# Energy Balance

## Optimum System Solutions for Renewable Energy and Energy Efficiency

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Wuppertal Institute
for Climate, Environment
and Energy

**Energy Balance**
Optimum System Solutions for Renewable Energy
and Energy Efficiency

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## Imprint

Energy Balance – Optimum System Solutions for
Renewable Energy and Energy Efficiency
**Summary of Project Results**

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# Introduction

In order to achieve ambitious climate protection objectives, measures are to be taken to simultaneously promote the use of renewable energy, increase energy efficiency and enforce energy saving. Although the significance of these strategic elements is beyond doubt, intertwining them at the institutional, instrumental and technical level still fails to be optimal and has not always been useful.

New questions arise which are becoming more urgent on the background of an increased market penetration of renewable energy and increasing demands on energy efficiency:

- How can **renewable energy be used most efficiently** (efficiency of renewable energy systems)?

  *For example, some poorly adapted pumps of solar collectors consume as much as 15 percent of the primary energy benefit of the system. And some biogas plants do not use the waste heat at all, or to a small extent only.*

- Conversely, how can particularly efficient **technologies and infrastructures use renewable energy in a technically and economically meaningful way** (renewable energy in efficient applications, especially in buildings and neighbourhoods)?

  *For example, the use of solar local heat or biomass heating is technically and economically more difficult in highly efficient passive houses.*

- How can the interaction between renewable energy and energy efficiency be optimized in the **political instruments?**

  *For example, the German Energy Savings Decree (Energieeinsparverordnung) stipulates that a lack of insulating measures can be compensated to a certain degree by renewable energy. Similarly, biofuels are credited to some extent to the necessary efficiency efforts under the $CO_2$ Passenger Car Directive.*

- How can energy policy **instruments** that are successful in the area of renewable energy be **transferred** to the energy efficiency sector and vice versa?

These questions were the starting point of the project "Energiebalance — Optimum System Solutions for Renewable Energy and Energy Efficiency".

### The "Energy Balance" Project

The project consisted of a systematic evaluation of the intertwining approaches in the fields of electricity, heat and traffic at various levels of analysis.

**Target Concepts and Scenarios**

Energy scenarios reveal possible developments of the entire energy system and help to identify the necessary energy policy strategies. Renewable energy and energy efficiency normally are among the fundamental strategic elements. In this context, the following was investigated with respect to various scenarios in Germany: Why is it important to strengthen renewable energy and to increase energy efficiency? In how far are intertwining effects and interactions accounted for?

In order to create an orientation framework for selecting and bundling climate protection activities, a number of energy and climate policy target concepts have emerged in the past few years, such as the "2000 Watt society", "Germany energieautark" or various bioenergy villages and 100 percent renewable communities. They are the models for the development and implementation of measures at various levels, from local concepts to national strategies.

Various national, regional and local government target concepts have been analysed with respect to their level of detail, the synergy effects between renewables and efficiency, and with regard to the implementation processes and stakeholder involvement. As the success of practical implementation basically also depends on whether or not the targets and measures can be readily communicated, the aspects of comprehensibility and public relations were equally included in the assessment.

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**Technologies**

At the technical level, you often find contradictions or negative influences between renewable energy and energy efficiency, for example, as regards the supply of highly efficient neighbourhoods with local heat from renewable energy. Contradictions and synergies of intertwining were identified with respect to some existing, relevant intertwined technologies as well as new technologies that have as yet to be established on the market (such as gas heat pumps, cold local heat, technical supply varieties for passive houses) by performing short technology impact assessments. Especially new and innovative intertwined technologies and concepts were identified and prized in the scope of a competition entitled “Energiebalance - Gut verzahnt geplant!” (well intertwined, well planned).

**Instruments**

One of the objectives of the “Energy balance” research project was to analyse the mechanisms of (mutual) incentives of fundamental promotional instruments of renewable energy and efficiency and to optimize the intertwining processes. In addition, ideas were generated for the design of cross-sectoral, integrated policy approaches. First, the scientific project team prepared input for current legislative projects and amendments by proposing possibilities of extending or amending the scope of intertwining renewable energy and energy efficiency. In addition, medium- and long-term opportunities of making amendments and intertwining were investigated.

The first important interrelationship between renewable energy **(RE)** and energy efficiency **(EE)** was identified when researching higher-level political objectives. In addition to the cross-sectoral climate protection goals, the **expansion goals for renewable energy** must be mentioned at this point which consist of a numerator — the provision of energy on the basis of renewable energy — and a denominator — the energy demand.

$$\textbf{Sectoral share of RE} = \frac{\textbf{RE generation}}{\textbf{Consumption in sector}}$$

Accordingly, the expansion goals can be achieved both by a dynamic growth in provision of renewable energy and plant utilization rate, and by reducing consumption. This is also recognized by the European Renewable Energy Directive: “In order to achieve more easily these [Renewable] targets laid down in this article, each Member State shall promote and encourage energy efficiency and energy saving.”

Systematic intertwining does not yet exist in the various sectors, the political spheres and fields of activities, however, it would not always be useful and possible, either. Still, there are some isolated projects that have explicitly taken up the aspect of intertwining renewable energy and energy efficiency.

### “Solar and Saving Schools”

One good example are the “Solar- und Sparschulen” (“Solar and Saving Schools”) in North Rhine-Westfalia (www.solarundspar.de). These school projects are concerned with combining the installation of major photo-voltaic plants with lighting renewal projects (installation of modern, efficient lighting systems) as well as other energy and water saving investments in a package solution. The investment package is financed through Citizens Contracting, i.e. by citizens acting as dormant shareholders who receive a return on their investment. The projects are part of the “100,000 Watt Solar Initiative” whose basic idea is to install 50 Watt of solar power generation per pupil at selected schools and at the same time to save 50 Watt of lighting power. Thus, a total of 100 Watt generated by conventional methods are saved per pupil.

# Introduction

**Figure 1: The Aggertal-Gymnasium secondary school, Engelskirchen, is one of the solar schools that save money and energy** (Source: Wuppertal Institut)

In this situation, the general question arises: Where would more systematic or more comprehensive intertwining between renewable energy and energy efficiency make sense, and where might it even be counterproductive? Where would it create synergies, and where competition?

The present brochure presents a fraction of the results of the "Energiebalance" project. Its subdivision into chapters reflects the four research aspects of the project:

- Scenarios and target concepts
- Building sector
- Electricity sector
- Traffic sector.

Shake flashlights are an example of "Energiebalance" on a small scale. They combine an efficient lighting technology (LED) with "biogenic" muscle power from the human metabolism and energy store (capacitor).

**Figure 2: The shake flashlight**
(Source: www.schuettel-lampe.de)

# Results and Findings of the Project

**Thesis 1: Multidimensional intertwining**
*"Intertwining" of renewable energy (RE) and energy efficiency (EE) as investigated by the "Energiebalance" project can take place at various levels: It affects both the efficiency* ***of*** *renewable energy systems and the use of renewable energy* ***in*** *efficient applications; it includes technical, social and economic aspects, as well as political instruments.*

**Thesis 2: General intertwining through final energy-related expansion goals**
*Since relative, final energy-related expansion goals have been defined (≥ 30 percent electricity; ≥ 18 percent final energy, etc.), intertwining of renewable energy and energy efficiency takes place through the simple fact that the* ***expansion goals*** *for renewable energy can be achieved through a dynamic expansion of renewable power plant capacities and their utilization, but also by reducing consumption.*

The expansion goals are defined by a numerator — RE generation — and a denominator — the final energy demand. Reducing the denominator by energy efficiency measures results in a reduction of the marginal cost of RE generation required for meeting the target. Therefore, achieving the efficiency goals and the measures to be taken in this respect enjoy high priority.

**Thesis 3: "Twin pillars" of a sustainable energy system**
*Renewable energy and energy efficiency are complementary pillars of the same strategy.*

The climate protection goals of the Federal Government and the abandonment of nuclear energy can be simultaneously achieved if the expansion of renewable energy is accompanied by intensified measures to strengthen energy efficiency.

**Thesis 4: Time base and "lost opportunities"**
*A far-sighted energy policy takes the different time bases and penetration velocities of RE and EE measures into account.*

While RE plants are normally quickly installed and available as a climate protection option within a relatively short period of time, efficiency measures are subject to the investment and substitution cycles, e.g., they are implemented when a new car is bought or a building is refurbished. Abandoning EE in favour of RE at this moment may turn out to be a "lost opportunity" with impacts that last for many years or even decades.

