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Policies to support renewable energies in the heat market

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ABSTRACT

Whereas the contribution from renewable energies in the electrical power market is increasing rapidly, similar progress in the heat market is yet to be made. A prerequisite for progress is the development of innovative support instruments that transcend the usual support through public subsidies or tax reductions. We present an overview of the various classes of possible instruments. Some particularly interesting instruments will be selected and evaluated, comparing them qualitatively and quantitatively for the case of Germany. The most favourable model is found to be a new, allocation-financed[1] model known as the Bonus Model. This model will be described in more detail.

1. Introduction

During the EU summit March 9, 2007, the heads of governments of the 27 EU member states agreed to a mandatory target of a 20% minimum share of renewable energy in total primary energy consumption by 2020 throughout the EU. Thus far, it is not clear how this overall goal will be distributed among the individual member states, and how the individual member states will then apportion their respective shares between the heat, electricity production, and transport sectors. These sectors developed different dynamics in the proliferation of renewable energy in the past. In the power sector a highly dynamic development in terms of newly installed capacities can be observed in the last years, which has been supported by highly advanced policy instruments. The heat sector, however, lacks significantly behind, both in terms of installations and sophisticated political instruments.

Against this background, this contribution introduces suitable models and instruments, evaluates them both juristically and economically, and compares them with each other. The goal is to identify particularly promising models and instruments and sufficiently specify the details for the decision makers. The details and results are based on a study for the German Environmental Ministry (Ministry of Environment, Nature Conservation and Nuclear Safety) on budget-independent instruments for the diffusion of renewable energy in the heat market by Nast et al. (2006).

The organisation of this contribution is as follows. Section 2 shows a brief overview of the framework conditions of the diffusion of systems for the use of renewable energy in the heat market and highlights a scenario for a sustainable future development path. Section 3 discusses the international experiences with the support of renewable energy in the heat sector and shows that most of the success in the proliferation of heat from renewable sources was rather small. For a systematic development of feasible instruments, Section 4 classifies the available political instruments by giving a comprehensive overview. Section 5 selects certain instruments for closer inspection applying juristic and economic criteria. In Section 6 suggestions for the design of a suitable instrument are derived from a detailed analysis of the advantages and disadvantages of the selected instruments in Section 5. The article concludes with a summary and recommendations.

2. Framework conditions

The share of heat from renewable energy sources (RES-H)[2] in the total heat demand (including cooling) currently amounts to

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[1] Some economic terms are explained in the glossary.

[2] RES-H in this paper denotes energy from renewable sources for heating *and* cooling purposes.

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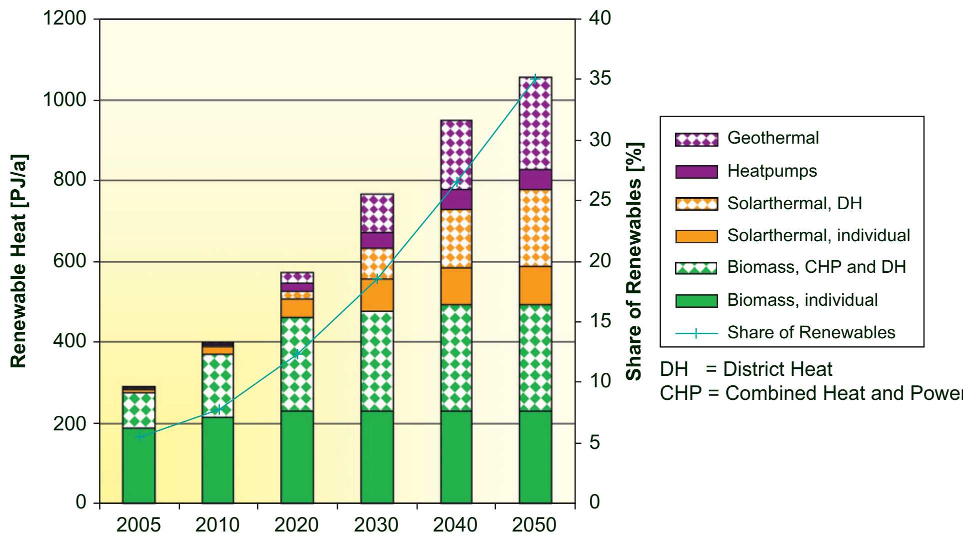

Fig. 1. Quantitative goals for renewable heat in Germany (Nitsch et al., 2004; Nast et al., 2006).

less than 10% in the EU (CEC, 2007). In Germany it is only about 6%. The European Community has not yet enacted any explicit regulation for promoting the use of renewable energy sources (RES) in the generation of heat and cold. However, in 1997 the goal of 12% from RES has been set, implicitly also creating an incentive to increase the share of RES-H. Thus far, biomass is the most prominent RES for heating purposes, with the largest share due to heat generation with wood in private households. The implementation of efficient hearths and boilers for wood combustion or for using biomass in combined heat and power (CHP) generation, as well as solar-thermal and geothermal systems, has grown only slowly in Europe. As a result, the contributions so far from the heat sector will not be sufficient to even fulfil the 12% goal set for 2010, let alone the later, more ambitious 20% goal.

In Germany, instruments based on ambitious expansion goals have been under consideration for several years now (see e.g. Nast et al., 2000). It would be desirable that these achieve similar success as the Renewable Energy Sources Act (EEG, Erneuerbare-Energien-Gesetz)[3] in the area of renewable power generation. A sustainability scenario (Fig. 1) for the German heat market that fulfils the climate-protection requirements, i.e. a reduction of the CO_2 emissions by 80% of the reference value from 1990, foresees about 1060 PJ of renewable heat in the year 2050—twice the amount produced today (Nast et al., 2006). The share of renewable heat in the overall heat demand (including process heat) would then amount to a total of 35%. If the heat demand that is met by renewable electricity (e.g. the renewable share of electricity used to operate heat pumps) is included in the calculation, then this share swells to 46%. These calculations already take into account that the heat demand between 2005 and 2050 will decrease by 44% due to improved thermal insulation and a more efficient use of energy.

