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Devising renewable heat policy: Overview of support options

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HIGHLIGHTS

- ▸ A range of policy options can support deployment of renewable heat technologies.
- ▸ Effective RES-H policy must consider wider regulation and planning issues.
- ▸ Effective RES-H policy must consider the relative maturity of technologies.

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ABSTRACT

Renewable energy sources of heat offer the substantial economic, environmental and social benefits associated with renewable electricity but policy to support their expansion is considerably less advanced. The potential for applying various support instruments to renewable heat is considered with advantages and disadvantages discussed.

1. Introduction

The increased use of renewable energy has been a key element of energy policy in many countries for at least two decades. Despite the benefits available in regard of all renewable energy sources the focus of much of renewable energy policy has been on renewable energy sources of electricity (RES-E), with some more recent efforts to support increased use of renewable transport fuels. The development and application of policy instruments to support renewable energy sources of heating (RES-H) is considerably less advanced despite the large portion of energy that is expended in meeting heating requirements and the considerable potential of RES-H (IPCC, 2011). Where long-term RES-H policy does apply, as for example in Sweden, Austria, Germany and Denmark, the sophistication of instruments trails RES-E significantly.

It has been suggested that heating accounts for as much as 48% of final energy consumption in Europe (RHC, 2011), significantly in excess of either electricity or transport demand, and it accounts for a substantial fraction of carbon emissions. Despite this, there is considerably less experience in applying support mechanisms and public debate over support is much less advanced. Data from the UK suggests that heating accounted for 46% of total final energy consumption in 2009 (76% of all energy in non-transport sectors), against 41% for transport and 8% for lighting and appliances (DECC, 2012). The UK Government suggests that around one third of national greenhouse gas emissions result from the use of energy for heating purposes (DECC, 2012).

Some of the potential policy instrument options available to support increased deployment of RES-H technologies are set out here. Each policy option and its essential components is described along with how they have been or might be applied to RES-H in practice, including any significant variations on the central mechanism that might be adopted and the implications of these variations. The constraints and characteristics inherent to the RES-H technologies and experience with application to renewable energy sources are discussed, most notably as regards RES-E, but regarding RES-H where applicable.

2. Goals of policy for renewable heating

The general aims of renewable energy policy are straightforward; to assist in reducing emissions damaging to the natural environment;

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to enhance energy security; to stimulate innovation and technological development and to stimulate new employment opportunities. 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 up to the highest level, 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.

3. RES-H technologies and characteristics

There are a diverse range of RES-H technologies, and these are heterogeneous in terms of their economics, usage and production of energy. Policies aiming to stimulate the full breadth of renewable heat applications will need to take this into account.

The technologies cover a range of scales and levels of technological maturity, and the technology characteristics are often quite different. Some technologies will require stimulation of more complex supply chains. Some technologies are small-scale applications only, while others vary from domestic through to industrial-scale application.

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 but is likely to be so for RES-H; heat's on-site generation and related metering issues. On site use will tend to mean more systems, and of smaller size. Subsidisation of small-scale sources of renewables may 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} annually) transactional and administrative cost must be taken into account in implementing policy to ensure these do not render the subsidy economically inefficient.

A key lesson arising from the RES-E policy experience is that the level of technological maturity of a technology will play an important part in determining whether a policy instrument is appropriate for effective stimulation of the technology (Foxon et al., 2005). The IEA (2007) and Seyboth et al. (2008) typologically assess RES-H 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) to a stage where no (important) technical improvements are to be expected (technologically mature technology). Commercial maturity relates to the difference in the technology production costs compared to conventional technology. The resulting 'cost gap' may be high (for uncompetitive options), low, nil or negative (renewables cheaper than the conventional option). As reference prices may vary over time, commercial maturity is not only dependent on development of the technology, but also on conventional fuel price development exogenously influencing its level. A technology may have different stages of maturity for the technological or commercial dimension. Most technologies are characterised by a range, as different types exist, but also because the reference technology varies in its energy cost.

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 are a better fit depending on technological and commercial maturity of the particular technology.

4. RES-H support mechanisms

A wide variety of different types of mechanisms have the potential to support the expansion of RES-H. Here a straightforward typology is applied: financial or fiscal mechanisms and non-financial mechanisms; the latter a wide-ranging grouping of instruments, including obligations on particular stakeholders to purchase or sell technology, promotional measures to support awareness and to assist with infrastructure and mechanisms which exist to address specific barriers to renewable energy deployment.

The basic form of each mechanism is described, with general aims and objectives; consideration is given to the stage of technological development when the particular mechanism might be applied most appropriately. Where applicable, variations in operation and application are described where these imply potential for different outcomes in stimulating RES-H. Likely advantages and disadvantages are described based on experience with RES-E or RES-H. A summary table of known advantages and disadvantages is presented in Appendix 1. Any potential for mechanisms to operate simultaneously with complementarity along with positive and negative experiences of such application is then discussed.

4.1. *Financial mechanisms with potential to support RES-H*

4.1.1. *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 et al., 2008; IEA, 2007), adopted in nations including Austria, Greece, Germany, the Netherlands, Poland, Sweden and the UK. The basic aim of grants is to defray the high capital cost of systems and make the technology more attractive to purchasers. Grants can be easy to administrate and are attractive to governments wishing to stimulate initial interest in easily targeted expansion of particular technologies. Grants are funded directly from the public purse, justified on public interest grounds. Since they are generally applied in relatively early stages of deployment the total costs can be limited, application to more commercially mature stages of the process implies higher costs 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 systems or directly to manufacturers, though the latter is less common as it can lead to competition issues and to undermining of quality. The focus here will thus be on operator facing grants.

