more successful in this area have tended to have tariff mechanisms as their main policy instrument for the support of renewable energy.

6.1.4.2 Key disadvantages of the tariff mechanism

The converse of one of the quota mechanism's advantages, a tariff mechanism is effectively open ended in terms of the possible costs that it can generate. A government adopting a feed-in tariff or bonus mechanism is effectively setting a price it will guarantee to all generators who deliver renewable energy from eligible technologies. While the government can choose a price informed by the available information as to the likely costs associated with each technology and estimate the potential for the market response to this price in terms of the projected new capacity it is likely to stimulate there is no certainty as to the actual volumes of new capacity that will be stimulated and thus of the total costs that will have to be borne by consumers or taxpayers footing the bill for the mechanism. This may be politically unattractive in terms of budgeting and in terms of achieving target. One proposed solution for the potential budgeting problem is the capping of the volume of new generating capacity to be subsidised. While this limits subsidy it can be argued that to do so is simply an admission that the price has been set too high, since it would be more economic to set a lower price and achieve the same new volume of capacity at a lower price. Additionally capping creates market uncertainty concerning eligibility for subsidy, especially at the margin (Wachsmann and Tolmasquim 2003). The solution to the limitation on tariffs to achieving targets can be addressed relatively straightforwardly through periodic adaptation of the mechanism, though care must be taken to ensure that this does not undermine the benefits the instrument can provide in terms of transparency and long-term stability.

It can be difficult for government to estimate the real costs of new technology which can make initial price setting difficult leading to either unexpected costs or lower than desired deployment. This problem is also linked to ensuring the benefits of technological cost reductions are passed on, as has already been mentioned alongside the approach of Germany has taken to try to address this with digression.

Politically, one of the disadvantages of the tariff mechanism is that it requires governments to select those technologies they wish to support; something which is unattractive to some, though not all, governments. Economically this has the potential to mean that funds are used to support technologies which may later fail to deliver on any of the goals of renewable energy policy. There remains debate as to what the role of government should be in the support of new technologies, and the extent to which they should be involved. National institutional frameworks which see governments work more closely with financial and other institutions may be more comfortable with this form of mechanism.

6.1.4.3 Applying a tariff or bonus mechanism to support RES-H/C

The application of a bonus mechanism to support renewable heat, as with previous mechanisms, will vary from that applied to support RES-E as a result of the differing characteristics of delivery of RES-E and RES-H/C and the absence of a single grid network for the delivery of the latter. The widest possible application of a bonus mechanism to support RES-H or RES-C would allow all generators employing eligible technologies, across the full range of scales and applications to qualify for the bonus payments.

One of the key design elements of a bonus scheme for RES-H/C is the organisation of the relationship between the beneficiaries and the parties obligated to pay the bonus. As with the quota mechanism, this is linked to the problem of the administrative and transactional costs for the large number of small-scale generators that could outweigh all or part of the financial benefits offered by the mechanism. One potential solution to this is the inclusion of regulations to allow or compel the consolidation of units, essentially making the bonus payment available through a consolidating company which would be responsible for assessing the energy generated by the large number of small-scale generators. Further reduction of costs might be achieved by reducing the number of occasions for reimbursement of consolidated bonus payments. The task of consolidation could be carried out by government, by a government mandated agency or by a private company determined by government, depending on the preference of government and limited by any local legal restrictions.[5]

The key problem remaining in this scenario is that of accurate assessment of generator output. The cost of heat metering relative to any available subsidy is likely to continue to be a disincentive for smaller generators, suggesting an alternative is needed. This could be based on a number of variables, taking in the form of RES-H/C technology adopted, the geographical location where this is relevant (for example, as with solar thermal) and system specific factors such as the assessed efficiency or Coefficient of Performance of the system as applicable. Such a system is likely to require restrictions on availability of bonus subsidies to systems pre-approved by the national or regional government providing the subsidy, or by a government delegated agency, to safeguard against the possibility of installation of low quality equipment.

Bonus payments to larger renewable heat generators would be applied based on more stringent checking of their output, as with the tariff mechanism as applied to RES-E.

A further problem with the application of a bonus mechanism to support RES-H may be an increased difficulty in terms of the justice of passing on the costs to energy consumers. This again arises from the key difference in delivery of heat compared with electric-

[5] A detailed description of the main architecture and associated procedures of a bonus model for RES-H/C for the specific market framework conditions in Germany is given by Bürger (2007).

ity. While electricity is in a single form at the point is use, the more heterogeneous delivery of heat, and of fuel stuffs used for heat production means that there is a far more diverse group of companies supplying the market. Some suppliers to the heat market can be identified easily, for example, suppliers of gas through grids, while others may prove more difficult to identify and to accurately assess in terms of the volume of their associated delivery of heat. Failure to include any companies supplying heat energy in the mechanism when assigning costs will effectively result in those companies gaining an economic advantage over their competitors.

Another disadvantage of applying the bonus mechanism to the RES-H/C sector may lie in the perception of high levels of complexity. This at least is the experience gained from the stakeholder process when attempts where made to implement such a system in Germany. The bonus model for RES-H/C is a rather new mechanism for this sector and there is no example for this kind of model anywhere in the world yet. As a result, a large amount of explaining is required to convince stakeholders (especially politicians and market actors) that such a new approach would have many advantages. Due to the large amount of transactions between those who are entitled to receive the support and those market actors that will pay for it, the model is perceived as being extremely complex and linked to high transaction costs.

6.1.5 Tendering mechanism

Significant examples of tendering mechanism have been used to support deployment of RES-E on three significant occasions within the European Union: the UK's Non-Fossil Fuel Obligation (NFFO), the Irish Alternative Energy Regulation (AER) and the French EOLE programme. They have yet to be applied to support RES-H/C and given the trend away from their use in the RES-E sector it seems unlikely that they will receive political support in application to RES-H/C. They are included here for completeness.

The operation of a tendering mechanism is based in rounds of competitive bidding by renewable energy developers for contracts to receive a particular subsidy against future generation. Underlying the mechanism is the idea that competition will allow the government to contract for the cheapest available new renewable capacity.

The basic form of the mechanism generally involves the announcement of a new round of bidding, with the specification of eligible technologies. Historically, bidding rounds have tended to band similar technologies together for purposes of competition, that is, different technologies do not compete against each other; wind projects compete together, biomass in another competition, etc, though this is not absolutely necessary.

The announcement might see government announce a specific volume of new capacity it wishes to see developed for each technology, though this is not a necessity, as the UK's NFFO demonstrated (Mitchell 1995).

Certain conditions might apply to any parties making bids, for example, the application of a 'will secure' test to ensure that the party was financially able to develop any contract won. A further option would be to award contracts only to projects which had already won planning permission. Either option has attendant problems. The inclusion or exclusion of this condition highlighted two corresponding problems. Not specifying planning permission opened the field but risked large numbers of contracts might never come to fruition due to failure to win planning permission. Specifying planning permission might mean significant additional costs to developers for projects which would never become economic if they failed to win bids. This issue was the subject of controversy in the application of the tendering mechanism in Ireland and the UK, wherein permission has to be won at the local level over the objections of any interested parties. It is possible that national planning regimes operating on the basis of assuming the granting of permission to renewable energy developments might more easily fit with the tendering mechanism.