[3] The EEG specifies that the producers of electricity from renewable energy sources can demand that the nearest power grid operator purchases the entire renewable electricity for a period of 20 years at a fixed rate (whereby the individual grid operators are obligated to equalise the burden amongst them and to distribute it in equal proportions to the final consumers). For more information about this feed-in tariff system and other instrumental approaches in the power sector, please see the communication from the EU commission from 7/12/2005 (KOM (2005) 627) on the promotion of electricity from renewable energy sources as well as the publication from the German Ministry of the Environment (2007): EEG—The Renewable Energy Sources Act. (http://www.erneuerbare-energien.de/files/pdfs/allgemein/application/pdf/eeg_brochure_engl.pdf).

A decisive condition for realising these shares is that about 2/3 of the renewable heat is distributed to the end consumers through local heat networks (Nitsch et al., 2004) because:

(1) Extracting large amounts of geothermal heat from depths greater than 2000 m is only economically feasible if a larger number of consumers are supplied at the same time, i.e. if they are connected to a local heat network.
(2) Storing solar heat in the larger heat stores of a local heat network is cheaper and can be done over a longer period of time than for individual buildings. Only in this way is it possible to store the summer heat of the sun cost-efficiently into the winter.
(3) CHP generation is only efficient for larger biomass plants. Furthermore, inexpensive, problematic biomass sources like straw, which require more effort to clean the flue gas, can be used in larger furnaces.

According to these results, the policy instruments for realising such an ambitious target-oriented scenario must accommodate various technologies and their specific learning curves and also incorporate the construction of the necessary infrastructure for heat networks.

3. International experience with support schemes

This section summarises the experience gained in European countries and Israel with instruments in the heat market in order to reflect upon the recommended support schemes in the light of observations made in the past. Until now only very few non-budgetary instruments have been implemented, the majority of them being use obligations.

Current measures in EU Member States for promoting RES-H production offer only limited incentives for dynamic, lasting growth. To date, they concentrate on three classes of budget-financed instruments. These instruments include investment incentives, tax measures (investment-based and fuel-based), and low-interest loans (Table 1 provides an overview for the EU-15). Such instruments, which in most cases are applied at the national level, are often combined with comparable local and regional policies. In the past, the greatest effectiveness in promoting heat production from renewable energy has been achieved in Germany and Austria, via investment incentives for solar-thermal collectors

Table 1
Overview, by technologies, of the most important instruments for promoting renewable energies (heat production) in the EU-15 (Ragwitz et al., 2005)

	Heat from biomass	Solar heat	Geothermal heat
Most important policy instrument (countries)	Investment incentive of 15–40% (AT, BE, DE, DK, ES, FI, FR, GR, LU, PT, UK) Tax break (IE, IT, NL, SE)	Investment incentive of 15–40% (AT, BE, DE, DK, ES, FR, GR, LU, PT, SE, UK) Tax break (IE, IT, NL, PT, SE) Use obligation (ES, IT)	Investment incentive of 15–40% (AT, BE, DE, DK, ES, GR, PT, UK) Tax break (IE, IT, SE) Use obligation (SE)

and modern biomass-fuelled heating systems, and in Greece, via investment-based tax measures on solar-thermal collectors. So far, however, none of these programmes could mobilise an energy-economically relevant amount of renewable heat—even though the initial successes in some cases were respectable. Furthermore, subsidies have the disadvantage that they burden the state or communal budgets and are therefore dependent upon the current political agenda and as a result cannot function as a permanent, reliable control mechanism.

One pertinent instrument is still quite new: *percentage-based obligations* for the use of heat from renewable energies. A limited number of EU Member States has introduced or is considering the introduction of such an instrument. These states include Spain (several municipalities, especially Barcelona and Madrid, and recently at the national level), Portugal, Italy (several municipalities including Rome, two regions, and at the national level), the region of Wallonia in Belgium, some Irish counties, and a number of UK local authorities (ESTIF, 2006). A national instrument is planned in the UK and the Netherlands. In Sweden, heat pumps are required for new buildings. Outside of the EU, Israel imposes requirements for the use of solar-thermal systems, and Australia has a system in place for trading certificates for renewable energies. The remainder of this section summarises the experience gained in Spain (including Barcelona), Italy, and Israel with obligations to use heat from solar-thermal systems.

In Spain, at the municipal level, Barcelona has been a leader for some years now in the area of regulating heat production from renewable energies. A "Solar Thermal Ordinance" required owners of all new buildings with hot water consumption exceeding 292 MJ/day (apartment buildings with at least about 16 households) to meet at least 60% of their domestic hot water demands via solar-thermal systems. These provisions also applied to extensively renovated buildings. The corresponding percentage for swimming pools is 100%. This regulation was revised in 2006, whereas the main change concerns the abolishment of the former consumption threshold for a building to be subject to the obligation. Similar concepts have since been developed for other major Spanish cities.

Spain is the only European country to make the installation of solar-thermal appliances obligatory in new and refurbished buildings on the national level. In order to transpose the requirements from the Directive on the Energy Performance of Buildings into national law, the Spanish Government approved the new Technical Buildings Code (CTE) in March 2006. The CTE includes an obligation to cover 30–70% of the domestic hot water (DHW) demand with solar-thermal energy. The mandatory minimum share depends on the total DHW demand of a building and the climate zone in which it is located. The obligation applies to all new buildings and those undergoing a renovation regardless of their use. Buildings that already meet their hot water demand by other RES or CHP are exempt from this regulation.

In Italy, several small municipalities and the city of Rome have adopted solar-thermal obligations for new buildings that are similar to the Spanish examples. The actual implementation details depend on the local decision (for example in Rome at least 30% of the total heat demand and at least 50% of the hot water heat demand must be fulfilled with solar-thermal collectors). Recently, the Italian Government has developed an updated proposal for the implementation of the EU Energy Performance of Buildings Directive, containing a nationwide obligation for new buildings to meet at least 50% of their hot water heat demand using solar-thermal collectors.