**Thesis 5: Intertwining in target concepts**
*At the level of social target concepts (bioenergy villages, 100 percent RE communities, 2000 Watt society, …), intertwining of renewable energy and energy efficiency takes place at different levels and with varying intensities.*

The national target concepts, such as the 2000 Watt society, emphasize the importance of intertwining activities, because they reflect this importance both as part of their targets and of their measures. However, the higher the level of implementation of the target concepts investigated, the more is intertwining pushed into the background. Especially as regards the regional target concepts, such as bioenergy villages or 100% RE regions, the focus frequently is on the expansion of renewable energy plants.

**Thesis 6: No mutual set-off between renewable energy and energy efficiency**
*Intertwining renewable energy and energy efficiency usually is counterproductive whenever ecologically-economically sensible efficiency measures can be undermined by renewable energy.*

Some examples show that a mutual set-off of RE measures and efficiency efforts is likely to prevent the measures that would actually be required for ecological and economic reasons. The two most far-reaching examples include the primary energy assessment of renewable energy under the Energy Saving Decree and the biofuels credit towards a portion of the 120 g $CO_2$ target for passenger vehicles. Conversely, however, recognizing efficiency measures as a substitute under the Renewable Energy Heat Act (EEWärmeG) may turn out to be useful because using renewable energy sources such as biomass may be more difficult in some cases in specially efficient buildings.

**Thesis 7: Disentanglement of RE and EE**
*Intertwining RE and EE in political instruments can also be achieved by a targeted disentanglement of the legal requirements.*

The envisaged amendments to the Energy Savings Decree 2009, as well as the requirements of the recently enacted Renewable Energy Heat Act, are associated with highly complex intertwining structures. Therefore, it was proposed by the Energiebalance project to stipulate a more transparent requirement concerning the quality of the building shell (such as a maximum heat and final energy demand) in future amendments to the Energy Savings Decree.

**Thesis 8: RE policy also promotes efficient plants**

*RE policy instruments contain a number of efficiency elements already today that have a direct vs. indirect, or explicit vs. implicit effect.*

For example, the strongest *implicit efficiency incentive* stipulated in the Renewable Energy Act (EEG) normally is the amount of remuneration paid. With a given input, increasing the power yield directly increases the amount of remuneration received. However, the EEG also provides for *explicit efficiency incentives* with respect to, e.g., biomass (CHP bonus, technology bonus), *efficiency requirements* (minimum criteria regarding the yield of a wind power location or the electrical efficiency of scrap wood plants laid down in the Biomass Regulation) as well as *implicit efficiency effects* (e.g. by a size graduation of remuneration rates).

**Thesis 9: Learning from the mistakes made in conventional energy supply**

*Intertwining of RE and EE also implies that highly efficient, decentralized CHP plants based on renewable energy must be expanded.*

When expanding renewable energy, we should learn from the current quite painstaking efforts to establish local heat structures on the basis of CHP plants in conventional energy supply - i.e. the decentralization of large power plants and centralization of individual heat generation plants. For this reason, the expansion of highly efficient, renewably fuelled CHP plants should be attributed particular importance.

**Thesis 10: Intertwining creates new incentives for innovation and system efficiency**

*Renewable energy policy should promote an efficient design of systems in the field of electricity, heat and traffic through explicit and implicit efficiency incentives and requirements, especially if these incentives and requirements supply new impulses for innovation or limit resource competition.*

The Energiebalance research team has worked out a vast number of useful efficiency requirements for various political instruments, such as the market incentive programme or the Renewable Energy Act.

**Thesis 11: First support, then demand, and constantly review this relationship**

*Support activates, whereas demands rather stabilize a situation. The relationship between support and demand must be permanently put to a test.*

Support triggers innovative impulses and enables new products and ideas. However, it must be constantly verified whether or not support has become a standard after a while. For example, supporting circulating pumps under the Market Incentive Programme provides an impulse for the development of efficient pumps. As soon as a solid market for particularly efficient pumps has emerged, the energy standard of the pump can be established as a demand.

**Thesis 12: Renewable energy supply for efficient buildings**

*The supply of low-energy, e. g. passive houses with renewable energy — through pipeline networks or individual plants — is associated with new challenges. Therefore, the policy instruments have to create the basis for new infrastructures adapted to new, efficient applications, such as especially efficient heat networks for the joint supply of highly efficient buildings.*

The aim must be to ensure that connection to renewable technology becomes more readily affordable through technical innovation and organizational-structural adjustments. On the other hand, so-called LowEx concepts could be implemented in order to try and lower the flow and return line temperatures to a level that heat distribution losses reach a tolerable range.

**Thesis 13: Innovative heat networks**

*In order to cover the residual heat demand of well-insulated buildings,* ***low-temperature sources*** *with a low exergy content are normally sufficient. Innovative ideas to research and promote heat networks must be developed. The new infrastructural measures, such as cold local heat networks, must be independently evaluated.*

Strategies have to be developed for the reasonable use of district heat systems in efficient neighbourhoods if heat networks are to be sustainably operated or even expanded in the future. This can be achieved, e.g., by using the return line temperatures and through cost-efficient installation solutions, but also by a development of neighbourhoods including older buildings by quarters. For passive houses in terraced house or block arrangements, local heat supply with feeding units and installation through the buildings - using an infrastructure conduit or in the basement - is an economically and environmentally reasonable solution. Even innovative solutions such as "cold local heat" could prove to be beneficial.

**Thesis 14: Simplification of building-related instruments**

*Especially in the area of residential buildings, where most different stakeholders are involved — from the owner up to the building or refurbishing contractor — substantial simplifications of the stipulations and procedures have to and can actually be made.*

A simplification would include not only the fundamental requirements (limit values) but also the calculation methods used.

In order to limit the tendency to "offset" efficiency measures against renewable energy especially as regards biomass, which in itself is limited in supply as a raw material, the primary energy factor of biomass in the German regulation should be changed. The calculation of these factors must also be revised with respect to district heat.

**Thesis 15: Higher transparency**

*A transparent presentation of costs and savings throughout the lifecycle of the RE or EE measure must be obtained to make a sound decision.*

Both with respect to the energy certificate and as part of energy consulting, the costs and savings attributable to the whole lifecycle of the components must be made transparent. For this reason, the integration of energy balance aspects is of special importance in energy consulting. Both training and further training topics must be further developed, tools must be provided and promotional programmes relating to energy consulting must be extended by the relevant requirements.

**Thesis 16: Building 2020 Roadmap**

*Defining a roadmap for future amendments to the Energy Savings Decree 2020 with respect to new buildings and refurbishment offers planning security to all parties involved.*

In concrete terms, this means that future developments are defined already now with respect to the requirements to be made on new buildings and on refurbishment. A good solution would be to use established standards, such as the passive house. As regards new buildings, passive house requirements should be a target already for 2015, and the refurbishment requirements could be gradually raised to the requirements of EnEV 2007 for new buildings less 50 percent (with respect to the insulation quality of the building shell) by the year 2020.

**Thesis 17: Intertwining approaches in the electricity sector**

*In the electricity sector, intertwining RE and EE is not as direct and hardly linked to technical considerations, because in contrast to heat supply, electricity is almost exclusively supplied by cables, and the origin of the electricity plays no role for the end consumer in terms of technology.*

The points of contact between RE and EE are more frequently found at the instrumental level for this reason.

**Thesis 18: Promoting efficiency under the EEG model (NEEG)**

*In Germany, the EEG (Renewable Energy Act) is a proven instrument for the promotion of renewable energy. In principle, the remuneration and new equalization scheme set forth in the EEG can be legally and practically transferred to the field of saving final energy. However, a policy instrument to be referred to as the Negawatt Feed Act (NEEG) in analogy to the EEG should be discussed and tested more in detail prior to its possible implementation. In addition, it has to be accompanied by sectoral and technology-specific programs, e.g., as part of a nationwide EnergySavingFund.*

An NEEG of this type could induce final energy savings, e.g. by offering innovation or market transformation bonuses for manufacturers and importers of energy-efficient technologies or lump-sum remunerations for those who offer energy saving programmes. In any case, a future NEEG must be complemented by sectoral and/or technology-specific programmes that specifically address the implementation impediments identified and target system optimization in addition to promoting standard measures and individual technologies.