One variation in the mechanism could include the option to pay all successful contracts a strike price, or to pay each at the rate at which its bid was made.

A further potentially significant variation was the inclusion or otherwise of penalties for developers winning contracts but failing to deliver on deployment. The UK variation on the mechanism lacked such a penalty and has been criticised for the absence on the basis that this encouraged unrealistically low bids based on overly optimistic projections of future cost reductions and additionally, encouraged companies to bid low in order to deny competitors access to contracts (Mitchell 2000; Mitchell and Connor 2004). Later versions of the Irish RES-E tendering mechanism included such penalties.

The UK variant was also criticised for the stop-start nature with which rounds of bidding were accomplished, which tended to preclude stable growth in deployment, and which thus failed to create the conditions for both developers and growth of domestic industry.

The mechanism is typically funded by obliging utilities to pay for costs; these can be passed to the consumer or to the government, if the government wishes to do so. Of the historical schemes applied to RES-E, costs were passed to energy consumers.

6.1.5.1 Key advantages and disadvantages of the tendering mechanism

The mechanism offers key elements of competition, compelling developers to reduce prices to wind contracts, to the benefit of consumers. However, there are complicating factors, including those described above, including the stimulus to lower prices too unrealistic and undeliverable levels.

The nature of the employment of discreet rounds of bidding employed in the mechanism could also throw up problems, preventing the development of stable growth in new deployment which has since been identified as a key element of sound renewable energy policy and is particularly to industrial development.

Dropping installation rates for projects awarded contracts in the UK led to perhaps the biggest political problem in the UK system: the mechanism came to be regarded as a failure. The UK variant was supplanted by a quota type mechanism from 2002, while the Irish variant was displaced by a tariff type mechanism from 2006. The French tendering policy variant, running alongside a tariff system is less wide ranging and limited to large-scale projects.

6.1.5.2 Applying a tendering mechanism to support RES-H/C

Given the contractual nature of the mechanism, its potential area of application seems likely to be confined to supporting large-scale applications of RES-H/C in the pre-commercial and supported commercial phases of technological development. Transaction and administrative costs and the complexities of bidding seem likely to render the mechanism inappropriate for the support of small-scale applications. Even at the larger scale, the application of the mechanism might not be straightforward. The absence of a heat grid corresponding to the electrical grid seems likely to limit the number of appropriate projects available for development for competitive bidding during any given tranche. If it was possible for a government to identify particular instances where a large-scale renewable heating or cooling application might be appropriate it might be possible to apply competitive bidding to find developers for those specific projects. This tends to suggest projects which might be carried out alongside district heating systems, with both elements subject to bidding. This would seem to bear some relation to public procurement, and might usefully apply to drive initial interest in Member States where these is little experience with these kinds of projects. Care would need to be taken to address the many problems of the mechanism to incentivise a higher likelihood of successful bidders bringing their projects to fruition. Another option may be support for industrial applications of renewable heat, with government effectively acting to try to incentivise pilot schemes through this mechanism.

Given the general trend away from the mechanism and the problems seemingly inherent to it, it seems unlikely that it would be able to attract sufficient political support to be adopted anywhere within the EU.

6.1.6 Levies

Levies are effectively a form of direct tax, placed to elicit behaviour change. Applied to energy sources their application can be used to favour specific technologies by provision of an exemption from the charge, effectively providing an economic advantage to the exempted technologies. This would allow the exempted technologies (e.g. RES-H/C technologies) to become competitive to those technologies that are subject to the levy. The funds raised through levies may additionally be used to provide further support to preferred technologies, e.g. through a grant programme.

6.1.7 Tax related instruments

There are a number of tax related instruments that can be applied to provide financial support to incentivise increased deployment of renewable energy technologies e.g. in the form of a grant programme. Bürger *et al* suggest four key areas where tax based instruments might be applied with implications for positive impacts on the economics of RES-H/C deployment:

1. creation of new taxes or expansion of current taxes on fossil fuels
2. subsidisation of renewable energy from current tax revenue
3. application of new revenue raising instruments with revenue directed specifically to support of new renewable energy deployment
4. provision of tax breaks for renewable energy systems, this option might include, exemption from VAT on purchases of generating equipment or of energy sourced from renewable generators and potentially other tax exemptions particular to national or regional taxation regimes, improved opportunities for depreciation of development costs, various subsidies and the earning of tax credits.

The first three of these represent methods for creation of revenue, since this document is considering how income might be applied to support renewable energy, the fourth of these is the main concern here. The application of taxation based instruments varies strongly between nations in tax codes and their political underpinnings however, some tax instruments have provide to be influential in aiding the expansion of RES-E at both the large and small scale, and these is considerable potential for their increased use to support RES-H/C. The IEA has suggested that tax incentives in support of the adoption of solar thermal devices in Greece – essentially a deduction of energy system costs against personal income - has been one of the most effective policy devices applied to RES-H in the EU to date (Kaldellis et al 2005; IEA 2007).

Tax Credits: Tax credits were first used to support the growth in of RES-E in the US in the 1970's with the introduction of PURPA (1978). They have been applied on an on-and-off basis since and – when applied alongside state mechanisms – are frequently cited as being a key element in the expansion of RES-E (Langniss and Wiser 2003). Credits within the US federal mechanism are earned by companies investing in development of eligible renewable energy technologies; credits against this expenditure can then be used to defray those companies' tax bills in other areas of business. Effectively this form of the mechanism stimulates established industry to become involved in a new sector in order to achieve benefits to their established interests. Tax credits used in this manner have been useful in providing a stable base for investment in multiple US states, most notably when used in conjunction with state level quota mechanisms (commonly known as RPS mechanisms in the US) (Langniss and Wiser 2003). They effectively guarantee a minimum return on investment which can then be expanded through the riskier quota mechanism. Since tax credits earned in this manner need to be defrayed against investment elsewhere, this application tends to be useful only to larger companies.

VAT and other tax exemptions: Since Member States can set different levels of VAT for different products this may be used as a tool to provide economic advantages to renewable energy generation by reducing VAT below the level of competitor technologies, though this potential may be limited in regimes where tax on energy and energy related goods is already low (for example, VAT on energy is only 5% in the UK). Reduction in VAT can apply to both purchases of energy and to purchases of technology for the purposes of installation. Application of VAT reductions is straightforward, effectively manifesting as a simple price reduction from the consumer perspective and requiring little complexity of change from the technology vendor.