In Israel, an obligation for the use of solar-thermal appliances for warm water production in new domestic buildings was introduced in 1980. The key motivation of this obligation was to enhance the security of supply. The obligation applies to all new buildings, with some exceptions (buildings for industrial or trade purposes or hospitals, and those higher than 27 m).

In Spain over the past 4 years, the area of installed solar-thermal systems has grown by 4 m^2 per thousand inhabitants, per year. This level is only about half of the growth rate in Germany. Israel, however, achieved considerable success with the instrument—more than 80% of all households now use solar thermal for warm water generation—solar thermal has become a mainstream technology in the meantime. Systems are widely available, installers are well acquainted with the technology, and system prices have decreased substantially over the years. The success of use obligations strongly depends on the possibilities of non-compliance. The possibilities are a substitute levy, which could be used to fund other RES-H projects and the imposition of a penalty payment. If the levy/penalty is low compared to the costs of compliance, the incentives are low as well.

4. Typical economic support instruments for RES-H—classification and description

So far, there is no standard procedure for the systematisation and classification of political instruments in environmental economics. Depending on the underlying different criteria, instruments can be grouped differently (see e.g. Jänicke et al., 2002 or Rentz et al., 2001), for instance by the depth of intervention of the instrument in the market development, the price- or amount-base of the instruments, the global vs. player-, technology, and obstacle-specificity of instruments, the market compatibility of the instrument, etc. An often-neglected point in the theoretical analysis of support instrument is their compatibility with existing legislation. Therefore, in the present study already during the pre-selection and classification phase particular value was put upon the compatibility of the promotion instruments with the existing national and international statutory provisions. For this purpose, the broad range of instrument options was summarised into the following four categories by similarity from a legal point of view:

1. Fiscal instruments
2. Purchase, sale, and remuneration obligation
3. Use obligations
4. Other regulatory approaches.

In the following we describe the elements of the three main categories of promotion instruments (fiscal instruments;

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purchase, sale and remuneration obligations; use obligations) in more detail.

4.1. Fiscal instruments

In many cases, renewable energy utilisation is still more expensive at present than the alternative option, namely fossil fuel use. These additional costs have to be taken into account. In general, this situation can be tackled effectively using fiscal instruments, either by making fossil fuels more expensive for the consumer or by reducing the price of renewable energy through the adoption of appropriate measures. The following four options are available in principle:

1. creating new and/or increasing existing taxes on fossil fuels
2. subsidising renewable energy from current tax revenue (government grants)
3. providing various types of tax breaks for renewable energy systems (exemption from VAT, improved depreciation opportunities, tax subsidies analogous to the former owner-occupied homes premium)
4. raising new revenue, to be deployed under the state's supervision to promote renewable energy (many different options exist here).

Since there is a huge body of literature on fiscal policies and environmental problems, it should suffice to note that the nation-specific legal conditions for taxes, levies, and grants have to be taken into account. The procedure for the allocation of public investment grants is well known and will therefore not be described in more detail here. An efficient allocation procedure, which is also suitable for smaller subsidies, is assumed. An example is the existing German handling procedures for the grant programme for the support of RES-H, where only about 100 people process well over 150,000 funding applications every year.

4.2. Purchase, sale, and remuneration obligations

The "purchase, sale, and remuneration obligations" category encompasses all the models that aim to achieve economic leverage effects without channelling the financial flows through a public-sector agency. It includes, in particular, models that, in terms of environmental economics, can be classified as quota or as price regulations. In practical terms, these could include obligations for traders to purchase or sell specific amounts from renewable energy systems, quota-based obligations for the fuel trade to purchase or sell heat products produced from renewable energy (Quota Model), or entitlements for the producers of heat from renewable energy to receive additional remuneration for RES-H used by other economic operators (Bonus Model).

The Bonus Model is a rather new concept in the discussion about suitable support options for RES-H. Significant elements of the Bonus Model are based on the Renewable Energy Sources Act. The Bonus Model can be characterised as a purchase/remuneration obligation with fixed reimbursement rates. The model involves major mechanisms of a classic feed-in scheme that is well known from the renewable energy sources—electricity (RES-E) sector. In all variants of the Bonus Model, operators of renewable energy systems will receive a fixed price per kWh (bonus) corresponding to the amount of heat they produce. The bonus level is set by the government and established by law. As is the case with RES-E under the EEG, bonus payments depend on the type of technologies used. The bonus level can be easily adapted and periodically adjusted to the specific needs of the various RES-H technologies. In legal terms the remuneration is the direct equivalent of the environmental benefit brought about by RES-H operators.

The interaction between those who operate renewable installations eligible to receive a bonus (beneficiaries) and those who are obliged to pay the bonuses (obliged parties) requires special attention. The relationship between the two parties in the heating sector differs significantly from the corresponding relationship in the electricity sector under the scope of the EEG. Under the EEG, electricity is physically fed into the grid, which allows for the distribution of a physical good. The situation is different in the heat sector. Heat is mainly produced in individual house systems and a homogeneous and country-wide transmission and distribution network is missing.

Under the Bonus Model, each household operating a solar collector would in principle be entitled to apply for funding. This situation would involve millions of beneficiaries leading to millions of transactions. Therefore, we have introduced a key position in our preferred variant of the Bonus Model, which is taken by pooling organisations (called "transactors"). The role of the transactors is to aggregate the interests and bonus claims of the beneficiaries thus acting on their behalf. All beneficiaries are obliged to join at least one transactor in order to be entitled to receive the bonus.

From the perspective of the renewables systems operators, these transactors replace the authority to which the investment grant applications are made in the first of the three models under comparison. Operators of small installations—i.e. the large majority of the beneficiaries—will have to submit more or less the same documents to the transactors as within a scheme of government grants. Furthermore, bonus payments could be aggregated over several years so that operators of a small RES-H installation would receive funding for all their eligible RES-H generation by only a few (e.g. two) payments. Larger installations would be subject to more stringent monitoring and must therefore provide annual evidence of the amount of renewable heat produced.