Attaching conditions to grants such that they are only available to support approved or certified models can assist in maintaining the quality of installed technology though care should be taken to ensure the certification process is transparent and easily accessible to new entrants. Key elements and variations on the application of grants include:

1. capacity installed subsidies (e.g., €/installed MW), these might be either direct subsidies to approved companies or rebates.
2. subsidies as a fixed percentage of total costs, with the fixed percentage specific to named technologies
3. a fixed upper limit per installation

Grant schemes will typically specify the total funding pot available, with awards often on a first come, first served basis.

Availability of funds may 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.

4.1.1.1. 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 ongoing operational generation. An IEA (2007) comparison of grant subsidies for solar thermal in different EU Member States showed considerable variation in energy generated per unit of investment.

Foxon et al. (2005) suggest grants are a appropriate for stimulating 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 their use in addition to other mechanisms for less mature large-scale applications alongside other instruments.

Grant schemes typically have low transaction costs, especially where the managing public administrative body is familiar with running such schemes, as with the German Market Incentive Programme, a grant scheme providing between €200 and 400 Mio annually that mainly addresses small-scale RES-H applications. Here about 100 people process over 150,000 funding applications annually (Bürger et al., 2008). The same authors estimate that transactions costs for a large-scale RES-H grant scheme in Germany would account for around 1.9% of total costs, with around two-thirds of these costs accruing to the German Government.

Grant schemes are generally popular with the recipients, the direct transfer of money being simpler to understand than tax breaks or energy output related payments, and less prone to later amendment or withdrawal.

Finally, grant schemes can be designed to provide incentives for structural goals such as technology diversification or 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 thus dependent on political agenda. Dependency on public budgets can lead to stop-go development, due to either frequently changing support conditions or limited availability of funding. Effective foresight for efficient planning of production and investments is made very difficult by the resulting demand fluctuations. It is relatively difficult to provide subsidy conditions that are stable over a longer time when based on investment grants.

It is likely there is considerable potential for a continuing role for grants to stimulate increased market demand for RES-H technologies, most notably in regard of smaller-scale applications and of less mature technologies.

4.1.1.2. Application of grants to RES-H. Grants may be offered directly from a government department or via a separate government funded body. The key element 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 funds are directed only into technologies that are of sufficient quality to warrant support. Public value may be further ensured by checks on whether generating equipment continues to be used a certain period after installation, though this implies added cost, and responsibility may become an issue for short lived grant programmes. Also key to achieving efficiency is to set grant levels such that maximum deployment occurs per unit of funding. Setting grants too high results in overpayment and less deployment achieved per unit cost to the taxpayer. Setting grants too low results in low uptake, with attendant delays in the growth of the technology and improvements in cost reduction.

4.1.2. 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 is generally aimed at moving technologies from the demonstration phase into and through the pre-commercial phase.

There are a number of possible variations on the basic form. To be effective, at the very least, steps have to be taken to ensure the quality of any supported technology. 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 (IEA 2007).

4.1.2.1. Advantages and disadvantages of public procurement. Public procurement 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 matures and expands and the scope of the market it is able to drive becomes less significant. There is some potential for the use of the mechanism in increasing public awareness.

The instrument directs public funds to technologies while they are still relatively expensive. Public procurement is supported directly from the public purse and there may be limits on ongoing political support, though the limited number of public buildings may place a natural limit on necessary funding.

4.1.2.2. Application of public procurement to support RES-H. Public procurement mechanism could be applied more widely to support stimulation of demand for multiple RES-H technologies. The mechanism has been successfully applied to RES-H in a number of territories. Application of public procurement might require some changes in legislation, specifically where government offices are compelled to purchase the cheapest possible option but in general adoption should be straightforward. The EU provides guidance on this kind of green procurement policy and its legal implications (European Commission, 2004a, 2004b).

4.1.3. Quota mechanism

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

The basic form of the mechanism typically places a legal obligation on energy supply companies to purchase a specified amount of renewable energy. 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 fraction can be fixed or can be set to increase over time.

All registered renewable energy generators receive certificates representing a unit of generated energy. Obligated parties demonstrate compliance by submitting certificates to the appropriate oversight body. Obligated parties typically obtain certificates by (i) direct purchase from licensed renewable energy generators, either with or separate from renewable electricity production, (ii) purchase from a third party, for example a certificate consolidator or other trader.

Enforcement of the mechanism is generally with a fine, payable by the obligated party for 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 stimulating renewable generation. Setting a low obligation will naturally lead to 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 opt to pay the fine.

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.

The central justification of the mechanism is that it stimulates a market for renewable energy while applying competition to deliver increased deployment at the lowest possible cost. Obligated parties compete to source the cheapest renewable energy, and renewable energy generators compete to deliver energy.

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 defaulting companies. The length of time over which the mechanism is guaranteed and the quota level significantly contribute to the stability and predictability of support; the RES-E experience suggests this is a key element of long-term sectoral development (Haas et al., 2004; Lipp, 2007; Haas et al., 2011a,b). The destination of the fine paid for non-fulfilment of supply obligations can be significant—generally these monies accrue to government or an appointed regulatory body, where they may or may not be directed into efforts to support renewable energy. A novel option is 'recycling', as occurs in the UK's central RES-E support mechanism, the Renewables Obligation. Here the collected fines are redistributed to those meeting their obligation. This has the effect of pushing up the value of certificates, effectively increasing the incentive for new capacity (Mitchell and Connor, 2004; Woodman and Mitchell, 2011).