Accelerated or Enhanced Depreciation: Some governments allow accelerated depreciation against purchases of named renewable energy and other clean technologies than would otherwise be accepted within their tax codes. The Netherlands VAMIL programme and the UK's Enhanced Capital Allowance Scheme are two examples. Purchasers allowed accelerated rates of depreciation are effectively able to take advantage of greater tax reductions than would otherwise be the case, effectively reducing the costs of investment. Adoption is fairly straightforward, with eligible technology simply listed as attracting enhanced status. The impact is likely to be enhanced by promotion of the availability of this status. The effectiveness of this instrument may vary in its impacts on demand, perhaps most notably between commercial and domestic consumers, with the former generally having more experience and a greater degree of interactivity with the relevant local tax authority.

Tax related instruments are effectively subsidised from the public purse, the degree of acceptability of this is likely to be linked specifically to the familiarity of the territory with the use of such instruments. An argument could be made that taxation based instruments are not consistent with the polluter pays principle, with public funds effectively subsidising business in making investment profitable.

6.1.8 Soft loans

One of the main barriers to the expansion of renewable energy is the comparative economic deficiency resulting from their high capital cost and the impact this has on the unit costs of the energy they produce. Perceptions of risk inherent in investing in less familiar technologies contribute to raising these costs or to preventing access to capital for those wishing to develop new capacity.

Many of the instruments detailed here act to address these barriers by directly reducing capital costs, by providing more secure income streams and thus reducing risk for those providing access to finance and by increasing the total of income. Provision of loans below the market rate is another mechanism for addressing this problem of high capital costs. Government mandated loan mechanisms of this nature can act to achieve two goals: to provide access to cheaper borrowing for developers, thus improving the economics of all the projects qualifying for the mechanism, and effectively also expanding the range of projects rendered economically feasible (albeit with some restrictions still applying on the grounds of prudence). The government, or its mandated agency, becomes a lender of last resort to these developers.

Making loans available to specific technologies at rates below those of the market is likely to be more acceptable in some territories than in others, with acceptability perhaps dependent on the historic role of government in the development of new technologies and industry and the institutional role of financing bodies within the particular national innovation structure. The presence of a framework of financial institutions able to make the loans available, alongside the political will needed to drive forward making loans available, is likely to play some part in determining their adoption as a support instrument. There may be some potential for amending national institutional frameworks where they are currently not appropriate but this may be difficult and seems likely to require specific attention in each regulatory territory.

Soft loans have been made available to support RES-E in Germany for some time. They can be regarded as being central to the rapid expansion of wind energy in Germany from the 1990s to the present. Loans have been made available through state owned banks at the national and regional levels and reflect the close links between the government, financial bodies and industry. Member States which do not have institutional frameworks which provide this form of loan seem less likely to adopt this form of mechanism, though there is the possibility of some variation to provide an investor of last resort. The UK's Carbon Trust, a private company funded by central government to invest in environmental technologies may represent a method for trying to introduce an institution to act as a funding body of last resort in an institutional framework which has previously not lent itself to interference with the lending market by government (Foxon and Pearson 2006). While there is scope for soft loans to come from ostensibly private banks they will typically represent funds from the public purse or which could effectively be invested more profitably elsewhere, that is, there is an opportunity cost to the public purse associated with funds not being made available at normal market rates. Again, the general justification is the necessary public good associated with their subjects, in terms of their environmental advantages and other potential benefits such as enhanced industrial and employment opportunities.

6.1.8.1 Key advantages and disadvantages of soft loans

Providing loans below market rate addresses the key issue of high capital costs that is a major barrier to accelerated deployment of renewable energy. Their application in Germany can be regarded as a significant stimulus for the wind energy sector and other sectors, and the same is true in other Member States.

Where there is a cultural fit with existing banking institutions, provision of soft loans should be fairly straightforward, and as with the example of the German solar thermal loan programme, administration of the loan programme can be highly efficient. Where financial institutions are not already established or are less culturally accepted then added complexity may result.

Making soft loans available has an advantage in comparison with offering grants in that it has less impact on public budgets, spreading costs over time, and is thus potentially more politically supportable.

At the domestic level it is possible that there would be social resistance to taking out loans which might significantly retard the usefulness of this mechanism, making soft loans less appropriate in comparison with their application at the commercial level. It is possible that grants may be a more appropriate method for addressing the domestic sector, though there will be different cost implications.

There may be political issues as regards interference with capital markets in some territories.

The adoption of soft loans may require some from of contingency to deal with borrowers who do not repay the full amount of their loan during the period of the agreement. Failure to repay can carry a certain amount of risk, linked to the unknown financing conditions that may prevail at the end of the loan period.

6.1.8.2 Applying soft loans to support RES-H/C

Access to cheap capital will remain a key issue for deployment of RES-H/C until it becomes fully commercial. Offering soft loans is likely to be as useful and as viable for supporting large-scale RES-H/C developments as it was for RES-E, though may be less appropriate to smaller-scale applications.

The German experience with wide availability of soft loans has tended to focus on the use of the mechanism not as the central tool for support, but as an additional instrument working alongside a tariff mechanism to widen project viability, and, it can be argued, effectively as a tool of German industrial policy (Lewis and Wiser 2007). As with the tariff mechanism, the application of soft loans is likely to be more appropriate for use with technologies at later stages of technological maturity.

As with application to RES-E, the useful application of soft loans is likely to be more easily applicable where the framework of financial institutions already favours the use of the tool. Where such a framework already exists adoption is likely to be easier, requiring political will and the involvement of the financial institutions. Where a framework does not already exist then adoption may require changes in regulation and legislation and must thus be politically acceptable. It is possible that some Member States will be less open to measures which act to interfere with the market for capital and adoption in such Member States may thus face political barriers. Options for adoption include the application of incentives to existing financial institutions – either state or privately owned – to participate and the creation of new financial institutions supported with government funds.

6.1.9 Support for research, development and demonstration

Funding for research, development and demonstration is fundamental to innovating technologies. The IEA records that funding for renewable energy in developed countries generally peaked in the early 1980s and then fell back; this includes RES-H/C technologies (IEA 2007). The IEA has also identified a number of key areas requiring R,D&D support for different RES-H/C technologies, including different elements of systems relating to solar thermal, geothermal, biomass and also including storage.

6.2 Non-financial mechanisms with potential to support RES-H/C

6.2.1 Use obligations

Use obligation mechanisms impose an obligation on parties specified in legislation or regulation to source a minimum amount of their energy use from renewable energy sources; this is usually expressed as a percentage of the total estimated energy demand of the building. In practice the obligated parties will usually be developers of new commercial or residential buildings, or those concerned with upgrading existing energy systems in buildings. Applied to larger developments with multiple buildings the obligation may be generalised if desired such that the developer can meet the target across the whole development. Apart from the building sector also larger installations that produce and supply heat (e.g. heat only plants, CHP plants) as well as industrial process heat could be subject to the obligation to cover a minimum share of heat by renewables.