Unlike an authority that is responsible for government grants, the transactors are not refinancing from taxation, but claim the bonus payments from the producers and importers of heating fuels (gas and oil) who initially placed these environment-damaging fuels on the market or supplied them to consumers. Incidentally, these parties are already registered, because they are liable to pay an energy tax. As this number of obligated parties (in Germany about 1000) is easily manageable, the transactors can claim the bonus that is due from each of these producers and importers in line with their obligations. Each obligated company is required to pay the bonus based on their market share. In each case, the basis for determining bonus payment amounts and pertinent obligations consists of the last reference year, and in the interests of simplicity, the amounts and obligations are set by a national authority based on the energy tax collection data.

It can be assumed that the fossil fuel traders will pass the additional costs on to consumers, so that the promotion scheme is ultimately funded by fuel consumers but not however by taxpayers, as before. This situation increases compliance with the "polluter-pays" principle as compared to a promotion scheme based on tax money.

The transactors' role entails substantial responsibility. The transactors (whose numbers should be limited by an appropriate procedure) form the link between the very large number of operators of renewable energy systems and the obligated companies. They process the applications submitted by operators for bonus payments, check them, and then enforce them (in private law) vis-à-vis the individual obligated companies. The transactors must ensure a high level of transparency in their dealings with these companies and are monitored by a national

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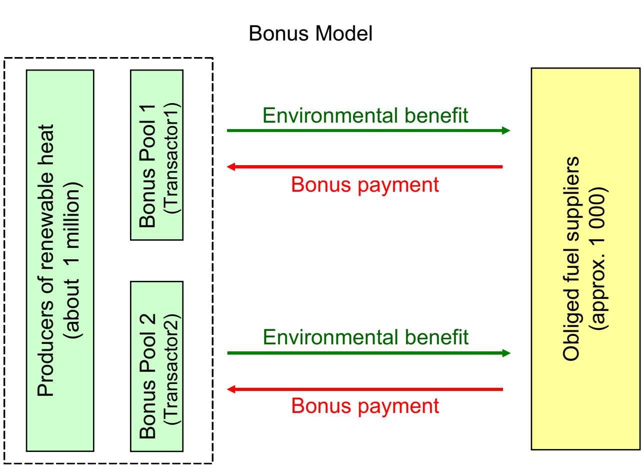
authority. Finally, the transactors—after deduction of their costs—pass the bonuses on to the operators of the renewable energy systems.

The function of the transactors can also be assumed by a public agency, should the national law allow it. Due to the strict restrictions in the German constitutional rules governing public finances, this solution is not possible in Germany (see Section 5).

The bonus obligation applies only to the proportion of fuels that are to be replaced by RES-H. It does not apply, for example, to fuels used in the electricity supply or to operate furnaces for the production of steel. Similar exemptions are already provided for in the German Energy Tax Act (EnergieStG). The Bonus Act will be based on this legislation, which greatly simplifies procedures.

Fig. 2 provides an overview of the transactions arising in the Bonus Model. The figure illustrates that the bonus payments serve as a payment for environmental services.



Advantage of this option:
The producers of renewable heat have a personal interest in building up the system.

Fig. 2. Overview of the Bonus Model.

4.3. Use obligations

The term "use obligation" means that an obligation is imposed on specific parties to utilise renewables to a defined extent. Spain was the first EU country to introduce a variant of a use obligation at national level.

The obligation to utilise renewable energy arises in connection with the new installation or replacement of heating systems. Earlier proposals that merely imposed an obligation to install a renewable energy system in new buildings would generally have minimal impact on the heat markets due to the decline in construction activity.

The advantage of the use obligation model is that its method of operation and impacts are very easy to communicate. However, it has significant weaknesses in terms of its technology-specific effects and the structural change in the heat sector (towards more network-based supply systems) that would be required in the longer term.

Three variants of the use obligation model are considered. In the basic variant, the authorities must be able to provide exemptions from the use obligation in hardship cases. The two modified variants provide for the opportunity of compensation without an exemption decision by the authorities, either as an obligation to pay a substitute levy or by offering the option to acquire/trade certificates for surpluses produced. The two latter alternatives offer advantages to the basic model: deficits in execution are less likely, they offer greater flexibility in implementation, and entail lower administrative overheads (as no costly individual exemption decisions are required).

The crucial point of these models is the introduction of a proportional use obligation for renewable heat for the areas of building and water heating. The regulation obligates every building owner who installs a new heating system or who replaces an existing system to meet a minimum proportion (e.g. an average of 10%) of the annual space heating and water heating demands for the building in question by using renewable energy. In order to ensure commensurability, a higher minimum proportion should be required for new buildings (e.g. 12%) than for existing buildings (e.g. 8%). A reduced minimum proportion for older buildings is justifiable since the respective owner would have to install a larger renewable energy system for the same space due to the generally lower thermal standards for the older structure.

Buildings that are connected to local/long-distance district heat networks are exempt from the use obligation. The obligation does apply, however, to the network operators and heat suppliers.

The use obligation may lead some building owners to postpone exchanging their heating systems in order to avoid having to install a renewable energy heating system. For this reason it should be considered to determine a space of time after which every building must meet the use obligation (e.g. in 2025), regardless of whether or not the heating system has been replaced by then.

The obligation does not apply to all building owners simultaneously, but only arises in connection with the new installation of heating systems. Furthermore, for some types of buildings, the obligation only arises with a time delay of some years (a distinction is made between single-family houses, apartment blocks, non-residential buildings, and new buildings, for example). Without this progressive system, the demand for renewable energy systems would increase so dramatically that the market would no longer be able to cope. At the same time, in the interest of a long-term sustainable energy policy, the legislator should not stop at a milestone set at one point in time. Instead, it should dynamically define the minimal obligation proportions, i.e. successively increase them over time.