# Results and Findings of the Project

**Thesis 19: Intertwining in traffic sector**
*Increasing energy efficiency, reducing fuel consumption and raising the share of RE fuels must preferably be pursued in parallel; the relevant instruments must be optimized independent of each other, and factors hindering or preventing these improvements, such as the various tax privileges for company cars, must be eliminated. Renewable energy and energy efficiency are hardly intertwined instrumentally in the traffic segment, with the exception of the biofuel credit towards the $CO_2$ target for passenger vehicles. This significant existing, yet negative intertwining element must be eliminated.*

This intertwining element is a negative approach from the point of view of climate protection because the efficiency objective and its implementation are watered down by the optional biofuel credit stipulated without giving additional impulses for expanding renewable fuels. The existing EE and RE intertwining approach set forth in the EU Directive on fleet consumption should be eliminated as soon as possible for this reason without raising the existing EE objective (120 g $CO_2$/km) for new vehicles and without further delaying its practical implementation.

**Thesis 20: Electromobility**
*Electromobility is a measure for increasing the efficiency of the drive train — which is defined as the final energy needed per passenger mile. Since the climate and energy balance (with respect to non-regenerative energy sources) of electric vehicles offers robust benefits over cars running on petrol or diesel if they are supplied with renewable energy, linking electric vehicles closely to power supply from regenerative sources will contribute to the desired goal.*

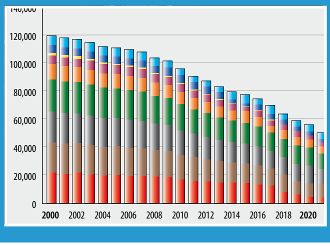
The focus of promotion should initially be on optimizing efficiency as a whole when developing new vehicles.

The coupling mechanism to be prepared should distinguish between the early market entry stage of electric vehicles and a long-term perspective. During the market entry stage, government promotion of electromobility should be intrinsically linked to renewable energy while ensuring that additional RE power is produced. When promoting vehicles by a tax relief or market incentive programme, a pragmatic mechanism should ensure that they are fuelled with green electricity. It must be ruled out that the emissions trading cap is adjusted by the additional amounts of electricity used by electric vehicles.

As a long-term perspective, a second characteristic of electric vehicles will gain in relevance in view of the increasing quantities of fluctuating renewable power generation from wind and solar systems: the possibility of deliberately charging and discharging the battery. The time flexibility in charging electric vehicles is not only a possibility, but also a technical necessity because otherwise grid restrictions could take effect, especially in the distribution network. A system integration bonus that is currently being envisaged under an EEG Decree will have to account for electric vehicles as movable loads.

**Thesis 21: Ambitious RE goals for traction electricity**
*The European 10 percent RE expansion goal for the transport sector must be economically promoted by maximizing the RE portion in the (electro-powered) railway traffic. The Federal Government should instruct its DB Energie infrastructure company accordingly.*

If its “nuclear power” portion is replaced by power from sources other than RE, the railway system will lose its climatic advantage over other modes of transport. This should be prevented, e.g. by specifying dynamic goals for the proportionate RE traction current. With 100 percent in 2020, the traction current could maximally contribute to the EU goal concerning the RE share in the traffic segment (10 percent in 2020), thus reducing the otherwise necessary quantity of biofuels. Public procurement policies can influence the efficiency of the railway fleet already today by drawing up the corresponding public invitations to tender. This should be accounted for more strongly by the federal states in the future. In general, efficiency and renewable energy can also be coupled in procurement policies. However, it is important to avoid crediting efficiency measures towards the expansion of regenerative energy with the result of negative intertwining effects.





## Energy balance in energy scenarios and concepts

What is the significance of expanding renewable energy and increasing energy efficiency in energy scenarios for Germany, and in how far were intertwining of RE and EE considered in addition? This question is answered by current, ambitious climate protection scenarios.[1] The aim of the Energiebalance project was to understand and present the significance and dynamics of the efficiency and renewables strategies selected within the context of the individual scenarios and to identify and assess possible intertwining of EE and RE.

The scenarios investigated demonstrate that there are various approaches and strategies for achieving the desired climate protection goals. The shares or the significance of renewable energy and energy efficiency clearly vary in this context. Figure 3 shows the contribution made by renewables and efficiency towards substituting for conventional energy sources in the various scenarios. The figure shows that both renewable energy and efficiency make significant - and by 2020 similarly important - contributions towards saving energy. However, the contribution of renewables and efficiency differs very much between sectors. In the heat sector, efficiency is normally predominant, whereas in the power sector it is the renewables. However, the scenarios under review do not provide any details concerning intertwining of renewable energy and energy efficiency.

**Primary energy savings by renewable energy and energy efficiency in different energy scenarios**
[in PJ/a]

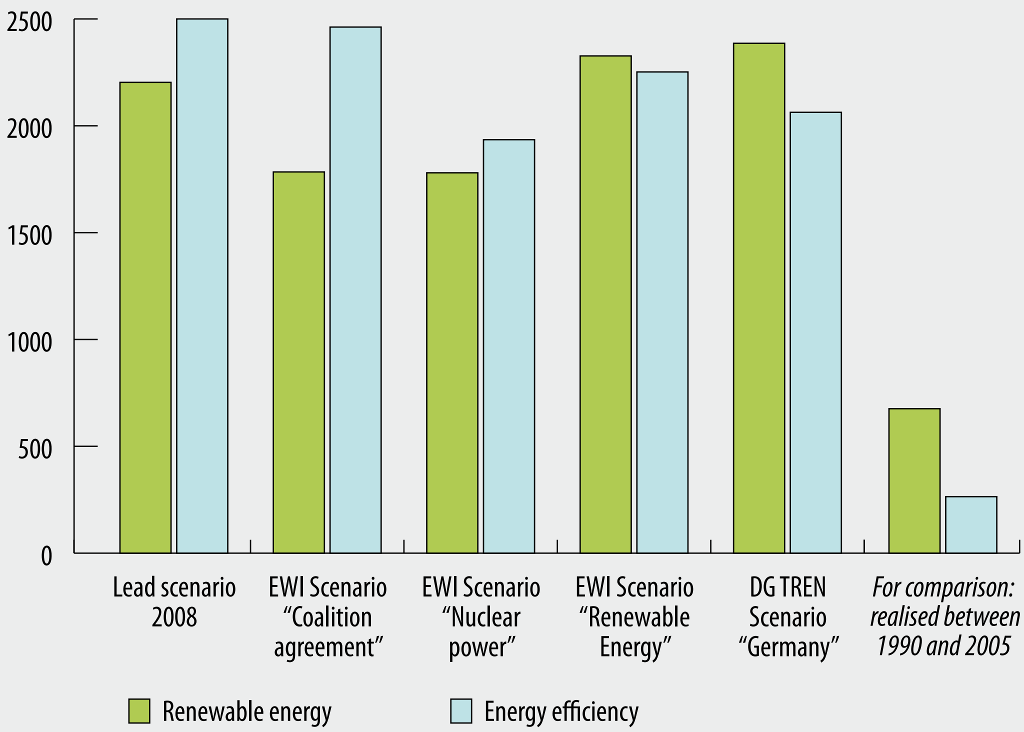
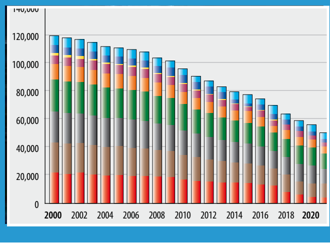



**Figure 3: Contributions of RE and EE to primary energy savings in different scenarios for Germany, 2005–2020**

1 Lead Study 2008 (by J. Nitsch on behalf of BMU), Energy scenarios for the 2007 energy summit (by Energiewirtschaftliches Institut (EW) and Prognos on behalf of BMWi), Target 2020 (by Wuppertal Institut on behalf of WWF), UBA climate protection scenario (UBA), Combined High Renewables and Efficiency Scenario (DG TREN 2006)




When assessing the effectiveness of strategies, the question as to whether or not the targets are reached is not the only aspect that plays an important role. Thus, the time dynamics of the strategy chosen (expansion of renewable energy, development of efficiency potentials, abandonment of nuclear energy or license extension) directly influences the allocation of investments and the drafting of balancing policy instruments or adjustments. This trend is most obvious in the scenarios under review dealing with nuclear power stations. The possible contribution towards saving energy through efficiency measures is lowest in the nuclear power scenario of ewi/Prognos (assuming 20-year license extension) compared to all other scenarios that adhere to the agreed abandonment.