Some quota mechanisms allow for banking, i.e., for certificates to be held over from one compliance period to the next (Mitchell and Connor, 2004; Woodman and Mitchell, 2011).

A key potential variation for quota mechanisms is the use of banding, discussed below.

4.1.3.1. Key advantages of quota mechanisms. The key theoretical advantage of the quota mechanism is that the competition should lead to the lowest possible cost to the consumer in subsidising renewable energy. There is an increasing body of evidence that this theoretical advantage does not necessarily manifest in practice (Butler and Neuhoff, 2005; Ragwitz et al., 2005, 2006; Mitchell et al., 2006; Lipp, 2007; DEFRA/BERR, 2007a,2007b; IEA, 2008; Alagappan et al., 2011). This is obviously significant, since this is often 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 excess cost within the system.

Linked to the competitive element, the mechanism may appeal to government on the grounds that it sets the market to choose which technologies are supported within the market, effectively relieving the government of the responsibility and the attendant political risk of supporting technologies that come to nothing. That is, it absolves a government from having to attempt to pick winners.

A significant political 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 energy. By doing so, the mechanism minimises interference with the wider electricity market. While the subsidy clearly makes the renewable energy sources more competitive and thus more likely to be purchased, the use of renewable electricity is not prioritised above other electricity on the market. This can be significant for territories with a political commitment to free markets.

A further political advantage is that the cost attached to quotas is predictable. Costs are effectively limited by the level of the quota and associated fine for parties not meeting their obligations. This potential for financial planning can be politically attractive to governments.

4.1.3.2. 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 technologies are at different stages of technological and commercial maturity this effectively means that the simple mechanism tends to support only the technologies which can deliver energy most cheaply when the mechanism is introduced. Less competitive technologies at this point are unlikely to attract investment as investors favour the cheaper technology. Unless further support is provided these technologies may be left stranded and fail to develop further.

There are a number of possible responses to the issue of stranding less mature technologies. The most obvious 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 implied additional costs is at odds with the underlying goal of the quota mechanism; minimisation of costs. Considering this point with the evidence that the quota mechanism does not seem to deliver renewable energy more cheaply appears to undermine the key reasons for its adoption.

More complex variations allow 'banding', this can operate in a number of ways. Banding the quota mechanism aims to support technologies across the range of maturity. One form of banding specifies different quotas for different technologies, for example, breaking down an overall technology blind RES target into smaller technology specific obligations This alternative is used in a number of US states, where it is known as a carve out. Another form of banding might see less mature technologies rewarded with different numbers of certificates. The introduction of either option acts to increase costs as it effectively introduces restrictions on utility choice of renewables, thus pushing up overall costs of meeting obligations. The two key forms of banding have different implications for the operational outputs of the mechanism. The first sees a government sets different targets for different technologies, this effectively means government is choosing a technology to support, removing the political advantage of allowing the market to decide and opens government up to potential failures in selecting technology for public funding. The second banding variant, awarding different numbers of certificates to units of energy from different renewable energy technologies avoids this problem to some extent but also decouples the availability of certificates from actual production, potentially resulting in either large numbers of certificates being awarded without corresponding generation or the converse. While a 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 (DTI, 2007).

A highly desirable quality of renewable energy policy mechanisms is to support a stable environment for investment by both developers and manufacturers. To facilitate this, mechanisms need to be transparently long-term, as well as being a substantial enough to allow economic viability (Jacobsson and Bergek, 2002). Quota mechanisms can provide some stability through political commitment to their long-term application; however, they can demonstrate some vulnerability to destabilising effects if their operational qualities require any amendment to address changing circumstances.

The use of the quota mechanism to support RES-E has been associated with increased investor risk in three, and possibly four, key areas which may not apply in alternative support instruments (Mitchell et al., 2006; Wood and Dow, 2011). 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 selling their electricity (and their certificates), volume risk as regards selling all of their output, and risk in the balancing market, which can be significant for intermittent generators. 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 account for these factors, and their impact on renewable energy costs. 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.

It must also be borne in mind that the mechanism does not necessarily lead to targets being met however, though the consumer may still bear substantial costs. To some degree the competitive element for supply companies should incentivise supplier behaviour for gaining competitive advantage through application of superior management, allowing consumers to switch suppliers away from companies which raise prices noncompetitively; however, the effect of this may not be that significant in terms of overall energy prices.

4.1.3.3. Applying a quota mechanism to support RES-H. 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 heating fuels will have implications for its application 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 oblige all suppliers of heating fuel to submit certificates representing the production or supply of a specified amount of heat energy, e.g., relative to the heat content of fuel supplied 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. There are a number of complicating factors to this scenario, and other scenarios are possible. Complicating factors include:

- Oversight and licensing of RES-H providers as regards certificates. While electricity metering is standard allowing easy oversight of production, heat production is not metered as standard, and meters can be expensive at the small scale. An alternative for small-scale installations (e.g., small domestic installations) would be to award certificates based on an assumed output (e.g., based on the installed capacity and an anticipated number of full load hours). Award of certificates could be aggregated over several years to reduce administrative costs so that operators of a small RES-H installation would receive certificates (and thus revenues from their sale) only a few (e.g., two) times over the installation lifetime. 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 produced. A similar mechanism for assessing output is suggested in the UK's RES-H tariff mechanism (DECC, 2010). Careful oversight of this process would also be needed to ensure that certificates are not awarded for generation output which is not used for any constructive purpose.
- Transactional and administrative costs in a quota mechanism tend to rise with the number of generators and of obligated parties. The small-scale nature of many RES-H technologies a rise likely to be implicit in supporting domestic and commercial RES-H. This will tend to mean complex licensing arrangements, and a low ratio of certificates earned against systems installed resulting in low transactional and administrative efficiencies.[1] This is likely to mean that the mechanism will be inappropriate to the support of small-scale applications of RES-H technologies or simplification of the administrative process needs to be implemented. Haas et al. emphasise that administrative and transactional costs may contribute significantly to policy cost effectiveness and that any assessment of support mechanism must include these costs to allow meaningful comparison (Haas et al., 2004, 2011a).
- While non-prioritisation of renewable electricity in the trading market under a quota mechanism is a significant advantage of the quota in supporting RES-E, the absence of a central grid for heat energy delivery will tend to mean this advantage does not apply in the case of renewable heat.

The absence of a prioritisation issue as well as the evidence that quotas do not deliver RE more cheaply than alternatives undermines the key justifications for the quota mechanism, along with the other RES-H specific problems list here suggest a quota mechanism is likely to be inappropriate to support many – and perhaps all – RES-H technologies.

It is notable that the UK, in selecting a policy instrument came to the conclusion that a tariff style mechanism was more economically attractive than a quota based alternative for the support of RES-H, despite its previous preference for a quota for the support of both RES-E and for renewable transport fuels(DEFRA/BERR, 2007a, 2007b; DECC, 2010).

[1] e.g., the UK included small-scale RES-E generators in its quota mechanism from 2007. In the period 2007–2008, the regulator's administrative costs linked to small generators where £650,000 against a total estimated subsidy of £400,000. This doubled the admin cost from the previous year for an increase in generating output of only 0.05%. This figure is not inclusive of transactional costs or of costs associated with consolidation of small numbers of certificates (Ofgem, 2009).

4.1.4. Tariff or bonus mechanism

Tariff or bonus mechanisms are essentially financial subsidies applied per unit of renewable energy generated. The term 'tariff mechanism' has become widely used in regard of RES-E, while the related 'bonus mechanism' has been used in the discussion of mechanisms to support RES-H in Germany. Tariff mechanisms have been applied widely to support RES-E in Europe where a large number of EU Member States have adopted them.

Care must be taken to differentiate tariff schemes from bonus schemes. In the latter the plant operator is required to market its energy output while receiving a bonus on top of this revenue whereas a feed-in scheme obligates a specific actor (e.g., the grid operator or a supply company) to take energy output and pay a fixed tariff per unit. Bürger et al. (2008) have suggested only the bonus type of system seems to be feasible to support RES-H – 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. However, the UK is in the process of adopting a tariff mechanism which pays out a fixed sum per unit generated which represents an interesting development.

The subsidy can be provided directly from government, with the costs met by the taxpayer or passed on to utilities and their consumers. This obligation can be on a geographical basis as was originally the case with the German RES-E feed-in tariff or on a socialised basis where costs are totalled and divided amongst all utilities. The latter method is now common practice as it provides a greater degree of justice for both utilities and consumers in bearing environmental costs and benefits of the scheme.

The mechanism aims to provide sufficient income to allow economically viable investment in new capacity. Whilst all variations on the model see generators receive a fixed remuneration per unit of renewable energy generated, as well as or instead of the base market value of the energy, the most common variation provides technology specific subsidy, 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 et al., 2008).

The level of the subsidy can be linked to overall energy prices, as has previously occurred in Germany 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, undermining support, 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 from a specific installation, for example, a fixed number of kWh generated. Some form of limit is now standard in order to constrain the total cost of the instrument and reducing the potential for excessive profit for developers and plant operators and discouraging exploitation of poorer 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 goal of support for renewable energy technologies is long-term cost reduction, with the aim of making them competitive and 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 through price degression. This mandates a percentage reduction in the available tariff annually. RE generating capacity which has already been built remains on the same tariff until it reaches the defined limits, but a generator coming on line in the following year would have the tariff reduced by the legislated fraction; this new level of tariff is then paid until that generator also reaches the defined subsidy limit. The level of the annual percentage reduction is defined as far ahead as possible to aid transparency in financial planning for developers.

While degression may help to reduce costs, and annual reductions are calculated to account for likely reductions in real world prices, there remains the danger that reductions in payments will outpace real world reductions and thus undermine the effectiveness of the mechanism by failing to provide a sufficient stimulus. For that reason a bonus or tariff system should allow for periodic review and adaptation of the subsidy level.

4.1.4.1. Key advantages of the tariff mechanism. The tariff or bonus mechanism enjoys a number of advantages. The availability of a guaranteed, fixed unit price paid on top of or instead of a market price, independent of the time of production, has allowed RES-H developers a solid foundation for financial planning, effectively eliminating or reducing price, volume and balancing risk (Mitchell, Bauknecht et al., 2006). The guarantee that payment will continue for a fixed period present in many national variations also means 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 RES-E capacities. 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.

Moreover, tariff or bonus schemes set incentives to locate RES-H 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 it is much more cost effective to fully cover the roofs of buildings with excellent insolation with solar collectors and to leave buildings with poorer conditions than to spread the same collector area over a wide range of buildings with differing solar conditions (as for example, with a use obligation).