In one variant of this group of instruments the obligated parties are allowed the possibility to pay a substitute levy instead of directly fulfilling their obligation. This substitute levy could, for example, amount to €1500 for a single-family house with an annual heat demand of 20 MWh. The affected building owners should be able to choose whether they will meet their proportional use obligation directly by installing a renewable energy system, or contribute indirectly to achieving the target goals. The latter is achieved when the revenue from the substitute levy is used to promote cost-efficient structural measures and large systems with heat networks, which are not sufficiently included in the underlying use obligation. This possibility to make the use obligation more flexible has not yet been implemented anywhere. It is also not included in the German use obligation legislation, which is anticipated to become effective in 2009.

4.4. Other regulatory approaches

Other regulatory approaches include proposals on how a new instrument to promote renewable energy in the heat market can be integrated into the existing (European) emissions trading system (Greenhouse Gas Emissions Trading Act—TEHG). The simplest conceivable variant is to expand the scope of application of this Act—which currently only covers energy generation installations with more than 20 MW firing capacity—to include the very large number of small-scale installations as well. However, this option is ruled out simply by the exorbitant transaction costs involved.

Other possible options are

- integrating fossil fuel suppliers into emissions trading by imposing a ceiling on CO_2 emissions caused by the burning of the fossil fuels initially placed on the market by them or
- integrating measures aimed at promoting renewable energy utilisation in the heat market as a contribution to CO_2 emissions reduction (akin to the integration of CDM measures) into the emissions trading scheme.

However, these options are unlikely to achieve the desired outcomes because their impact, especially in encouraging more heat production from renewable energy, is difficult to quantify and may well be negligible.

5. Juristic and economic criteria

In this section we describe the juristic, economic, and other criteria used for the selection of the most suitable policy instruments. Accordingly, we first summarise the essential results of the preliminary juristic examination, before going into detail about criteria from environmental economics. The method of juristic pre-selection itself is transferable to all countries, even though the following details are to some extent only valid for Germany (e.g. regarding the German constitutional law).

5.1. Juristic pre-selection

The preliminary juristic examination must refer to three fundamental levels:

WTO law is affected if trade barriers could result from the instrument (in which case the GATT[4] terms must be observed and also the Agreement on Subsidies[5] if subsidies are involved) or if a product-related technical regulation should be issued (then the TBT[6] should be applied in this respect).

The Germany-based study did not produce any fundamental problems with respect to the WTO law because firstly subsidy programmes must and can be formulated in such a way that they do not fall under the category of specific subsidies as described by Art. 2 of the Agreement on Subsidies. In practice, the agreement can become important if the subsidy does not benefit the users or the particular technology, but rather the suppliers or merchants. Secondly, should the regulation produce effects that limit the free world trade and that are not covered by the TBT or the GATT (generally not the case), then it can principally be assumed that the regulation is sufficiently justified as it is pursuing recognised environmental protection goals.

So far there are no special directives in *EU law* that limit the member states. However, the specifications of the EC Treaty (EC) must be observed with regard to the strict prohibition of interfering with the free movement of goods (Art. 28 EC) and of state subsidies for businesses (Art. 87 EC).

Possible trade-limiting effects (Art. 28 EC) caused by an instrument are permitted when justified by high-ranking climate-protection goals. The approach applied in the decision by the European Court of Justice on 13 March 2001,[7] regarding the German "Act on the Sale of the Electricity to the Grid" from 1990/1998,[8] can be referenced as an example. However, restrictions may possibly arise with regard to the European Subsidy Law (Art. 87 EC). If a state institution grants a cash benefit to certain businesses or commercial lines, then it can be assumed that a subsidy as described by Art. 87 par. 1 EC is existent. Such a subsidy can only be permitted as an exception as long as the criteria described by the Community guidelines on state aid for environmental protection (2001[9]) are observed. These guidelines contain limiting conditions for financial incentives for the use of renewable energy (in particular, the additional costs for renewable energy measures may only be completely compensated for in exceptional cases).

As a result, instruments that lead to the payment of cash benefits to private parties can be considered as compatible with the guidelines of EC Law in the following three cases:

(a) the cash benefit does not go to a commercial business, but rather to a private individual, *or*
(b) the cash benefit is not granted by the state, or agencies commissioned by it, but rather results from an obligation in civil law that is directed at other market participants (like the German EEG in which the obligation to pay for renewable electricity lies with the local operators of the power grids), *or*
(c) the cash benefit is granted by the state, or agencies commissioned by it, and these abide by the conditions defined in the community guidelines on state aid for environmental protection.

At the level of *national constitutional law* it must be examined whether the type of instrument is allowed in the constitutional structure of the country and also ensure that the burdens resulting from the instrument are just and reasonable (commensurability principle).

In those cases where the financially burdening effects are relatively high, it may be necessary to work with exact differentiations, longer transitional periods, exemptions for hardship cases, or supplemental subsidies. In principle, these conditions can be met without substantially weakening the effectiveness of the instrument. A special feature of the German Constitutional Law is that the state is not allowed to collect just any public levies, but is bound to certain forms that are covered by the constitution. The allowed forms are strictly limited to the tax forms foreseen in the constitution and levies that are based on a quid pro quo relationship (basis: the fee that the citizen must pay for a state service). Exceptions can only be permitted under very restrictively interpreted conditions according to a ruling of the German Federal Constitutional Court.[10]

A result of Germany's constitutional levy provisions particularity is that it is not possible in Germany to introduce a regulation that would e.g. obligate the merchants and importers of heating oil and natural gas to pay a levy that would go into a publicly administered fund to be used for financing the promotion of renewable energy use. This very interesting solution would be categorised as an illegal special levy according to German law. However, this path could be followed in other countries.

[4] General Agreement on Tariffs and Trade (1994), OJ EC 1994 L 336/11.

[5] Agreement on Subsidies and Countervailing Measures (1994), OJ EC 1994 L 336/156.

[6] Agreement on Technical Barriers of Trade (1994), OJ EC 1994 L 336/86.

[7] Case C 379/98 („PreußenElektra").

[8] The "Act on the Sale of the Electricity to the Grid"was the forerunner to the current EEG. The Court of Justice declared it to be compatible with the EC Treaty.