Use obligations may be technology specific or allow baskets of different technologies, and ongoing examples allow combinations of RES-E and RES-H (Bürger, Klinski *et al* 2008; Puig 2008). Making the obligation technology specific allows government to direct efforts to the creation of demand for the chosen technology, while allowing a basket of technologies permits greater flexibility in the response of the obligated party to local conditions and to the ongoing comparative economics of the technologies. The mechanism may include a hardship clause to protect developers in unusual circumstances. The hardship clause may require some alternative payment by the obligated party, for example in the form of the payment of a fine or by the purchase of surplus generation elsewhere (for example, by sourcing certificates representing renewable generation. It may also allow the party simply to be exempted without penalty. Alternatively, the obligation may allow obligated parties to option to pay a form of fine or levy to exempt themselves from their obligation, with the funds going to a general fund contributing to increased deployment of renewable energy.

The other key variants in the mechanism are the level of the obligation, the technologies included, the range of parties to which it applies, and as regards the use obligation applying to renovation of buildings, the point at which the obligation applies. The robustness or otherwise of the hardship clause will tend to have some implications for the effectiveness of the mechanism.

Spain was the first Member State to introduce a use obligation nationally with the 2006 federal requirement for all new and renovated buildings to install 30-70%. This followed the adoption of use obligations in various cities across Spain, originating with Barcelona in 2000. The use obligation mechanism is somewhat unusual in that it has the potential to be adopted at many different levels of government. It has so far been adopted independently at municipal and regional levels as well as at the national level with relative ease, though this will sometimes be dependent on how powers are devolved to the different levels of government. The Spanish example followed this pattern while a similar phenomenon has occurred in the UK, where use obligations are currently in place only at the municipal level. The scope for local adoption may be limited in some territories but this is likely to be a possibility at local and regional levels in a number of Member States.

Germany adopted a use obligation at the national level in 2008. The obligation is limited to new buildings whereas the deployment of RES-H in the building stock is addressed by a grant programme. The minimum share applied is 15% in the case of solar thermal, 30% for biogas and 50% for liquid or solid biomass as well as for geothermal appliances and heat pumps. The use of biogas is restricted to CHP appliances, the use of liquid biomass to condensing boilers. Alternatively building owners can fulfil the obligation by using a minimum share of waste heat or heat from CHP, by being connected to a DH system or by over-fulfilling the efficiency standard for the building (defined by the building code) by 15%. The German Bundesländer are authorised to expand the use obligation to the building stock. Baden-Württemberg was the first Bundesland to implement such a regulation. The owners of existing buildings in Baden-Württemberg are obliged to fulfil a 10% use obligation that becomes when the boiler is replaced.

6.2.1.1 Key advantages and disadvantages of use obligations

The use obligation offers an opportunity to create demand for multiple technologies at a fairly early stage in the move of a technology into the pre-commercial phase, essentially acting to accelerate demand beyond demonstration. It creates market demand with very stable growth features due to the link between demand and the slow turnover of housing stock. By stimulating demand across the full geographical area included in the obligation the mechanism can potentially achieve a number of important technology innovation goals: reduction in the costs of the technology, incentivisation of training of the personnel needed to install the technologies included in the obligation and a broadening in the availability of the technologies in the wider marketplace.

While useful in providing this demand, different variations in the mechanism may be limited in the scale of the market it can create. Applied only to new building construction the demand is dependent on construction rates for housing and market demand created by the mechanism may plateau. Reductions in the rate of increase may even fall if levels of construction drop. Again, where the use obligation is applied only to new buildings, wide ranging integration of renewable energy into buildings will tend to be slow since it will be dependent on the rapidity with which buildings are replaced. Since some Member States replace only 1% of their building stock annually, roll out of integrated renewable penetration could take up to a century using this method alone. Despite this, application of this instrument can significantly impact on the attitudes and experience of the building sector in employing new technologies, and thus in both driving demand and in incentivising investment in training of personnel. Since, retrofitting of the technology costs more than fitting it as part of original construction, addressing new build specifically also exploits opportunities for installing the technology at what is likely to be a lower cost. Expanding the mechanism to compel refurbishment as noted above should go some way to addressing both of these issues.

A disadvantage of the use obligation is its rather low economic efficiency due to the lack of incentives to install RES-H/C devices according to the geographical distribution of potentials. For instance as all buildings are subject to the regulation; a use obligation does not incentivise the installation of RES-H/C devices where it is deemed most profitable. Furthermore, lacking a mechanism to benefit of the production of surplus RES-H/C building owners would not profit from the installation of a RES-H/C application (e.g. a solar collector) that is exceeding the minimum share which is set by the obligation.

In addition the instrument is setting a focus on individual house systems lacking a real incentive to e.g. set up DH-systems. For countries in which a larger market penetration of DH systems is deemed necessary to meet mid to long term RES-H/C targets accompanying measures would be necessary to stimulate the respective structural change in the heating and cooling sector.

Finally the effectiveness of a use obligation strongly depends on the way compliance is verified. In several countries the experience with building codes is that compliance is rather low due to a lack of effective routines to verify whether obliged parties do what they are expected to do. Non compliance is due to information deficits meaning that building owners simply do not know the obligation or by purpose to save money.

Where the use obligation requires adoption of renewable energy sources to apply to refurbishment of properties there is the danger that the mechanism will discourage replacement of older equipment. This can be addressed by the setting of a final date by which all affected buildings must be modernised, though this can be regarded as only a partial solution.

Politically, the mechanism can be attractive in that it can easily be constructed such that it doesn’t require any obvious increase in energy prices or taxes associated with energy for the ordinary consumer. Moreover the type of regulation is easy to understand and obliged building owners know comparable regulations/obligations from the building sector (e.g. building standards). However, such a regulation can be subject to protests from companies and industry associations linked to the housing sector.

6.2.1.2 Applying use obligations to support RES-H/C

Use obligations offer considerable potential for stimulating deployment of RES-H, and could usefully stimulate even small-scale technologies which might offer problems in regard of some other options. The mechanisms provide a useful way to create an initial demand for RES-H technologies, though there may be some limitations on the ability of the mechanism to expand demand in the long term application of some variants. The mechanism is perhaps most appropriate for application to technologies which are through the R,D&D phases but which require the growth of niche markets for their application.

Specific to support of RES-H, the application of any use obligation should consider the likely demand for both space and water heating in any buildings to which it applies. A sensible approach to the application of a use obligation would see it paired with an obligation to build to minimum thermal standards in the case of new build. Care must be taken to take into account less stringent standards when applying the mechanism for refurbishment of older buildings to which it is applied.

Care must also be taken to ensure that a use obligation applies to create a level of demand that is capable of being serviced by the existing infrastructure and which acts to create a stable demand over time such that it does not restrain development, does not unduly punish willing parties who are unable to source technology, allows time for the training of staff to meet demand and which does not create a boom and bust type stimulus of technology.