As can be seen in the different scenarios, very high efficiency gains must be realized, and possible "rebound effects" resulting from higher utilization must be simultaneously avoided, if the defined climate protection or emission goals are to be achieved. The assumptions made in the scenarios and the goals for the development of energy efficiency by far exceed the efficiency gains achieved in the past (this is explicitly discussed in the 2008 Lead Scenario). However, some of these gains must be interpreted as a response to climate protection options in other areas that are difficult to implement (e.g. expansion of CHP and offshore wind power). It will be correspondingly difficult to balance a possible lack in efficiency gains by these other options which are equally time-critical, especially with respect to the goals envisaged for the year 2020. Therefore, the high efficiency gains assumed in the scenarios must be generally believed to be highly time critical — there is little "scope" for their implementation.

Those areas in which **renewable energy and energy efficiency mutually impair** each other are of great importance. This is the case whenever the use of renewable energy increasingly becomes uneconomic as a result of exhausting efficiency potentials, so that fossil supply options are maintained or even expanded.

The scenarios investigated hardly ever deal with a possible mutual impairment of energy efficiency and renewable energy. Destructive dynamics of this kind may emerge, e.g., in the field of heat generation where the use of renewable energy (especially for heating buildings) is uneconomic below a certain capacity due to the infrastructures to be established (installation of heat networks). The better the insulation of buildings, the lower is the demand for heat in winter and for air conditioning in summer. Regenerative supply solutions as well as efficient CHP stations sometimes also reach their technical-economic limits in this case.

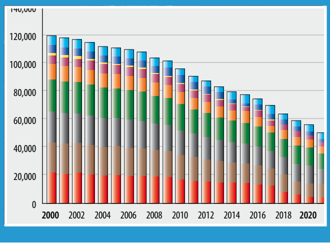
## From the bioenergy village to the 2000 Watt society: Energy policy target concepts

In order to create an orientation framework for selecting and bundling climate protection activities, a number of energy and climate policy target concepts have emerged in the past few years, such as the "2000 Watt society", "Germany energieautark" or various bioenergy villages and 100 percent renewable communities. They are the models for the development and implementation of measures at various levels, from local concepts to national strategies.

The concept analysis focused on the assessment of intertwining of renewable energy and efficiency. How are these two models accounted for already in the definition of the target? Are both areas equally taken into consideration in the implementation of measures? Are different priorities defined if the target concept provides for different levels (national, regional, local)?

National target concepts communicate a vision and define targets. These targets normally are very ambitious, therefore, they require parallel efforts concerning renewable energy and energy efficiency, and can easily benefit from intertwining. The importance of intertwining is illustrated by the example of the 2000 Watt

**What is a target concept?** A target concept is distinguished from an utopia or a vision by a viable model with a well communicable title that is backed by detailed, workable intermediate goals and packages of measures. The way towards reaching the target is included in the definition of the target concept.





**Example: The 2000 Watt society**

Anyone living in Switzerland consumes roughly 5000 Watt of power on average for the most diverse purposes and needs, emitting some 8 to 9 tons of $CO_2$ equivalents per year, whereas globally speaking, the same person gets by (or has to get by) with only 2000 Watt on average. The aim of the 2000 Watt society is to ensure that no-one uses more energetic power for a living also at the national scale.

This goal is to be attained by increasing the efficiency of transforming primary energy into useful energy and by reducing the final energy consumption through improved technologies and new concepts. The concept of the 2000 Watt society initially is a purely resource-related efficiency goal. Intertwining with an expansion strategy in the renewables segment occurs by limiting the fossil share to 500 Watt per person and by defining an upper limit for $CO_2$ emissions (1 ton per capita per annum).

Switzerland has laid down the 2000 Watt society in its strategic goals. It is the responsibility of the Swiss Federal Office of Energy (SFOE). In addition, a number of cantons, local governments and communities have included the 2000 Watt society in their mission statements. This regionalization of the 2000 Watt society gives the concept additional plasticity.

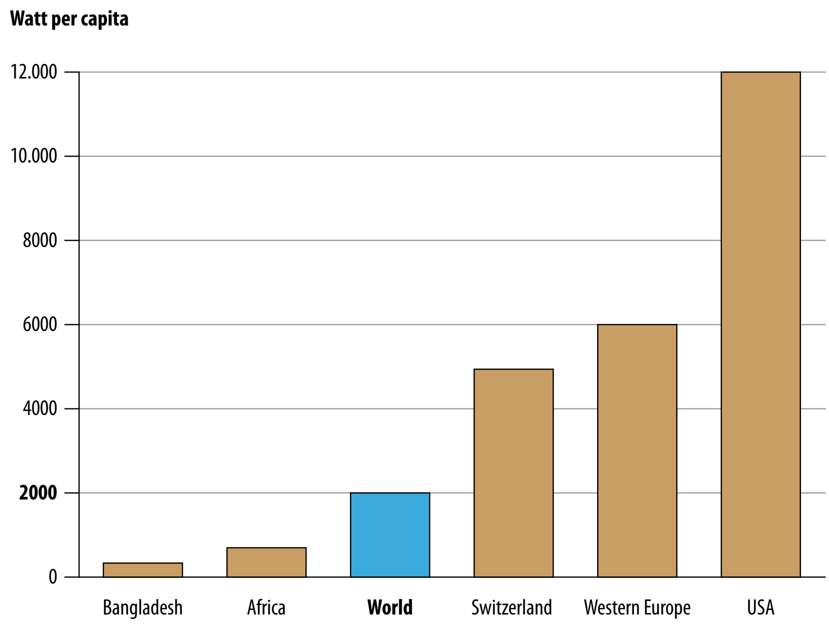
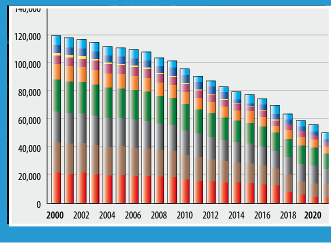



**Figure 4: Average power consumption in global comparison** (Source: novatlantis)

society (cf. Infobox). Renewable and efficiency aspects are accounted for both in the definition of the target (2000 Watt per person, including maximally 500 Watt from fossil energy sources) and in the conceptualization of the fields of action.

A good target in itself is not sufficient. Therefore, national target concepts must not neglect the implementation level, i.e. the actors at the local and regional level. A central element of a national target concept is the link between top-down concepts and bottom-up implementation provisions.




Public awareness of a national target concept is strengthened by an easily communicable title and a strong support by political stakeholders. Detailed targets should be laid down as binding rules in order to ensure that the target concept is a reliable and verifiable foundation. A neutral guardian of the target concept, such as ETH/Novatlantis in the example of the 2000 Watt society, promotes the acceptance, enforceability and durability of a national target concept.

Political implementation processes frequently are very comprehensive, therefore, only few projects have so far been implemented in the scope of national target concepts. This is quite different with communal target concepts, such as the 100% renewable communities. Here, the implementation of specific measures often plays the most important role, and some communities or villages already receive 100% renewable energy supply.

The focus of most of the regional/communal target concepts is directed at renewable energy. Although increasing energy efficiency and implementing energy saving measures are both accounted for in the targets, the implementation of efficiency projects is much more complex and local, so that these measures often take the back seat.

Even progressive target concepts often exhibit few intertwining elements both at the institutional and conceptual level and at the action level. However, some examples for links can be found, including the following:

- As part of its wood energy contracting, the company solarcomplex also *renovates* the heating energy *distribution* when *replacing a boiler*. Reducing the distribution losses by the hydraulic adjustment, the installation of a new pump with differential pressure regulation, and the insulation of distribution lines basically is in the interest of solarcomplex in order to improve the economic efficiency of the plant.
- Another important area where communities can exert their influence is the definition of outline conditions concerning *solar land use planning*. Purchase agreements for properties located in a communal sphere of influence could be amended by structural minimum standards as well as requirements concerning the proportionate use of RE.
- Requirements could also be included in a new *local refurbishment standard*. Under such a standard, the quality of refurbishment can be promoted and verified. Similar to solar land use planning, refurbishment could also be made subject to structural efficiency standards and the use of RE plants.
- In the rural district of Ebersberg, for example, a *"Sustainable building" competition* has been advertised. Under this competition, projects receive a prize that submit especially innovative concepts in the fields of thermal insulation, building materials, energy and water supply.
- In Güssing, every new district heat customer receives *free energy consulting* and a subsidy for the connection cost.