[9] OJ EC 2001, 37/3.

[10] See BVerfG (German Federal Constitution Court), Case 2 BvR 413/88 und 1300/93 ("Wasserpfennig"), Decision of March 7, 1995.

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5.2. Economic criteria

The classical environmental economic criteria are static and dynamic efficiency, achievement of objectives, and operability in terms of acceptance and administrative feasibility (see for instance Stavins (2007) for a recent overview). Static efficiency represents the classical cost efficiency of a political instrument that leads to an overall adjustment of marginal costs and prevents incentives to arbitrage gains or windfall profits. Dynamic efficiency is connected to the incentive to innovate given by the policy. Innovators for instance can gain from an emission tax, because the investment in new technology and research will be paid for by the savings in taxes. The achievement of the objectives criterion is particularly important in environmental economics, and can be analysed in terms of overall achievement (will the target be reached at all?) and in terms of speed of achievement (how long does it take to achieve the target?). Command and control instruments such as laws that abolish a certain technology tend to be very precise in terms of achievement but have a very low performance in terms of economic efficiency, for example. The criterion of operability is rather related to the political reality of implementation of instruments. Any instrument with a very low acceptance within interest groups or the general public will cause additional costs in terms of lawsuits, etc. Additionally, if the administrative implementation of an instrument is too complex, unnecessary transaction costs have to be incurred.

Summing up, a new instrument to support RES-H must ensure that the goals defined for expanding renewable energy use in the heat market are achieved in practice. The goals should be achieved at minimum costs, so that not only the direct financial expenditures, but also the administration and inspection efforts must be minimised. Windfall profits should be avoided as far as possible: Someone who would be building with renewables anyway—whether the reasons are environmental consciousness, ownership pride, or personal hedging against negative developments in the fuel market—does not require additional financial support.

5.3. Further criteria

From the viewpoint of ecological effectiveness and economic efficiency, while choosing and designing the policy instruments for achieving defined goals, it is important to decide whether the legislator should concentrate on conceiving a specific instrument exclusively for the RES-H sector, or whether comprehensive, global instruments (like emissions trading or the ecological tax) are sufficient to achieve the goals. In our opinion, there are several substantial reasons supporting the introduction of a promotion instrument specifically tailored to the RES-H market:

- *Long-term perspectives*: Global instruments like emissions trading effect rather short-term adjustment reactions due to their intended changes. For areas like the RES-H market, however, such instruments often fail to provide sufficiently effective price signals and therefore lead to suboptimal results in the end. A suitable promotion instrument must be designed for a long-term horizon in order to effect the required adjustments in the heat market infrastructure.
- *Technology portfolio*: The transformation of markets in terms of a sustainable, future-viable development requires a large measure of "learning investments", i.e. new options must be developed, and existing but not yet economic options must be retained, in order to be able to access a sufficiently large technology portfolio in the long term. Global instruments which lead to a market behaviour that tends to align with short-term demands on investment returns are to a large extent blind to such long-term requirements.
- *Special market barriers*: Beyond the existence of external effects, the RES-H market exhibits several particular market barriers and imperfections that cannot be precisely addressed by global steering instruments. These include, for example, information deficits, insufficient know-how for implementation, as well as structures that are not transparent or open to competition and dominated markets for the grid-bound energies.
- *Multidimensionality*: The spectrum of goals for a sustainable, future-viable development in the heat sector is not as one-dimensional as the steering impact of global instruments, which generally aim exclusively to internalise external effects. A bundle of sector-specific instruments, however, is appropriate to achieve a multitude of specific steering impacts (like climate protection, resource conservation, supply security, regional economic promotion, etc.).

In the long run and with the growing significance of renewable energies in the heat market, the promotion of heat production with renewables using tax revenues should be shifted to other, budget-independent forms of financing. The tax-financed support now in effect has reached its limits in the past time and again. The main reason is that public support programmes are dependent on the cash position of the public authorities. Cutbacks in the subsidy rates, followed by potential investors hoping that the subsidy conditions will improve again, frequently lead to a very irregular market growth.

It is easy to overlook the fact that such an instrument should set the course today for structural changes effective in the long term. Such changes include:

- the increased use of biomass in cogeneration plants,
- the development of the so far little-used potential for solar heat in multistoried and industrial buildings as well as the development of cost-efficient seasonal heat storages,
- the cost-efficient construction of local heat distribution grids, which is indispensable for the use of (deep) geothermal energy and also vitally important for the efficient use of solar heat or biomass.

In particular, the task of fulfilling these long-term requirements cannot be left to the market forces, which are blind in this regard.

5.4. Selection of three specific support schemes

In Section 4 we identified three main categories of instruments (financial instruments, purchase, sale and remuneration obligations, and use obligations) and their respective variants of implementation. In the following the most promising variants from each category will be selected applying the criteria defined above. Section 6 compares and evaluates the selected variants.

Among the financial instruments the classic *government grant* seems most suited though it is budget dependent. Tax breaks offer almost no advantage in comparison to grants but besides the drawbacks there are problems concerning social equity. Increased tax on fossil fuels would have to be very substantial to have any significant impact. This increase would give rise to major problems with public acceptance. Raising new revenues aimed at governmental funding of renewable energy is an interesting option but at least in Germany there is little margin to define such a support scheme according to the levy provisions of the German constitution.

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Of the three models falling into the "purchase, sale, and remuneration obligations" category, the *Bonus Model* appears to be particularly promising and was therefore selected. The Quota Model has shortfalls in transaction procedures and, additionally, the present European experiences in the electricity market with respect to this instrument are not very promising. The third model, which obliges the manufacturers of heating systems to construct a minimum number of renewable energy systems that is fixed by quota, is an interesting option. However, it has shortcomings relating to transaction costs and other economic aspects, and was therefore not pursued further.

In the case of the Bonus Model, the state must adopt the necessary regulations, but does not play a role in the processing and especially the administration of the financial flows. Instead, this becomes the subject of exchange relationships between private persons. This situation removes the risk to get in conflict with the levy provisions of the German constitution.