Use obligations have yet to be applied to the support of RES-C, though there is potential to do so. As with RES-H, there is a need for RES-C technologies to be sufficiently advanced that technology would be available in the market place to allow obligated parties to access and install the technology without overly onerous additional costs and which is of sufficient quality to meet consumer needs. Since the use obligation is dependent on replacing a fraction of cooling capacity normally powered by fossil fuels with renewable energy, there needs to first be a demand for cooling. This demand is currently largely centred on southern Europe which is likely to make that the focus for the useful application of this mechanism. Adoption of RES-C use obligations in northern Europe may prove less significant in driving additional capacity.

6.2.2 Skills, education and training

A clear lesson of the experience gained in regard of both RES-E and RES-H has been the need for industry to have ready access to a workforce with the requisite skills to support their growth. The absence of skilled personnel represents a significant barrier to both deployment and to industrial development. Government can contribute to overcoming this barrier by working with industry to identify areas where there is a need for increased educational provision and taking action with educators and other stakeholders to provide this. This will tend to vary based on the educational structure of the states concerned.

Appropriately educated and trained personnel will be necessary to meet a requirement across a full range of skills. Occupations necessary for the efficient expansion of the sector include managers and other professionals, technicians, crafts-people, semi-skilled crafts-people, commercial and administrative personnel and trainees including graduates and apprentices. Requirements for individual examples of these occupations will tend to vary by technology and with the level of maturity of the industry relevant to each technology. The educational needs appropriate to each of these occupations and to different stakeholders within those occupational groups will vary considerably, ranging from short courses for semi-skilled crafts-people through to university based graduate or postgraduate programmes running over a number of years and which may need to be integrated into wider structures for professional accreditation. As an example, in the case of Upper Austria, there have been two major skills gaps. Firstly, a shortage of plumbers and other installers with the requisite skills to install RES-H systems and secondly trained personnel able to effectively manage energy needs in public and other buildings.

The need for occupational skills will change over time and oversight of educational needs combined with responsiveness in provision of training opportunities will be required to service both the RES-H and RES-C sectors. Educational structures vary between Member States, requiring national, and perhaps regional, strategies to respond within the context of local educational structures.

Having said that, this does not mean that co-ordinated action at EU level to improve national skills, education and training is not needed. As indicated above, setting up regional education centres lies at the local, regional and national level. However, significant added value could be achieved if an EU body could make sure that lessons learnt in front-running Member States are effectively transferred to the other countries. Another aspect is making sure that EU-wide standards apply for RES-H/C technologies. More info on this can be found in section 6.2.4.

The absence of programmes to provide skills and education may act to slow the process of expansion of RES-H/C, slowing deployment and retarding competitive advantage of nascent industry.

6.2.3 Information, awareness and promotion strategies

Regardless of the economics, deployment of RES-H and RES-C technologies is dependent on awareness of the technology amongst consumers, developers and installers concerning its potential and appropriate application, and of the various subsidy and other support instruments available to support it.

Installers have to be both aware of the technology and to be able to respond to demand with trained sales and installation personnel able to respond to that demand, thus targeting promotion of the technology to that sector tied to support for increased availability of training opportunities can yield positive results.

6.2.4 Standardisation

Experience with both RES-E and RES-H has demonstrated that availability of financial incentives, combined with a public willingness to engage with technologies perceived to be better for the environment despite being less familiar have tended to attract to the market products which do not perform adequately. This can undermine public confidence in the new technology and also essentially means that public funds are not achieving goals in terms of deployment, in terms of pushing innovation of the technology to improved performance or in driving manufacturing capacity of newer and more efficient examples of the technology.

Setting minimum performance standards for new RES-H technologies can address each of these problems. The introduction of standards for RES-H and RES-C microgeneration allows consumers increased confidence that products will meet their requirements. Governments, by limiting subsidising funds to only those technologies which meet their standards can act to ensure that the public purse is more wisely spent. Standards are thus a useful tool to partner many of the policy instruments detailed above. The current draft of the new Renewables Directive, if passed into law, will compel all Member State governments to establish harmonised microgeneration certification schemes as part of efforts to ensure free trade in the technologies.

The Solar Keymark is an example of a voluntary standardisation scheme put in place by the solar thermal energy industry. The standard claims several advantages for industry, amongst which are reduced testing and administration costs, enhanced customer confidence and helping to access the European solar thermal market (ESTIF 2009). The Solar Keymark is mentioned explicitly is some incentive schemes. For example, in the case of Upper Austria funding for solar thermal appliances is dependent on the certification status: a Keymarked installation can claim higher funding[6].

New products entering the market can expect easier uptake once they are recognised through standards. Examples of such new products may be solar combi systems and other integrated systems, for example based on heat pumps.

The wood pellet market is also an example where standardisation has its benefits. It can be observed that rigorously applied wood pellet standards are a provision for developing a significant wood pellet market.

Finally, standardisation is also important when retrofitting or replacing renewable heating and cooling installations.

6.3 The application of multiple policy instruments to more effectively drive RES-H/C deployment and development

As has been noted, there is considerable evidence that a single instrument may not be sufficient to provide the different kinds of support that technologies at different stages of technological maturity require. Further, experience with RES-E suggests that more effective renewable energy policy outcomes can be gained from combining different

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[6] In Upper Austria, base funding for solar thermal installations is EUR 1100, with an additional 100 EUR/m^2 (for a flat plate collector) or 140 EUR/m^2 (for a vacuum collector). Systems without the Solar Keymark certificate receive reduced funding of 75 EUR/m^2 (flat plate collector) or 110 EUR/m^2 (vacuum collector) for each additional square meter. Other limitations and requirements also apply (EurObserv'ER 2008).

instruments, that is, that individual or groups of technologies can benefit from the application of multiple policy instruments deployed simultaneously. Policy makers need to consider both of these points when creating policy.

6.3.1 Applying policy to support technology at different stages of maturity

Foxon *et al* (2005) and others (e.g. Seyboth *et al* 2008) note that technologies at different stages of maturity require different forms of policy instrument to support their maturation more effectively. They provide some classification of some RES-H technologies specific to the UK instance and also some comment as to the stage of maturity at which certain instruments may be most appropriate. It is worth noting that it can not be assumed that technologies will be at the same stage of maturity in all nations simultaneously, especially since installers and their skills are always country-specific. It is necessary for countries and regions considering adoption of policy relating to RES-H/C to consider the stage of maturity of any technology they wish to support and to design accordingly. This does have the potential to throw up some political difficulty. Some policy makers shy away from creating policy which requires that they 'pick winners', preferring instead to adopt policies which allow the market the greatest possible leeway to decide which option is best suited to meeting customer needs. Adopting a 'one size fits all' policy in this manner is likely to lead to some renewable energy technologies being disadvantaged compared to others, and potentially to their being excluded from commercialisation. The typical example is of quota mechanisms such as the UK's Renewable Obligation only providing support to those technologies closest to market. Applied alone they risk the foregoing of technologies with long term potential for cost reduction and potential industrial opportunities.