While this may provide some inequities in terms of access to subsidies by potential developers, it does support more effective application of subsidy to maximise renewable energy deployment and generation, which is regarded as being a key element of appropriate policy design (Haas et al., 2011b; Schallenberg-Rodriguez and Haas, 2012).

4.1.4.2. 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 tariff or bonus mechanism is effectively guaranteeing a price to all eligible renewable energy generators. While the government can model likely uptake against proposed tariff setting there is no certainty as to the actual volumes of new capacity that will be stimulated and thus of the total costs to be borne by consumers or taxpayers. This may be politically unattractive in terms of both budgeting and achieving targets. One proposed solution for the potential budgeting problem is the capping of the volume of new generating capacity to be subsidised. While this limits total cost 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 may create market uncertainty concerning eligibility for subsidy, especially at the margin (Wachsmann and Tolmasquim, 2003).

Politically, a further disadvantage of the tariff mechanism is that it requires governments to select technologies for support; something which is unattractive to some, though not all, governments. 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.

4.1.4.3. Applying a tariff or bonus mechanism to support renewable energy sources of heat. The application of a tariff or bonus mechanism to support renewable heat will vary from those applied to support RES-E as a result of the differing characteristics of delivery of RES-E and RES-H 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 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 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.[2]

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. One example is the method initially proposed within the UK's Renewable Heat incentive, which would have seen the heat outputs from small and medium systems estimated or 'deemed' and awarded a payment based on the estimated demand of the RES-H system location (DECC, 2010). This has since been dropped for commercial premises due to problems with developing a working system, it remains to be seen whether it is applied in the domestic sector. The initial plan allowed for multiple variables to be taken into account, including the kind of RES-H technology adopted, the geographical location (where 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 would be likely to require restrictions on availability of bonus subsidies to systems pre-approved by government or 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 metering of their output, as with the UK's Renewable Heat Incentive (DECC, 2011).

Reporting on the performance of tariffs to support RES-E, Groba et al. (2011) also present evidence that the design of the tariff mechanism is hugely important in contributing to the success of the mechanism, more important that the simple act of simply introducing a tariff mechanism. This seems likely to be something that can usefully inform the development and design of RES-H bonus instruments.

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 electricity. While electricity is in a single form at the point is use, the more heterogeneous delivery of heat, and of heating fuels, 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 sector may lie in the perception of high levels of complexity. This at least is the experience gained from the stakeholder process when attempts were made to implement such a system in Germany. A RES-H bonus model is a rather new mechanism for the sector with few comparator examples 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 in Germany at least was perceived as being extremely complex and linked to high transaction costs.

4.1.5. *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 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. Discussion is included here for completeness.

A tendering mechanism is based on competitive bidding by renewable energy developers for contracts to receive a particular subsidy against future generation. The underlying idea is that competition will allow the government to stimulate new renewable capacity at the lowest price. The mechanism is typically funded by obliging utilities to pay for costs and passing these on to the consumer.

Historically, bidding rounds have tended to band similar technologies together for purposes of competition, for example, wind projects compete together, biomass in another competition, etc, though this is not absolutely necessary. Government typically announce a specific volume of new capacity, though this is not a necessity, as the UK's NFFO demonstrated (Mitchell, 1995).

Issues relating to planning permission, penalties (or their absence) for non-completion of contracts and other problems

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

have been noted as regards competitive tendering, along with the problems relating to the stop-start nature of some tendering processes (Mitchell, 2000a; Mitchell and Connor, 2004).

4.1.5.1. Applying a tendering mechanism to support renewable energy sources of heat. Given the contractual nature of the mechanism, any potential seems likely to be confined to supporting large-scale RES-H in the pre-commercial and supported commercial phases of technological development. Even at the larger scale application might not be straightforward, with suitability of heat loads potentially reducing opportunity for application. Government identification of suitable loads for large-scale renewable heating application might make competitive bidding for specific projects useful. For example, projects located with district heating systems, with both elements subject to bidding similar to public procurement might usefully drive initial interest in territories where these is little experience with RES-H. Projects could be facilitated through state oversight of the planning process. 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 its problems, it seems unlikely to attract sufficient political support to be adopted for RES-H.

4.1.6. Levies

Levies are effectively a form of direct tax, placed to elicit behaviour change. Applied to energy sources they can economically advantage of desired technologies via an exemption. The funds raised through levies may additionally be used to provide further support to preferred technologies, e.g., through a grant programme. As an example, the use of fossil fuels in heat production is subject to a carbon tax in Denmark, Finland, Norway and Sweden, with obvious implications for the comparative economics of RES-H.

4.1.7. Tax related instruments

The application of taxation based instruments varies strongly between nations dependent on tax codes and their political underpinnings. Some tax instruments have proved influential in aiding RES-E expansion at both large and small-scales, and there is considerable potential for their increased use to support RES-H. The IEA has suggested that tax incentives in support of the adoption of solar thermal devices in Greece – essentially a deduction against energy system costs – 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: First used to support RES-E growth in the US of the 1970s with the introduction of PURPA (1978). They have been applied on an on-and-off basis since and – when applied alongside state mechanisms – are cited as a key element in the expansion of RES-E in the US (Langniss and Wiser, 2003). Credits are earned within the US federal mechanism when companies invest in eligible renewable energy technologies and can be used to defray tax bills in other business areas. This 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 in conjunction with state level quota (RPS) mechanisms (Langniss and Wiser, 2003). They effectively guarantee a minimum return on investment which may then be expanded through the riskier quota mechanism. Since tax credits earned in this manner need to be defrayed against investment elsewhere, they tend to be useful only to larger companies already active commercially within the US.