Out of the three variants of the use obligation, the model that allows the payment of a *substitution levy* instead of building a RES-H plant is chosen. In comparison to the basic variant deficits in execution are less likely, the cost of administrative overhead is reduced, and there is the possibility to finance cost-efficient structural measures in favour of RES-H. The third variant with the option to trade certificates for surpluses produced is more complex and thus this variant would result in higher transaction cost.

From this first assessment our further qualitative and quantitative comparison will focus on government grants, the Bonus Model, and use obligations with substitution levy. These variants have already been described in Section 4.

6. Valuation of main instruments

6.1. Qualitative assessment

Table 2 shows a qualitative economic comparison of the three models. Portions of each of the instruments exhibit particular advantages and disadvantages.

(a) *Government grants*: Investment grants are on principle popular with the recipients. The acceptance is correspondingly high for the large number of operators of subsidised renewable energy systems. Politicians are familiar with this type of support. Additionally, the sum of the transaction costs is particularly low for this model.
The acceptance is lowest for the trade associations representing renewable energies. This statement is at first surprising, but results from the budget dependence of the public grants. In Germany this dependence has consistently led to a stop-and-go development in the renewable energy sector, depending on whether the public funding is exhausted at the time, or if a support programme is issued using new tax 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. This problem is the main disadvantage of public grants as a promotion instrument.

(b) *Use obligation*: The general conditions that are provided by a statutory use obligation are definitely more reliable than a subsidy using tax funds. The market growth can be calculated, resulting in planning security and low investment risks when building up production capacity. Renewable energy trade associations therefore prefer a use obligation.
The most serious disadvantage of use obligations is their deficits in long-term efficiency. A use obligation leaves relatively little margin for economic optimisation. The total system will not be optimised, but rather just the renewable energy systems so that the respective building meets the legal minimum requirement. More structural adjustments in favour of renewable energy, like the construction of local heat networks, can at best be provided only indirectly through the targeted use of the substitute levy. Deficits in technology development also result, because a market for the potentially very efficient large systems is lacking, which could stimulate commercial research and development activities. These deficits are particularly apparent in the long-term perspective.
A further disadvantage of the use obligation is that the necessary replacement of an outdated central-heating boiler might be postponed even longer, in order to delay the onset of the obligation to use renewable energies. This secondary effect of the use obligation is contra-productive.

(c) *Bonus Model*: The Bonus Model has the great advantage that the support can be targeted as precisely as with investment grants, but without the disadvantage of a budget dependence.

Table 2
Instrument comparison

	Government grants	Bonus Model	Use obligation with substitute levy
Cost efficiency and transaction costs			
Establish stable and reliable investment conditions	–	+	+
Medium-term efficiency	+	+	o
Long-term efficiency	+	++	o
Avoid windfall profits	o	+	+
Transaction costs, total	++	+	o
Transaction costs, regulatory	+	+	o
Incentive for efficient system operation	–	+	–
Acceptance			
Degree of change/communication	++	–	+
Politics	+/o	–	o
Citizens	++	+	o
RES trade associations	–	+	o
Fuel associations	o	––	–
Other			
Promotion of technology development	+	+	–
"Polluter-pays" principle	–	++	+
Distribution and social justness	+	+	–
Contra-productive secondary effects	+	+	–

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The necessary developments in infrastructure and technology can thus be specifically supported in a sufficiently continuous manner. For these reasons this model receives favourable valuations for cost efficiency and for acceptance by the renewable energy trade associations. A further advantage of the Bonus Model is its compliance with the polluter-pays principle, since the additional costs for the renewable energy is finally borne by the fuel consumers, who are the ones burdening the climate and the environment with the emissions from their heating systems.

The disadvantages of the Bonus Model lie in the acceptance. One barrier is that there is no example for this kind of model anywhere in the world yet. Politicians and citizens could refer to the success of such a programme if it existed. As a result, a large amount of explaining is required and there are problems with acceptance. The feed-in laws in the electricity market are successful and structured similarly. In the electricity market there is a high degree of resistance against the EEG from power companies. A similar law for the heat market is likely to cause similar resistance from the fuel suppliers, which would also further impede the acceptance by the other groups of players.

6.2. *Quantitative assessment*

All three variants described here were designed to achieve the same quantitative goal for the expansion of renewable heat generation in 2020.

In this section we present the quantitative assessment of the impacts of the different promotion mechanisms using the Invert Simulation Tool. For a detailed description of the model see Stadler et al. (2007). The Invert Simulation Tool is a comprehensive computer model supporting the design of energy planning for RES and the rational use of energy (RUE), with particular focus on the building sector. Invert allows the simulation of the existing and new building stock in terms of demand-side management and the supply side (heating, cooling, DHW systems, solar thermal). In this way, the tool allows the simulation of the impact of various promotion schemes (investment subsidies, bonus systems, use obligations, tax exemptions, subsidy on fuel inputs, CO_2 taxes, soft loans on the penetration of RES and RUE technologies, CO_2 emissions, public expenses, investment needs, etc.)

As already mentioned, Invert is a disaggregated bottom-up model; it allows the definition of any desired building type, specified by a certain thermal quality or any desired single renewable power plant. In the building-related part (heating, cooling, DHW), the algorithm is based on the modelling of the decision-making process of various stakeholders regarding a certain heating/cooling/DHW system option and the insulation/window replacement option. A major element is the implementation of various restrictions, like technological, economic, or cultural parameters such as comfort aspects of energy systems. In particular the "willingness to pay" by private consumers, which has been observed in the past for many renewable heating technologies, can be implemented in the Invert model.

Table 3 shows a quantitative comparison of the three models based on the conditions in Germany (i.e. number of buildings, age structure, quality, etc.). All models result in the same share of renewable energy in the heat market of 12.3% or 570 PJ in 2020. In order to achieve this goal, different parameters were adjusted for each model: the amount of grant funding for the government grant model, the amount of the subsidised share of renewable energy for the use obligation, and the value of the bonuses for the Bonus Model.