6.3.2 Combining policy instruments

Renewable energy technologies face multiple barriers to becoming commercial. The instruments detailed in this document apply different methods to assist in overcoming these barriers and in providing stimuli to drive innovation of renewable energy technologies. Even where applying to single technologies, or to technologies which are at the same level of technological maturity, these instruments do not have to be applied in isolation, but can be combined to provide more effective policy solutions. It is a fundamental lesson of the RES-E policy experience that multiple policy instruments are necessary for addressing the full range of barriers preventing uptake of renewable energy technology. It is obvious that this will hold true for RES-H/C. There are numerous examples of nations combining instruments to this end, indeed most European nations which have adopted policies to support renewable energy will have chosen different instruments for different technologies or to support a single technology.

- Germany has provided a tariff mechanism to support RES-E since 1990, German banks, directed by the state have provided soft loans for much of this period. This has acted to drive down the high capital costs associated with many renewable energy technologies – and which can be a central barrier to deployment – from two directions. The tariff allows greater predictability of income reducing the risk and thus the cost of investment; the loans reduce the cost of borrowing further. Efforts have been additionally supported with promotional activities to increase awareness, with educational activity to ensure a skill base for workers appropriate to the sector, with planning reform and more.

- The US has a federally mandated tax credit available for companies investing in eligible renewable energy technologies. When combined with quota mechanisms adopted at the state level the credits have proven to be useful in providing a guaranteed and predictable base income, while the additional funding deriving from the quota mechanism can provide sufficient extra stimulus to drive significant levels of deployment.

Since many of the barriers to accelerated deployment – or any deployment at all – are not financial in nature, or may not be most efficiently addressed by financial instruments then there is often a clear need to combine financial instruments with non-financial instruments with the goal of simultaneously overcoming multiple barriers. Support instruments can take both a stick and carrot approach, and these can be combined to create effective incentives as appropriate. Efforts can be further bolstered by promotional activities designed to increase awareness of the technology and its benefits, of support available to potential purchasers and installers of technology and of commercial opportunities. Again there are numerous examples of multiple instruments being successfully addressed in both EU Member States and beyond, for example, with reforms of electrical regulation, with government supported education, training and information schemes all being applied concurrently with financial mechanisms in a mutually supportive manner.

Ideally, instruments should be mutually supportive, should create a continuum of effect such that there are no gaps in providing support to technologies, thus allowing technologies to be left behind. Support should however also have a cut off point, to avoid open-ended support becoming too great a burden on consumers or taxpayers. The need for a holistic approach, while important with regard to efficient support of all renewable energy technologies, is likely to have particular significance for biomass use. The more extended supply chain linked to biomass adds complications which require support not just for the technology but for ensuring there is sufficient fuel to supply it. A holistic approach to RES policy on bioenergy looks increasingly like it will need to consider both RES-E and biofuel use and the potential for conflict with biomass use for RES-H/C.

7 Regulatory and Other Issues

Policy mechanisms have been applied to provide the financial support essential to driving the deployment and thus the technical innovation of renewable energy sources of electricity for over two decades. However, some barriers to the growth of renewable energy can not be addressed simply by application of financial stimuli, or where financial solutions may be valid, other solutions may be more effective and more economically efficient.

It has become apparent that greater consideration of the wider regulatory and societal context in which RES-E is developed is needed in addressing the full range of barriers to increased deployment. It is possible that similar barriers may exist to block or retard the greater penetration of RES-H/C. Areas of concern which have impacted on the development of RES-E and which may also impact on RES-H/C include:

- National and regional planning processes
- Building regulations
- Regulation of the wider market

7.1 National and regional planning processes

Planning processes vary considerably at the national level, with regional variations in some Member States. The extent to which planning processes can act to assist or inhibit the development of renewables will depend on the overarching regime, how easy it is to amend to facilitate specifically desired outcomes and the willingness of political entities to make changes. It is apparent from current experience that some planning regimes can place significant barriers to growth. Research connected to RES-E suggests planning is seen as risky across Europe, and that perception of risk does not necessarily correlate with rates of deployment (Butler and Neuhoff 2005). Some Member States' planning processes have been amended considerably to remove barriers to deployment, for example, by switching to a system where approval is automatic unless stakeholders with a demonstrable interest can show a reason why development should not go ahead. Planning processes in other Member States continue to retard growth across the range of renewable energy technologies. Wind generation has for example, faced opposition in a number of countries including the UK, Denmark, Sweden and elsewhere, and planning processes have led to deployment being slowed. Proposals for biomass combustion plants have faced similar opposition in the UK, Ireland and elsewhere. The range of scales of application for RES-H and RES-C, along with the variance in prominence of different technologies, means there is potential for different technologies to be impacted to different extents by planning regimes. Smaller technologies which integrate on to buildings easily are likely to encounter less problems that large-scale technologies such as commercial biomass exploitation, for example. Nevertheless, there is a need for national – and where applicable, regional – planning regimes to respond to planning barriers as they become apparent with the aim of minimising their impacts on deployment.

7.2 Building regulations

Building regulations can offer barriers to growth of renewables, for example, by making it difficult to match renewable systems to other systems but with proper application can also facilitate growth, for example, by insisting on the installation of technology which would make later installation of renewables easier and cheaper, as with district heating or solar thermal water heating. Since barriers linked to building regulations will be territory specific the first step to addressing them must be their identification in the extent regulatory regime. This must be followed by stakeholder consultation to ascertain what changes can be made to overcome them without entailing excessive costs. The national workshops planned in the RES-H Policy project will deliver specific information for the countries considered (see Introduction of this report for a listing of countries considered).

The implementation of the European Directive 2002/91/EC on the energy performance of buildings (EPBD) is an important step forward in institutionalising the attention paid to renewable energy systems in new constructions and renovation processes. Minimum requirements on the energy performance of new buildings and of large existing buildings being subject to major renovation have to be in place in all Member States on short notice. Mid 2011 Member States are obliged to report to the Commission on the measures put in place for complying with the EPBD. More information in the EPBD is provided in section 3.2.

In general, tightening energy performance requirements is expected to have a positive influence on the penetration of renewable heating and cooling options. It can be observed however, for example in the Netherlands, that this effect does not immediately apply: often the less costly options, i.e. the *low hanging fruit* like increased thermal insulation are measures that benefit first.

7.3 Regulation of the wider market

The heat supply market of any Member State is complex, reflecting the different consumer needs, different economic advantages and disadvantages of a diverse mix of technologies and the regulatory history of the market in which heat is provided.

Enhanced provision of heat energy from renewable sources can not be accomplished without reference to the wider regulatory context in which overall heat energy supply exists.

The RES-E policy experience has made it apparent that existing regulatory regimes have developed to cope with extant energy delivery systems and that they can drive the creation of operating conditions that can favour some technologies over others or which can act to raise barriers to new entrants to the system, even where this is not the intention. It is essential to the long term exploitation of renewable heating and cooling technologies that their respective markets offer a position of neutral regulation.

One possible example of this kind of regulatory barrier is accessibility for biogas and biogas producers to gas supply grids. There may be numerous others which may become apparent as consideration of the system increases.