Value Added Tax and other tax exemptions: Can provide an economic advantage to renewable energy generation by reducing costs comparative with competitor technologies. Potential may be limited in regimes where tax on energy and energy-related goods is already low. Reduction in VAT can apply to purchases of both energy and technology. Application of VAT reductions is straightforward, effectively manifesting as a simple price reduction for the consumer and requiring little complexity of change from the vendor.

Accelerated or Enhanced Depreciation: Some governments allow accelerated depreciation against purchases of named renewable energy and other clean technologies than would be the case for other goods, reducing the costs of investment. The Netherlands VAMIL programme and the UK's Enhanced Capital Allowance Scheme are two examples. Adoption is fairly straightforward, with eligible technology simply listed as attracting enhanced status. Impact is likely to be enhanced by promotion of the availability of this status. The effectiveness of this instrument may vary, perhaps most notably between commercial and domestic consumers, with the former having more experience and interaction with the local tax authority and tax code.

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, rather than costs falling on the electricity consumer.

4.1.8. Soft loans

High initial capital cost is a key barrier to renewable energy deployment. Many of the instruments detailed here act to address these barriers by directly reducing capital costs, by increasing total income, providing more secure income streams and thus reducing risk for those providing finance. Providing capital below the market rate also addresses the problem of high capital costs. This is likely to be more acceptable in some territories, with acceptability often dependent on the historic role of government in developing new technologies and industry, and on the institutional role of financing bodies within a 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 be significant in determining 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 and can be regarded as central to the rapid expansion of wind energy in Germany from the 1990s to the present (Bechberger and Reiche, 2004). Loans there have been made available through state owned banks at the national and regional levels, reflecting close links between the government, financial bodies and industry. Countries without 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 introducing an institution to act as a funding body of last resort in an institutional framework which has previously not lent itself to government interference with the lending market (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, as such there is an opportunity cost to the public purse. As with other support instruments, the justification is the potential public good in terms of environmental advantages and other potential benefits such as enhanced industrial and employment opportunities.

4.1.8.1. Key advantages and disadvantages of soft loans. Providing soft loans has the advantage over grants of less impact on public budgets, spreading costs over time, and is thus potentially more politically supportable.

Social resistance to taking loans at the domestic level is likely to mean soft loans are more appropriate at the commercial level. Grants may be a more appropriate for the domestic sector, despite the different cost implications.

The adoption of soft loans may require some form of contingency to deal with defaulters.

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

4.1.8.2. Applying soft loans to support renewable energy sources of heat. Offering soft loans is likely to be as useful and as viable for supporting large-scale RES-H developments as for RES-E, though may be less appropriate to smaller-scale applications on the grounds of transactional costs.

The German experience with wide availability of soft loans has tended to focus on their use 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, soft loans may 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 less 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 potentially new responsibilities for financial bodies and must be politically acceptable. 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.

4.1.9. 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; including for RES-H technologies (IEA, 2007). The IEA has also identified a number of key areas requiring R,D&D support for different RES-H technologies, including different elements of systems relating to solar thermal, geothermal, biomass and also including storage.

5. Regulatory and other issues

Policy instruments have been applied to provide the financial support essential to driving deployment and technical innovation of RES-E for over two decades. However, many barriers to the growth of renewable energy cannot 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 is apparent from the RES-E experience that consideration of the wider regulatory and societal context is necessary to address all barriers to deployment and this seems likely to also apply to RES-H. Some areas of concern which may impact on RES-H are described below.

5.1. Non-financial mechanisms with potential to support RES-H

5.1.1. Use obligations

A ‘use obligation’ imposes a regulatory obligation on building developers and/or owners to source a minimum amount of their energy from renewable sources; usually expressed as a fraction of the total estimated energy demand of a building or buildings. Obligated parties will usually be developers of new commercial or residential buildings, or those upgrading existing buildings. Obligations can apply as far down as the individual householder.

Use obligations may be technology specific or allow baskets of different technologies, and ongoing examples allow combinations of RES-E and RES-H (Bürger 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 or fine by the obligated party, or by the purchase of surplus generation elsewhere (for example, by sourcing green certificates) or may allow exemption without penalty, according to circumstance. The robustness of the hardship clause may have implications for the effectiveness of the mechanism.

The key variants in the mechanism are the level of the obligation, the technologies included, the range of parties to which it applies, and whether the obligation applies to renovation as well as new build.

Spain introduced a use obligation nationally in 2006 with a federal requirement for all new and renovated buildings to install RES capable of delivering 30–70% of building need. This followed the adoption of use obligations in various cities across Spain, originating with Barcelona in 2000 (Element Energy/NERA, 2011).

The use obligation mechanism is somewhat unusual in that it has the potential to be adopted at many scales and at different levels of government. It has so far been variously adopted at municipal, regional levels and national levels, though this will be dependent on how powers are devolved to different levels of government. The Spanish example began at the municipal level and expanded to national adoption while in the UK obligations are currently in place only at the municipal level.

Germany adopted a use obligation at the national level in 2008. The obligation is limited to new buildings while RES-H deployment in the building stock is addressed by a grant programme. The minimum share is 15% for 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 district heating system or by exceeding the efficiency standard for the building (defined by the building code) by 15%. The German regions are authorised to expand the use obligation to building stock.