The most important categories in this table demonstrate the advantages of investment grants or a Bonus Model over a use obligation:

- The number of systems that must be installed by 2020 in order to reach the goal is significantly larger in the use obligation model than for the other two models. The other two models also feed more renewable energy into heat networks, which is a structural advantage over the use obligation.
- For investment grants and the Bonus Model, the total investment costs (including heat networks) is lower than in the use obligation model. The origin for this difference lies in the construction of cost-efficient large systems, which can be specifically targeted by investment grants or through the design possibilities in the Bonus Model. The lower total investment costs indicate an overall better economic efficiency of these two models.
- The overall transaction costs are low for all models. However, here the investment grants and the Bonus Model both indicate advantages, especially in the costs for the authorities.

Burdens result in different ways in the models. These burdens can be quantified, but cannot be directly compared with each other. The funding from the *investment grants* must be allocated to all tax-payers or saved somewhere else in the budget. In principle, tax-based financing is conceivable, but the absolute sum of the subsidies needed makes this model appear less suitable over the long term than the other two models. In the *use obligation* model ca. 120,000 buildings will be affected within the first year of its coming into effect. Once all types of buildings are included in the obligation to use renewable energy, about 700,000 house or apartment owners will be affected each year. The cost-sharing mechanism in the *Bonus Model*, which will affect all consumers of heating oil or gas, amounts to about 0.007 ct/kWh in the first year after the regulation comes into effect, and 0.14 ct/kWh in 2020. This price corresponds to additional costs of 0.1% and 2.8%, respectively, on today's fuel prices. This cost calculation assumes that the price of oil—starting from the price from

Table 3
Quantitative comparison of the instruments for the example of Germany

	Government grants	Bonus Model	Use obligation with substitute levy
Heat production from renewable energy in 2020	570 PJ	570 PJ	570 PJ
Proportion derived from local district heating	48%	48%	31%
Investment to 2020	€47.6 billion	€47.6 billion	€68.1 billion
Proportion derived from the substitute levy	–	–	€5.6 billion (8%)
Grants or bonus payments in 2020	€1.1 billion	€1.1 billion	–
Total grants or bonus payments to 2020	€13 billion	€10.6 billion	–
Number of new renewable energy systems to 2020	4.0 million	4.0 million	11.4 million
Transaction costs in 2020	€20.9 million	€29.3 million	€31.5 million
Proportion of transaction costs resulting on the authorities' side	€13.7 million	€1.7 million	€8.7 million

mid-2006—does not increase more than 1% per year. A higher rate of price increase would lead to reduced bonus costs.

Various points of view are important when weighing the advantages and disadvantages of the models. Today's perceptions in public and in politics are decisive at first for the practical implementation of a supporting measure. In this area of acceptance we find advantages for investment grants and use obligation. From the point of view of environmental and climate protection, however, today's subjective acceptance is not essential, but rather the future impacts and the efficiency of the instrument are decisive. Here we find the advantages of the Bonus Model. One of the scientific tasks will be to point up the factual advantages of the Bonus Model far enough that sufficient acceptance develops for the introduction of this model.

7. Summary and results

Worldwide and in the EU it will not be possible to meet the requirements of climate protection without increasing the use of renewable energies in the heat market. The instruments in place so far, particularly government grants subsidising the investment costs of solar or biomass systems, will not be sufficient. For this reason, we investigated various innovative instruments. The Bonus Model received the best valuation. This model uses an allocation procedure to distribute the additional costs that are still involved today with the use of RES systems among all fuel consumers according to the ''polluter-pays'' principle. The Bonus Model is distinguished on the one hand by being sufficiently flexible to be able to primarily exploit cost-efficiency potentials and also to advance the necessary long-term infrastructure changes. On the other hand, it enables a reliable return on investment due to the legally guaranteed bonuses for renewable heat, providing the operators of RES systems with a secure calculation base. Risk surcharges can thus be avoided and the bank loans necessary for the construction of systems are also easier to obtain.

Some countries already have similar allocation methods to the advantage of renewable energy in the electricity market. This method is still new in the heat market and therefore runs into problems with acceptance. This publication should help to clarify the factual advantages of the Bonus Model so that the acceptance problems can be overcome.

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Glossary of central economic terms

Allocation-financed measures are paid for by all households. For instance, in the Bonus Model, described in this paper, the necessary amount of money to finance the RES-heat systems is collected from all fossil energy consumers.

Demand-side management (DSM) describes measures by power producers that influence either the time profile or the amount of energy consumption. Peak loads can be shifted by centrally controlling large machinery in the production sector and energy consumption can be influenced by information campaigns on efficient appliances in the household sector.

Feed-in scheme describes a support mechanism for electricity from renewable sources, where a fixed amount of money is paid to the electricity producer per kilowatt hour ''fed'' into the grid.

Non-budgetary instruments do not show up in the government budget. They are financed by fees that are collected from private players and redistributed to beneficiaries. Examples are the feed-in system (electricity consumers pay a surcharge per amount of electricity consumed, transmission grid operators collect the money and distribute it to producers of electricity from RES) or the Bonus Model suggested in this paper.

Use obligation denotes a legal binding direction for the use of certain RES technologies in the housing and building sector.

Quota Models set a share of RES in the energy mix (heat and/or electricity) that has to be reached by producers. Some countries use a quota approach to fulfil the EC targets. Since a Quota Model needs to provide an option if the required shares are not reached, the success of the Quota Models crucially hinges on the opting-out possibilities (amount of penalty for not fulfilling the quota).

Soft loans are supported by the government. They either exhibit lower interest rates (below market rates) or phases with no redemption or other forms of support.

Transaction costs are any costs that arise from execution of a political measure for instance administration costs, legal costs in the case of lawsuits, etc. Transaction costs typically rise with the complexity of an instrument and the degree to which different levels of administration are involved.

Windfall profits are ''lucky gains''. They are profits that do not result from a firm's own activities but often from legal changes or unexpected changes in relative prices.