It is possible that the characteristics in which heat delivery varies from electricity delivery will also impact in this area, reducing the potential for regulation impacting unevenly on renewable and other actors., nevertheless, this is an area which warrants further investigation at the level at which the regulatory framework exists in the heat supply market of each of the Member States. The relatively less advanced position of renewable heat policy means this is an area which has as yet received little attention.

The nature of the demand for cooling, and the much less diverse technological response to delivering renewable cooling may mean less problems and that these are easier to address, nevertheless there is still potential for problems, for example, issues relating to connection to district cooling systems and regulatory measures to prevent stranded costs following large scale investment.

7.4 Interaction with other policies

In addition to the regulatory framework directly relating to heat energy, the development of renewables has to co-exist in the wider world with policies aiming to achieve other goals, including, but not limited to social, environmental, economic and cultural objectives.

Some of these are likely to have greater potential for conflict with RES-H/C policy than others. An obvious example is the potential for interaction between the biomass sector and the various support mechanisms offered to the agricultural sector. At the European level the Common Agricultural Policy (CAP) strongly influences the economics of crop and meat production and this would seem to have the potential to conflict with land use for fuel production. It is possible however that some way might be found to allow the CAP to assist in the development of bioenergy, given the potentially overlapping goals of EU and Member State security of supply, though this is not currently planned. Agricultural policy at the Member State level, with strong variations at the national level, also has some potential for conflict, depending on the goals and the extent to land use is impacted.

It is possible that some of these areas of conflict (or potentially even areas of mutual support) will only become apparent once efforts are made to adopt wider policies and the problems are assessed in greater depth, or even after policies have been adopted and the conflict becomes apparent as a result of policy failure or the development of unexpected barriers.

8 Conclusion

Addressing the need for more sustainable sources of heat, and increasingly of cooling, will have to become a major component of renewable energy policy in Member States if the EU is to achieve its targets for 2020 and if innovation and deployment are to continue beyond that date. Perhaps the overarching lesson of the RES-E policy experience is the need to develop a holistic policy environment, addressing all elements of policy in order to be effective. The different levels of technological maturity represented by the RES-H/C technologies will mean they require different policy instruments if they are to progress through from the demonstration phases to commerciality. These policies will need to provide both appropriately targeted financial support to create opportunity for demonstration and increasing demand for technologies, whilst applying other instruments to assist in overcoming barriers to penetration of technologies. Action to expand stakeholder awareness and engagement must be leavened with practical assistance to expand the base of trained personnel capable and willing to deliver systems to consumers. The lesson from Austria is that making the process as easy and painless as possible will more easily attract consumers to engage with the technology.

Some policy instruments may prove to be more apposite for application in some Member States than others and it is important to emphasise that no single set of policy instruments may be able to deliver the holistic solution described above in all Member States. It is important however that all Member States have a clear view of what they are trying to achieve with their respective renewable energy policy strategies, to take into account the advantages and disadvantages of different instruments and to draw conclusions as to the most appropriate based on comparative assessment alone. Evidence from the RES-E experience, such as, the failure of quota mechanisms to deliver on their promise of the cheapest possible renewable energy as a result of the competitive process, must inform decisions concerning instruments to support RESH/C.

The RES-E policy experience represents a rich source of information regarding the practical application of policy instruments to support renewable energy and one which must be drawn upon if Member States are not to relearn lessons already learned at considerable expense. Nevertheless, care must be taken to account for the differences between RES-E and RES-H/C when applying instruments to the latter. The different characteristics of the delivery and trading of electricity and heat will have significant implications for application of some policy instruments, their relative merits and demerits and potentially for the costs of their application. The heterogeneous nature of the RES-H technologies may well compound some of these issues, requiring technology specific combinations of policy instruments and other solutions.

Policy for the increase of renewable cooling can also draw on the experience with RES-E, again while needing to derive from the needs of the technology and in the context of the Member State. There is also a clear need to ensure that policy to support renewable heating and cooling coheres with policies to support increased energy efficiency, reductions in fuel poverty, increased use of waste energy and that RES-H/C policy complements policy for the support of RES-E and biofuels, particularly in areas where there is potential competition for resource, as with biomass.

Annex 1 précis's some of the key points arising from this document, including summaries of the key advantages and disadvantages of the policy instruments discussed in the text.

9 References

Berry, T. and M. Jaccard (2001). "The Renewable Portfolio Standard: Design Considerations and an Implementation Survey." Energy Policy **29**(4): 263-277.

Bürger, V. (2007). "A Bonus Model as a new concept to support market penetration of Solar Thermal Appliances". Estec Proceedings 2007.

Bürger, V., S. Klinski, *et al*. (2008). "Policies to Support Renewable Energies in the Heat Market." Energy Policy **36**: 3150-3159.

Butler, L. and K. Neuhoff (2005). "Comparison of Feed in Tariff, Quota and Auction Mechanisms to Support Wind Power Development." Cambridge Working Papers in Economics **CWPE 0503**.

DEFRA/BERR (2007a). Renewable Heat Initial Business Case. London.

DEFRA/BERR (2007b). Renewable Heat Support Mechanisms. London

EREC. (2006). "European Renewable Energy Council." from www.erec-renewables.org.

ESTIF (2009). CEN Keymark Scheme for Solar Thermal Products Retrieved 13/05/2009, from http://www.estif.org/solarkeymark/

EurObserv'ER (2008). "EurObserv'ER interactive Database." Retrieved 2009, from www.eurobserv-er.org.

European Commission (2005). The Support of Renewable Energy Sources. Brussels. COM (2005) 627.

European Commission (2006). The Support of Electricity from Renewable Energy Sources. Brussels.

European Commission (2007). Renewable Energy Road Map. Brussels

Foxon, T. J. and P. J. Pearson (2006). Policy Processes for Low Carbon Innovation in the UK: Successes, failures and lessons. Environmental Economy and Policy Research: Discussion Paper Series. Cambridge.

Haas, R., W. Eichhammer, et al. (2004). "How to Promote Renewable Energy Systems Successfully and Effectively." Energy Policy **32**(6): 833-839.

IEA (2007). Renewables for Heating and Cooling: Untapped Potential. Paris, International Energy Agency.

IEA (2008). Deploying Renewables: Principles for Effective Policies. Paris

Jacobsson, S. and A. Bergek (2002). Transforming the Energy Sector: The Evolution of Technological Systems in Renewable Energy Technology. Conference on the Human Dimensions of Global Environmental Change, Berlin.

Kaldellis, J. K., K. A. Kavadias, et al. (2005). "Investigating the Real Situation of Greek Solar Water Heating Market." Renewable & Sustainable Energy Reviews **9**: 499-520.

Langniss, O. and R. Wiser (2003). "The Renewables Portfolio Standard in Texas: an Early Assessment." Energy Policy **31**(6): 527-535.