There are many different ways of implementing local target concepts. This variety is mainly caused by the diversity of institutional integration levels of the target concept and of the stakeholders implementing it. Communal projects are often carried out by a "committed protagonist" who promotes the project through his/her personal contacts and goals. Whether or not the inherent dynamics of a target concept are sufficient for successful implementation depends on the time these protagonists can be active (such as the term of office of a mayor). A single, competent, independent stakeholder can do a lot, as can be seen by the large number of current and successful projects.

On this background, the Energiebalance project proposed to establish a funding mechanism for "Energiebalance regions" which should strongly focus on the expansion of renewable energy and the implementation of projects to save energy and increase efficiency. This proposal was put into practice in an amended form in the scope of the National Climate Protection Initiative.


**Figure 5: The energy-autonomous town of Güssing in Austria** (Source: EEE GmbH)

### Example: "Güssing"

As early as in 1990, the local council resolved to save electricity and heating energy in the buildings of the Austrian community of Güssing. However, it was not before great efforts had been made to refurbish the public buildings that the goal of replacing fossil energy supply solutions and search for alternatives was defined. In 1991, the biomass district heat supply concept was presented at the initiative of some individuals and adopted by the local council. A district heat supply network with a length of 27 km has supplied all public buildings, large commercial consumers and many small-scale consumers with affordable heat from biomass.

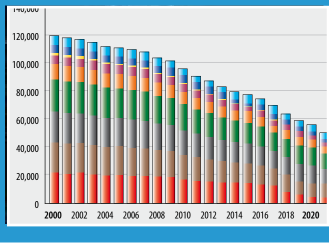
When this initial success had been achieved, the idea was born to produce the entire energy demand (including electricity and fuel) from renewable sources. The cogeneration project was started. Since 2004, more than the entire energy demand of Güssing (heat, electricity and fuel) has been generated from regional raw materials. As much as approx. Euro 13 million per annum remain in town — the starting point for regional structural change.

The idea was born and the initiative was taken for this project by a small group of persons living in the community. Based on the difficult economic situation in Güssing (70 Percent weekly commuters, a strong movement of labour, and bad infrastructural conditions), the concept was accepted and implemented due to its regional development opportunities.

At the same time, Güssing is a good example of a target concept without an intertwining element at the target definition level. Intertwining took place one level below, in form of the activities. For example, all public buildings in the centre of town were energetically refurbished (thermal insulation, new windows, and refurbishment of the heating distribution network) and connected to the biomass district heat network. A further training centre was established (e.g. training tradesmen to become solar fitters or specialists in efficiency upgrades in plumbing). In addition, the community of Güssing provided energy consulting to all final customers replacing their old oil-fired boiler with district heat, and subsidized connection to district heat.

The success is basically owing to the unanimity of those who had the idea and their political environment, such as considerable subsidies from the European Union and the Federal Government. One major impediment — the availability of a natural gas infrastructure — did not exist in Güssing. In addition, interim success such as the signing of long-term supply contracts with the forestry association through the personal commitment of the mayor, helped to keep district heat prices stable. This resulted in a sustainable image improvement of district heat.

And last but not least, the general model role of this project is to be mentioned. When the biomass heating station for district heat supply was built in Güssing, it was the first of its kind in Austria. The erection of the fluidized bed gasification plant was accompanied by a relocation of research to this region, and a promotion of "energy tourism". This technological model role is continued by the fuel cell test facilities, solar air conditioning systems and a renewable energy research centre today.



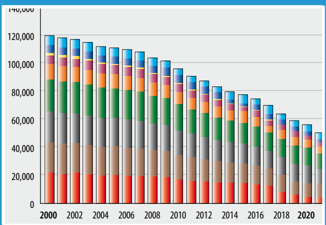

## "Gut verzahnt geplant!" competition — or "Well inter-twined, well planned"

In search of technologies and concepts that intertwine the efficient use of energy resources and the use of renewable energy in an exemplary manner, the **"Energiebalance — gut verzahnt geplant!"** competition was advertised. The purpose of this competition was to award a prize to innovative technologies and concepts, to make them popular, and at the same time to collect evidence of intertwining activities for the current project. The invitation to participate in the competition was started in fall 2007 and was aimed at developers, engineers and designers from trade, industry, and crafts, at companies and consultants from the service sector as well as research institutions, local governments and energy agencies.

More than 50 project descriptions, concepts and products of different kinds were submitted by 31 Dec. 2007. A jury composed of experts in energy technology and business assessed the prize winners with respect to their degree of intertwining, innovative character, market potential and final energy savings. The products or plants had to be available as prototypes, and their operational capability had to be evidenced. In addition, realistic forecasts concerning the costs, economic efficiency and market potential were to be submitted.

As regards the concepts, great importance was placed on a description of methods, an outline of the target groups, a quantification of the potential effects and the identification of application areas. A description of the renewable energy and energy efficiency segments intertwined was of special importance for both the products and the concepts. Out of the total of 56 submissions, 21 referred to building concepts, thus clearly emphasizing the importance of intertwining in the building segment.


**Figure 6: Prize winners of the "Gut verzahnt geplant!" competition at the award ceremony at 6 May 2008 in Berlin**






### Winner in the buildings category: Graw planning office with its project "Solar neighbourhood in Cologne Ossendorf"

The jury declared the Cologne Ossendorf project the winner of the competition. In this project, a housing development built in the 1960s with decentralized energy supply (coal or night storage heaters) was thoroughly refurbished despite being occupied. A particularly efficient building standard could be achieved with respect to an ideal cost-benefit ratio.

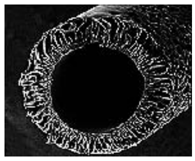
Building energy supply was centralized, and is now generated by a biomass boiler combined with a flue gas condensation system that also uses the latent heat and reduces the fine dust emissions.

The jury was especially impressed by the consistent application of the "insulation first, installation afterwards" approach and the successful integration of the most important stakeholders — the tenants and the building society. This example demonstrates that high savings of $CO_2$ and energy cost can even be achieved in difficult economic situations and in publicly funded housing developments without compromising the quality of the work, renewable energy using innovative technologies or design aspects.

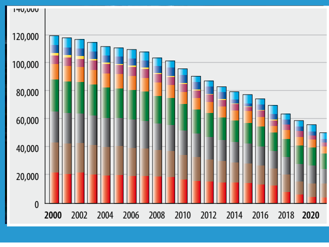
### Runner-up in the buildings category: THP-Architekten for the "Blankenfelde Town Estate — refurbishment according to the model of the 2000 Watt society"

The non-profit organisation "Verein Stadtgut Blankenfelde e.V." is highly committed to establishing a regenerative 2,000 Watt society on location. The jury hereby awards a prize to a demanding project that combines both sufficiency — through the joint and prudent use of resources, rooms and equipment — and high efficiency — even under the difficult conditions presented by monument preservation requirements — in the scope of the $CO_2$ neutral heating concept. 18 buildings, 18 concepts: the Town Estate demonstrates a sensitive yet holistically designed overall concept.

### Runner-up in the industry and infrastructure category: Makatec GmbH with the "Heating and cooling using the membrane absorption technology for heat exchange" project



A new heat exchanger developed by Makatec GmbH on polymer basis could take the absorption technology on the road to success especially in the low-power segment. This innovative membrane technology brings us much closer to a cost-efficient utilization of exhaust heat currents, the development of small, affordable gas heat pumps and efficient solar cooling. Even entirely new approaches to cooling without additional energy input in the mobile freight and car segment are thus conceivable.




### 3rd place in the industry and infrastructure category: Viessmann Werke GmbH & Co KG for the "Efficiency-Plus" project

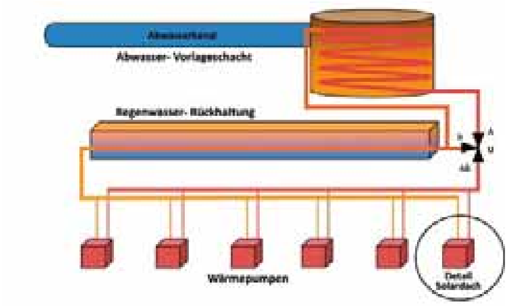
The jury was especially impressed by the consistent implementation of the triple improvement consisting of reduced consumption, efficient energy converters and renewable supply of the residual energy demand along the entire value-added chain. Innovative technologies, such as ORC turbines and Stirling machines, and proven measures such as the insulation of the building shell, lighting according to need and the optimization of industrial processes, are performed in parallel here.