5.1.1.1. 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 pre-commercial phase, accelerating 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 and because it can be slowly ramped up by increasing the level of obligation. 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 installer personnel training and a broadening in the availability of the technologies in the marketplace.

While useful in driving demand, 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 and market demand created by the mechanism may plateau. The rate of increase may even fall if levels of construction drop. Plateauing of demand may be a sign that additional mechanisms or a widening of the obligation are needed in order to continue expansion in demand.

The 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.

A disadvantage of the use obligation is its low economic efficiency due to the disconnect between installation and potential, since all buildings are subject to the regulation. Furthermore, lacking a mechanism to benefit the production from RES-H, building owners are not incentivised to exceed the minimum obligation. While there is scope of increasing the level of the obligation over time, one disbenefit of this is that once installation is complete it will tend to tie a development into that system for 1 period of 10–20 years, depending on the lifetime of the system.

In addition the instrument focuses on individual building systems lacking a real incentive to stimulate larger infrastructure, for example as with district heating (DH) systems. Countries where a larger market penetration of DH systems is deemed necessary to meet mid to long-term RES-H targets accompanying measures may find it necessary to otherwise stimulate structural change in the heating sector.

Finally the effectiveness of a use obligation depends strongly on compliance verification. Non-compliance can be due to information deficits such that building owners simply do not know of their obligation or intentional to save money. National attitudes to policing may impact significantly on compliance.

Where the use obligation requires adoption of RES in property refurbishment 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 does not 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 opposition from companies and industry associations linked to the housing sector.

An argument can also be made that a use obligation is not consistent with the polluter pays principle, on the grounds that it effectively impacts on an arbitrary selection of stakeholders

5.1.1.2. Applying use obligations to support renewable energy sources of heat. 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 applying a use obligation might see it paired with an obligation to build to minimum thermal standards in the case of new build. Care must be taken to account for less stringent standards when applying the mechanism for refurbishment of older buildings.

Care must also be taken to ensure that a use obligation creates a level of demand that is capable of being serviced by the existing infrastructure and which acts to create a stable or steadily increasing 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.

5.1.2. 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 access to a workforce skilled to support growth. The absence of sufficient skilled personnel represents a significant barrier to rapidity of deployment and 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.

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 will tend to vary by technology and with the level of maturity of the industry relevant to each technology. Educational needs will vary considerably, ranging from short courses for semi-skilled crafts-people through to university based graduate or postgraduate programmes which may need to be integrated into wider structures for professional accreditation. Expansion of RES-H in Upper Austria has, for example, highlighted two major skills gaps. First, 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 (Egger et al., 2009).

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 the RES-H sector. Educational structures vary, requiring national, and perhaps regional, strategies to respond within the context of local educational structures.

5.1.3. Information, awareness and promotion strategies

Regardless of the economics, deployment of RES-H 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.

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

5.1.4. Standardisation

Experience with RES-E and RES-H has demonstrated that financial incentives combined with a public willingness to engage with technologies perceived to be better for the environment have tended to attract to the market products which do not perform adequately. This can undermine public confidence while squandering public and private funds.

Setting minimum performance standards for new RES-H technologies can address this. The introduction of standards for RES-H micro-generation allows consumers increased confidence that products will meet their requirements. Governments, by limiting subsidising funds to only those technologies which meet their standards can ensure public funds are more efficiently directed. Standards can thus usefully partner many policy instruments. Finally, standardisation is also important when retrofitting or replacing renewable heating installations. The 2009 EU Renewables Directive compels all EU Member State governments to establish harmonised microgeneration certification schemes.

5.2. Application of complementary policy instruments

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 and that more effective renewable energy policy outcomes can be gained from combining different instruments. Policy makers need to consider the potential of reinforcement when creating policy.

5.2.1. 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. Foxon et al. provide some classification of some RES-H technologies specific to the UK instance and comment as to the stage of maturity at which certain policy instruments may be most appropriate. It is worth noting that it cannot 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 to consider the stage of maturity of any technology they wish to support and to design accordingly. This has the potential to throw up political difficulty. Some policy makers shy away from creating policy which requires 'picking winners', preferring instead to adopt policies which allow the market the greatest possible leeway to decide which technology best meets customer needs. Adopting a 'one size fits all' policy in this manner is likely to lead to some RES-H technologies being disadvantaged compared to others, and potentially undermining their commercialisation with an attendant risk to long term potential for cost reduction and industrial opportunities. The typical example is of technology blind quota mechanisms such as the UK's Renewable Obligation providing support only to those technologies closest to market.

5.2.2. 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 barriers and in stimulating innovation. Even where applied to single technologies, or to technologies 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. There are numerous examples of nations combining instruments to this end:

- 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 mitigated the high capital costs which are a central barrier to deployment of many renewable energy technologies. 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 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 deployment.

Since many of the barriers to deployment 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 and non-financial instruments to simultaneously overcome 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, or of barriers being removed via regulation whilst also applying financial stimuli.

Ideally, instruments should be mutually supportive, and should create a continuum of effect over time such that there are no gaps in providing support to technologies to avoid leaving them behind. Support should however also have a cutoff point, to avoid placing 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 potential conflict with biomass use for RES-H with both RES-E and biofuel (Mitchell, 2008).