Lewis, J. I. and R. H. Wiser (2007). "Fostering a Renewable Energy Industry: An International Comparison of Wind Industry Policy Support Mechanisms." Energy Policy **35**(3): 1844-1857.

Lipp, J. (2007). "Lessons for Effective Renewable Electricity Policy from Denmark, Germany and the United Kingdom." Energy Policy **35**(11): 5481-5495.

Menanteau, P., D. Finon, *et al*. (2003). "Price versus Quantities: Choosing Policies for Promoting the Development of Renewable Energy." Energy Policy **31**(8): 799-812.

Meyer, N. I. and A. L. Koefoed (2003). "Danish Energy Reform: Policy Implications for Renewables." Energy Policy **31**: 597-607.

Mitchell, C. (1995). "The Renewables NFFO: A Review." Energy Policy **23**(12): 1077-1091.

Mitchell, C. (2000). Renewables in the UK - How are we doing? The International Energy Experience. G. MacKerron and P. Pearson. London, Imperial College Press**:** 205-218.

Mitchell, C., D. Bauknecht, *et al*. (2006). "Effectiveness through Risk Reduction: A Comparison of the Renewable Obligation in England and Wales and the feed-in system in Germany." Energy Policy **34**(3): 297-305.

Mitchell, C. and P. Connor (2004). "Renewable Energy Policy in the UK 1990-2003." Energy Policy **32**(17): 1935-1947.

Ofgem (2009). Renewables Obligation Annual Report 2007-2008. London, Ofgem.

Owen, A. D. (2006). "Renewable Energy: Externality Costs as Market Barriers." Energy Policy **34**: 632-642.

Puig, J. (2008). Barcelona and the Power of Solar Ordinances: Political Will, Capacity Building and People's Participation. Urban Energy Transition: From Fossil Fuels to Renewable Power. P. Droege. London, Elsevier**:** 433-450.

PURPA (1978). Public Utility Regulatory Policies Act. 16 USC 2601-2645.

Rader, N. A. and R. B. Norgaard (1996). "Efficiency and Sustainability in Restructured Electricity Markets: The Renewables Portfolio Standard." The Electricity Journal **9**(6): 37-49.

Ragwitz, M., A. Held, et al. (2006). OPTRES: Assessment and Optimisation of Renewable Energy Support Schemes in the European Electricity Market. Karlsruhe

Ragwitz, M., C. Huber, et al. (2005). FORRES 2020: Analysis of the renewable energy sources' evolution up to 2020. Karlsruhe.

Sawin, J. L. (2006). Chapter 2: Policies. Renewable Energy - A Global Review of Technologies, Policies and Markets. London, Earthscan**:** 71-168.

Seyboth, K., L. Beurskens, *et al*. (2008). "Recognising the Potential for Renewable Energy Heating and Cooling." Energy Policy **38**: 2460-2463.

SOLEM Consulting (2008). Understanding Solar Cooling Technologies.

Wachsmann, U. and M. T. Tolmasquim (2003). "Wind Power in Brazil - Transition using German Experience." Renewable Energy **28**(7): 1029-1038

Wiser, R. and G. Barbose (2008). Renewable Portfolio Standards in the United States: A Status Report with Data through 2007, Lawrence Berkeley National Laboratory.

Woodman, B. and P. Baker (2008). "Regulatory Frameworks for Decentralised Energy." Energy Policy **36**: 4527-4531.

10 Annex 1: Characteristics of existing or potential RES-H/C support mechanisms

RES-H/C support mechanisms		Previous experience in Europe		Capability to differentiate		Cost efficiency[1]		Political feasibility[2]	Predictable effectiveness[3]	Certainty for RES industry	Main advantages/disadvantages
		RES-H/C	RES-E	RES technologies	Small/large scale	Government	End user				
Financial mechanism	Investment subsidy	✓	✓	✓	✓	☹	☺	☺	😐	😐	+High stakeholder acceptance -Budget dependency=> future uncertainty
Financial mechanism	Public procurement	✓		✓	✓	☹	☺	☺	☺	😐	+Ability to create initial market for nascent RES technology -Limited applicability
Financial mechanism	Quota mechanism*		✓			☺	☹	☹	☺	😐	+Effective; little political involvement -Supports only the currently most competitive RES technology; the certificate price mechanism may lead to overcompensation and high end-user costs; high administrative and transaction costs for small scale application
Financial mechanism	Tariff mechanism*		✓	✓	✓	☺	😐	😐	😐	☺	+Capability to support not yet commercial RES technologies and nurture initial market; provide certainty for RES industry -High administrative and transaction costs for small scale application
Financial mechanism	Tendering*		✓			☺	☺	😐	☺	☹	-Tranche-based nature fails to create stable demand conditions; associated with previous failure; not suitable for small scale
Financial mechanism	Levies (eg. CO_2 tax)	✓			✓	☺	☹	☹	☹	☹	+Target the externalities (e.g. emissions)=> promotes both RES and efficient use of fossil fuels -Low predictable effectiveness; unpopular with end users
Financial mechanism	Tax incentives (e.g. no VAT)	✓		✓	✓	😐	☺	☺	😐	😐	+Cost efficient; uncomplicated -Low predictable effectiveness; reduce government incomes
Financial mechanism	Soft loans	✓	✓	✓	✓	☹	☺	☺	😐	😐	Similar characteristics as investment subsidies but less attractive for end-users in the residential sector. -May be difficult to support in some financial/institutional frameworks
Non-financial mechanisms	Use obligation (buildings)	✓		✓	✓	☺	☹	😐	☺	☺	+Promotes stable growth; stimulates learning in the building sector on the integration of RES-H/C technologies in buildings. -Limited market; promotes individual systems over district heating (unless DH is also eligible)
Non-financial mechanisms	Skills, education & training	✓	✓	✓	✓	😐	☺	☺	☹	😐	+Promotes (correct) deployment assuming there is a demand for RES-H/C; necessary for industrial growth and may assist in contributing to competitive advantage
Non-financial mechanisms	Information & awareness	✓		✓		😐	☺	☺	☹	☹	+Potentially cheap; improve the functioning of other support mechanisms -Low predictable effectiveness
Non-financial mechanisms	Standardisation	✓	✓	✓	✓	😐	☺	☺	☹	☺	+Displaces less efficient equipment=>public confidence -Potentially costly for small manufacturers

*evaluated based on performance as RES-E support mechanisms.

[1]Cost efficiency of the policy instrument refers to the ratio between the *additional costs* of instruments and the increased use of RES-H/C achieved through the implementation of the policy instruments. Long-term effects are not taken into account.

The *government perspective* focuses on government budget costs including administrative and monitoring cost and transfers (e.g. subsidies).

The *end user perspective* focuses on the additional costs experienced by the end user, including additional investments, increased operational costs, as well as transfers (received subsidy, paid tax etc).

[2]The political feasibility may vary greatly between countries depending on the institutional setting and policy tradition.

[3]Predictable effectiveness refers to the ability of the policy instruments to in a predictable way achieve RES-H/C targets.