### 3rd place in the buildings category: Frankfurt building department for the "Passive house school on Riedberg" project

Additional cost of only 5 percent was incurred to build the Riedberg school as a passive house in combination with renewable energy. It is a successful model that sets standards for new public buildings in the city of Frankfurt on Main to be built in the future. Based on the positive experience made with this project, any new public buildings will have to be erected according to the passive house standard. Thus, the city has managed to implement an innovative project in the non-residential building sector with a broad publicity effect.

### Special prize: 3E-Consult for the "Cold local heat" project

Increasing energetic demands on building standards and innovative building technology also call for new solutions for a heat infrastructure. The "Cold local heat" project sets innovative standards in this context: the centralized provision of solar heat and waste heat at a low temperature level and the distribution of this "cold local heat" to decentralized, very low-loss heat pumps at low cost could be a method of providing even well-insulated developments with efficient, low-cost energy.




For more detailed information on the projects, please refer to the pdf brochure of the competition that is available for download at www.ifeu.de/energiebalance or www.wupperinst.org/projekte/fg1.



## Energy balance in the building sector

Intertwining renewables and efficiency is of special importance in the building sector. In the year 2007, almost 2,700 PJ of energy were expended for heating and hot water supply. The significance of ideal intertwining in the building sector becomes obvious when looking at the following examples of the current situation:

- About one-third of all $CO_2$ emissions in Germany are caused by the building sector (i.e. more than 3 tons of $CO_2$ per capita per year), with a decisive share being attributable to residential buildings.
- Multi-family houses consume 173 kWh/$m^2$a of natural gas for heating and hot water on average, whereas passive houses achieve the same goal with an energy demand of less than 30 kWh/$m^2$a.
- With a share of more than 70 percent, oil and gas are the most important energy sources for heat generation in the building sector.
- 1.4 million dwellings in Germany — one out of 25 — are still electrically heated.
- Some 70 percent of the heat generated by RE today comes from individual plants, mostly from biomass.

In the building sector, renewables and efficiency are particularly closely intertwined. The decisions concerning a heating system and building insulation cannot be made independently. However, there is competition in this important sector for the achievement of climate protection goals which prevents intertwining. In the scope of the Energiebalance project, expert interviews and workshops were conducted and instruments were analysed to identify the manifold impediments preventing an intertwined approach in the building sector. In addition, the Energiebalance project tried to answer the question which technologies of renewable heat supply can be reasonably used in efficient buildings with respect to technical and energy requirements, and which infrastructure has to be provided.

**Technologies for intertwining efficiency and renewables — the example of gas heat pumps**

Gas heat pumps basically function in the same way as a refrigerator: they extract heat from their environment and deliver it at a higher temperature level. Either air, earth or water (such as well water or wastewater) may serve as heat source. Electrically operated heat pumps have become increasingly popular especially in new buildings, and exhibited high growth rates in the past few years.

While electric heat pumps are commercially available and gain ever more importance, gas heat pumps for use in single and multi-family homes still remain at an early market stage. The gas heat pump may be designed as a gas motor or a gas sorption system. The first variety uses a gas motor instead of an electric motor to drive the compressor. The engine's waste heat has a relatively high temperature level and is supplied to the heating circuit in addition to the ambient heat actually used in the process. In the sorption variety, natural gas is burnt in a burner, and the resulting heat is used for the regeneration process of the coolant. For applications requiring higher amounts of energy — e.g. to heat and dehumidify pools — heat pumps driven by gas motors are already available today.

Like electric heat pumps, gas heat pumps are capable of supplying ambient heat, i.e. a certain regenerative portion, to a heating system. Low-temperature heating systems of the type found in surface heating systems with low flow temperatures have a positive effect on the efficiency of the plant (high seasonal performance factor SPF). Low-temperature heating systems normally require a good insulation level of the building. For this reason, heat pumps are especially suitable in new buildings and in energetically well refurbished old buildings. Gas heat pumps may use their burner or motor as a higher-level heat source in addition to the ambient heat, which makes them also suitable — with

certain restrictions — for existing buildings with lower insulation levels. Since it is not always possible to retrofit earth loops to existing buildings, a gas motor heat pump or a sorption heat pump with a solar air collector may be an option which generally has a more positive energetic effect than electrically operated air heat pumps.

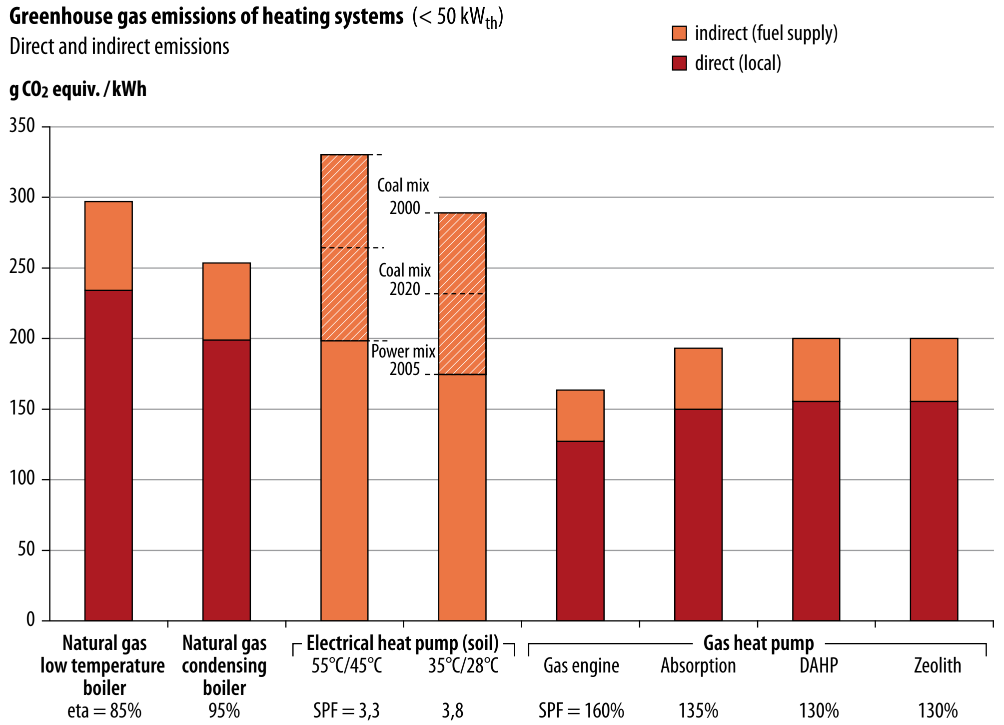



**Figure 7: Bandwidth of greenhouse gas emissions of electric and gas heat pumps compared to natural gas boilers (eta: efficiency / SPF: Seasonal performance factor / DAHP: Diffusion Absorption Heat Pump)**

Heat pumps can also be designed as air conditioners. Since a growing demand for air conditioning is to be expected in the future as a result of global warming, this would be an additional argument for using heat pumps. Under the aspect of integrated planning, however, first it should always be tried to keep the air conditioning demand as low as possible through a number of different measures (insulation, shadowing, reducing internal cooling loads, night cooling etc.).

From the ecological point of view, gas heat pumps are superior to the gas condensing technology already today and offer additional potential for optimization which lets us expect an even greater ecological margin in the future. Potential $CO_2$ savings of gas heat pumps can be estimated at approx. 20 percent to 40 percent compared to the reference technology. The ecological comparison with electric heat pumps is largely determined by the assumptions concerning the power generation for the heat pumps. When assuming the „power mix" (which favours electric heat pumps), gas and electric heat pumps approximately reach equal levels (Figure 7). In the less favourable case of a "carbon mix", the natural gas heat pump offers considerable ecological benefits over the electric heat pump. The ecological benefit of the natural gas heat pump over the electric heat pump disappears with reduced $CO_2$ emissions in electricity generation. On the other hand, however, the increased use of biogas in the future will improve the life cycle assessment of the natural gas heat pump. The precise effects are difficult to estimate at the moment.