5.3. National and regional planning processes

Planning processes vary considerably between and within territories. The extent to which planning processes can act to assist or inhibit renewable energy development 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 entail significant barriers to growth. Research connected to RES-E suggests planning is seen as risky across much of Europe, and that perception of risk does not necessarily correlate with rates of deployment (Butler and Neuhoff, 2005). Some EU 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. The range of scales of application for RES-H, along with the variance in prominence of different technologies, suggests potential for different technologies to be impacted to different extents by planning regimes. Smaller technologies which integrate on to buildings easily are less likely to encounter problems than large-scale technologies such as commercial biomass exploitation, for example.

5.4. Integration of RES-H support policy with 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 may also facilitate growth. Since barriers linked to building regulations will be territory specific the first step to addressing them must be their identification in the extant regulatory regime. This must be followed by stakeholder consultation to ascertain what changes can be made to overcome them without entailing excessive costs. Application of a 'use obligation' (see Section 5.1.1 above) is a form of building regulation but wider consideration must also go to how building regulation for energy efficiency can work with regulation on heat consumption and generation to achieve economic efficiency and return on investment.

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

5.5. Regulation of the wider market

The heat supply market of any nation is complex, reflecting the different consumer needs, different economic advantages and disadvantages of a diverse mix of technologies and the regulatory history of the specific heat market. Enhanced provision of RES-H cannot be accomplished without reference to the wider regulatory context in which heat supply exists.

The RES-E policy experience has made it apparent that existing regulatory regimes have developed to cope with extant energy delivery systems; these technologies drive the creation of operating conditions that favour dominant technologies while raising barriers to new entrants to the system, even where this is not the intention (Mitchell, 2000b). It is essential to the long term exploitation of renewable heating technologies that their respective markets offer a position of neutral regulation.

One example of this kind of RES-H regulatory barrier is accessibility to gas supply grids for biogas and biogas producers. There may be numerous others which may become apparent with wider system consideration.

It is possible that the characteristics in which heat delivery varies from electricity delivery will influence the scope of these issues; the relatively less advanced position of renewable heat policy means this is an area which has received little attention.

5.6. 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 social, environmental, economic and cultural objectives. Some of these are likely to have greater potential for conflict with RES-H 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. Agricultural policies for food production in the EU and US have the potential to conflict with land use for fuel production. Emissions trading is likely to be another area with potential for significant interaction with RES-H policy.

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.

6. Discussion

Getting renewable energy policy right is not an easy task. Effective policy must consider many factors, addressing multiple barriers and requiring different instruments to be applied simultaneously whilst avoiding overspending and conflicts with multiple stakeholders and maintaining political support. There is a need to be able to identify and satisfy the particular support needs of disparate technologies and preferably to get it right first time to avoid financial and political costs. Attention must be paid as to when one instrument should give way to another and when a technology should be abandoned.

Designing support for RES-H needs to be firmly rooted in the lessons learned from RES-E policy – learning them over again would ignore one fundamental lesson, minimisation of costs – but must note the limits of those lessons and the added complexity that stems from the different operating conditions of the RES-H technologies and the different nature of supply and demand for heat energy.

Addressing the need for more sustainable sources of heat will have to become a major component of renewable energy policy if nations are to achieve long term targets for CO_2 emission reduction and if innovation and deployment are to be adequately stimulated. 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 and commercial maturity represented by the RES-H technologies will require different policy instruments if they are to progress 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. Experience in Upper Austria, a region which is among the most advanced in developing RES-H Policy and deploying RES-H technology is that making the process as easy and painless as possible more easily attract consumers to engage with the technology (Egger et al., 2009).

Some policy instruments may prove to be more apt for application in some places than others and it is important to emphasise that no single set of policy instruments is likely to

Table A1

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
Public procurement	✓		✓	✓	☹	☺	☺	☺	😐	+ Ability to create initial market for nascent RES technology − Limited applicability
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
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
Tendering*		✓			☺	☺	😐	☺	☹	− Tranche-based nature fails to create stable demand conditions; associated with previous failure; not suitable for small scale
Levies (e.g., 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
Tax incentives (e.g., no VAT)	✓		✓	✓	😐	☺	☺	😐	😐	+ Cost efficient; uncomplicated − Low predictable effectiveness; reduce government incomes
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)
Skills, education and 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
Information and awareness	✓		✓		😐	☺	☺	☹	☹	+ Potentially cheap; improve the functioning of other support mechanisms − Low predictable effectiveness
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.

deliver a holistic solution everywhere. It is important however that all 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 and on practical experience with the application of policy instruments.

It seems likely that the EU will be the focal point for much in the way of initial efforts in applying RES-H policy, since action is already legally mandated by the 2009 Renewables Directive. It should be noted that China is by some margin the global leader in both production and installation of solar thermal but that this is not the result of a specific policy. This EU focus seems likely to mean that as regards RES-H that there should be less of a place for any repetition of the debate as to the relative merits of quota and tariff mechanisms, as has been the case with RES-E policy. Many of the arguments for quota instruments are less apparent for RES-H and with the steady undermining of the economic case for quota mechanisms as a result of the evidence in their application to RES-E the case for applying subsidy through some form of tariff mechanism seems to be indicated. However, it is also apparent that a number of states appear to favour some form of regulation, most notably in the form of a Use Obligation on individual developers. It is perhaps here that there is potential for an instrument to compete with tariffs as a driver for growth in RES-H, though this is unlikely to be desirable and the sooner that conclusions can be drawn as to their relative merits in practice the better off both nations and taxpayers are likely to be.

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Appendix 1. Characteristics of existing or potential RES-H/C support mechanisms

See Appendix Table A1.

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