The following applies to the economic comparison: Regardless of the fact that only prototypes (made by Buderus and Vaillant) are currently available for the lower power range and that no reliable information can be provided concerning the specific investment for this reason, the future development of electricity and gas prices will be a decisive factor for deciding whether electricity-based or gas-based heat pumps will be more cost-efficient in the future. In practice, the efficiency of the plant (gas or electric heat pump) considerably diverges from the values advertised by manufacturers, associations and some political sources in some cases. This problem should be addressed by suitable quality assurance, i.e. proper planning and installation on the one hand and consistent energy monitoring on the other.

## Intertwining technologies — supply of renewable energy to highly efficient buildings

The Energiebalance project performed a detailed comparison of nine different supply options by the example of a passive house neighbourhood (cf. Table 1). The primary objective was to find out in how far the use of CHP still makes sense given the low standard of energy demand, and in how far district heat supply networks still are economically and ecologically competitive compared to alternative options of individual and local heat supply. For this purpose, the heat network losses, the total annual cost for various price increase scenarios as well as the $CO_2$ emissions were determined with special emphasis on the possibilities of district or local heat supply using centralized or local energy generation. The results of the study with respect to the three principal criteria outlined above have been summarized in table 1.

The model calculations showed the following relevant and reliable results as regards the infrastructural supply of passive houses.

**District heat networks** in conventional design (with stub lines) cannot be recommended, and in innovative design (with infrastructure conduit, feeding units or central district heat transfer station), they can be partially recommended in terms of energy and climate policy due to the high proportional loss compared to the final energy actually purchased. Despite the proven economic efficiency of innovative variants, the connection of highly efficient buildings or neighbourhoods is in many cases not interesting from the point of view of energy suppliers, and sometimes even denied in practice due to the relatively high investment costs. However, integrating the feed line flow of a neighbourhood of passive buildings in a conventional district heat return flow may also be an interesting option for energy suppliers. The climate protection effects of district heat supply can't generally be presumed but must be assessed on a case-to-case basis.

**Local heat supply networks** are a more interesting option than district heat with respect to the three principal criteria. Integrating renewable energy or a major CHP portion are also possible here. There are no district heat losses, and the losses in the local heat network can be reduced through various measures, in particular, by installing the pipelines inside the buildings. Considerable cost savings can be achieved by providing a prefabricated infrastructure channel already during the construction stage. Small networks may even do without transfer stations and supply heat to the radiators in the building directly. Feeding units supplied by wood pellet boilers combined with solar thermal plants score positively both with respect to $CO_2$ emissions and in terms of economic efficiency. The distribution losses are small, and by combining the heat supply for several individual buildings, conventionally sized boilers may be installed. One problem of the supply option with feeding units is the question as to who owns the plant and who operates it. The different building owners have to make a private-law agreement to jointly operate and finance a power plant. Plant contracting could be a solution to such problems associated with responsibilities. In addition to the variant with wood pellets, a local heat CHP station as well as cold local heat achieve good results for the items under investigation.

The centralized supply solutions described above were compared to the **individual supply options:** direct electric heaters and the heat supply by compact heat pump units. Their network losses are practically zero. Direct electric

**Table 1: Heat supply options of a passive house settlement and their assessment**

| No. | Description | Network loss | Climate protection | Economic efficiency | Recommendation |
|---|---|---|---|---|---|
| **District heat (CHP share > 50%)** | | | | | |
| 0 | Conventional district heat supply (stub lines) | - - | +/- [1] | - | Not recommended |
| 1 | District heat supply pipe through the buildings (infrastrcture conduit) | - | +/- [1] | + | Partially recommended |
| 2 | District heat transfer at terminals (block supply) | - - | +/- [1] | + | Partially recommended |
| 3 | Centralized district heat transfer station and local heat supply through the buildings (infrastructure conduit) | - | +/- [1] | + + | (Partially) recommended |
| **Local heat** | | | | | |
| 4 | Decentralized local heat supply network through the buildings with CHP (CHP share > 50%) | + | + | + + | Recommended |
| 5 | Wood pellet boiler at feeding unit | + | + + | + + | Highly recommended |
| 6 | Cold local heat supply from borehole heat exchanger field and heat pumps in feeding units | + | +/o [2] | + + | Recommended |
| **Individual supply** | | | | | |
| 7 | Direct electric heater | + + | - - | o | Not recommended |
| 8 | Compact heat pump unit | + + | +/o [2] | - | Partially recommended |

[1] Subject to type of cogeneration station (fuel, efficiency) and quality, temperature level and size of the district heat network (pipeline losses)

[2] Subject to the assumptions concerning the way in which power is generated for the electric heat pump (power plant mix, marginal power station, etc.)

++ great benefits
+ benefits
o neutral
- disadvantages
-- great disadvantages

heating is attractive because of its low investment cost, but at the same time, it is associated with the highest operating cost and the highest impact on the climate. Direct electric heating cannot be recommended because of its unfavourable environmental balance and because this variant is particularly susceptible to future electricity cost increases. Compact heat pumps are approximately three times more efficient than direct electric heaters. The life cycle assessment of their impact on the climate and the consumption cost is accordingly better. However, their economic efficiency continues to be in the mid-range only because of the as yet high investments involved. Especially when assuming lower prices for compact units in the future, they are an interesting solution for the individual supply of passive houses.

For all variants (except Var. 1 and 4), the integration of **solar thermal plants** for hot water generation was additionally examined. This analysis shows that the inclusion of solar energy has a very positive effect on the climate (reduction of $CO_2$ emissions by up to 30 percent). However, without subsidies, the economic effi-



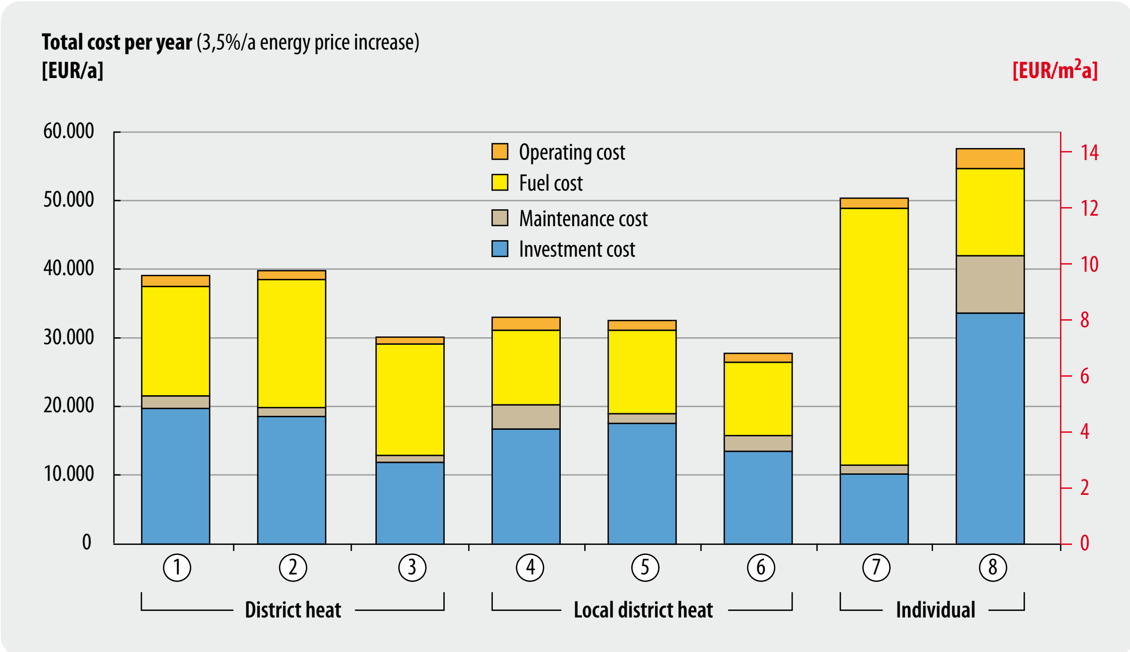



**Figure 8: Total annual cost of heat supply of a passive house neighbourhood comprising 34 dwellings with a floor space of 120 m² each (calculation to VDI 2067, energy price increase of 3.5% p.a.).**

1 Pipe through buildings (infrastructure conduit)
2 Terminals (block supply)
3 Centralized heat transfer station / pipe through buildings
4 Block heat and power plant (CHP)
5 Wood pellet boiler (block supply)
6 Cold local heat
7 Direct electric heater
8 Compact heat pump unit

ciency of this option is rather doubtful given the current energy prices.

In order to cover the residual heat demand of well-insulated buildings, low-temperature sources with a low exergy content are normally sufficient. In the future, these so-called “low-ex concepts” will increasingly gain significance for the supply of highly efficient buildings with renewable energy. They provide for, e.g., the graduated provision of heat at two temperature levels (heating water / potable hot water) or the connection of low-energy houses or neighbourhoods to the district heat return line of a conventional district heat network with its currently relatively high flow temperatures. Even “cold local heat” is such a concept which is characterized by heat transport at a very low temperature level (e.g. flow/return line 20°C/15°C and less). As a result, both the heat distribution losses (network losses, especially in summer) and the installation costs (through lower insulation material thickness or no pipeline insulation in most parts at all) could be considerably reduced. Suitable heat sources include, in particular, regenerative low-temperature sources such as solar energy, environmental heat (e.g. rain water, river water, ground water, surface water, tunnel water, leakage water), geothermal heat and “waste heat” from local sources, such as industrial plants. Electric or gas heat pumps can be used to raise the low flow temperatures to a useful level.

## Disentanglement or intertwining? The Energy Savings Decree and the Act on the Promotion of Renewable Energies in the Heat Sector

Special intertwining provisions concerning renewables and efficiency have been implemented by the so-called **Energy Savings Decree (EnEV)** which stipulates technical requirements as to buildings and sets forth the boundary conditions for the preparation and presentation of the building energy certificates. The purpose of the EnEV is to reduce the energy demand of heating, hot drinking water and for cooling, ventilation, etc.

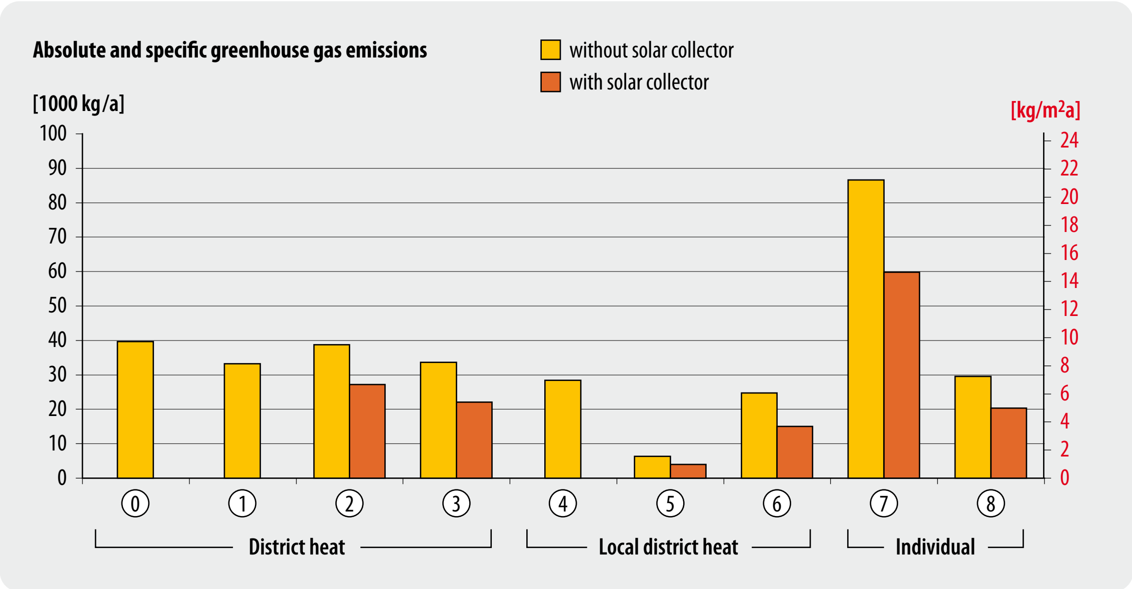



**Figure 9: Absolute and floor space related annual greenhouse gas emissions of the whole neighbourhood (with and without solar plant)**

0 Conventional (stub lines)
1 Pipe through buildings (infrastructure conduit)
2 Terminals (block supply)
3 Centralized heat transfer station / pipe through buildings
4 Block heat and power plant (CHP)
5 Wood pellet boiler (block supply)
6 Cold local heat
7 Direct electric heater
8 Compact heat pump unit

Among other requirements, the following limits have been defined in the EnEV for the different areas (residential or non-residential building, new building or refurbishment of existing structures):

- **The annual primary energy demand ($q_p$)** describes the energy required for heating, hot water preparation, ventilation, air conditioning, etc., that has been evaluated with respect to the demand for fossil-nuclear resources. In addition to the quality of the building shell, the utilization rate and the type of fuel of the building technology contributes to this factor. Renewable energy carriers lead to a very low annual primary energy demand.
- **The transmission heat loss ($H_T$')** describes the mean k value (in German: "U value") of all structural elements of a building, i.e. the quality of the building shell insulation.
- If only certain parts of a building are refurbished, the requirements concerning the U values of individual structural components must be complied with.

The benefit of these multiple limit values is the increased flexibility in planning and architectural freedom. A certain disadvantage for climate protection lies in the fact that measures may be shifted with the result that a lower quality of structural elements is chosen in order to be able to afford renewable energy.

In addition to the EnEV, another building-specific instrument was introduced as per 1/1/2009, the **Renewable Energy Heat Act (EEWärmeG).** According to this Act, a share of the thermal energy demand of newly constructed buildings must be covered with renewable energy. Different types of renewable energy can be used by themselves or combined. The Act also sets forth the different shares to be fulfilled by the various thermal sources for covering the thermal energy demand. In addition, requirements are stipulated concerning the technologies used (e.g. quality seals for solar panels).

If no renewable energy systems are to be or can be used, other climate-friendly measures, so-called alternative measures, can be taken, such as improved thermal insulation of the building 15 percent beyond the measure required under EnEV, use of waste heat and, if certain conditions are met, from local and district heat supply or cogeneration (CHP).



### Reference building method

For residential buildings, a so-called reference building procedure was introduced in the EnEV 2009. Design requirements concerning the quality of thermal insulation (k values) and the building technology apply to the reference building. Among other things, the reference building has a solar-powered central drinking water heater. The primary energy limit value thus already implies a renewable energy share.

Using this reference data, the corresponding primary energy demand is calculated for each individual building which is then taken as the limit value for the actual building. In addition, the maximum specific transmission heat losses were specified for certain building types (single family home, small and big multi-family home). The k values for the refurbishment of structural components became much stricter.

Thus, the EnEV 2009 provides for multiple intertwining between renewables and efficiency. The limit value of EnEV accounts for a solar plant, whereas the EEwärmeG not only stipulates efficiency requirements for such a plant, but also permits improved insulation instead of a renewable energy system.

The Energiebalance project tried to verify this complicated system by calculating the relevant values for five model buildings. The preliminaries of these calculations were contributed to the discussion process surrounding the Renewable Energy Heat Act.

## Newly erected buildings

The results of the calculations[2] concerning the transmission heat loss of five selected types of buildings (Figure 10) show that the explicit $H_T'$ requirements stipulated in EnEV 2009 (draft) (■) are more strict for almost all buildings (except terraced houses) than those set forth in the currently applicable EnEV 2007 (◆). However, the $H_T'$ value can also be calculated from the primary energy demand: For example, if calculations are based on a fuel oil heater without renewable energy, a relatively strict $H_T'$ value has to be complied with because a solar plant was assumed to exist in the reference building which must be compensated by improved insulation or tightness of the building or by heat recovery in this case (▲).

In addition, however, such a building also has to comply with the provisions of the Renewable Energies in the Heat Sector Act. When assuming that the building is not connected to a heat supply network or the like, it would additionally have to remain below the requirements of EnEV by 15 Percent — both with respect to the primary energy limit and $H_T'$. This would result in even stricter $H_T'$ requirements some of which can only be complied with if passive house components are used (○). However, there is a possibility in these cases to compensate increasingly strict primary energy requirements by installing ventilation systems with heat recovery, for example.

This contrasts with the use of renewable energy carriers, such as biomass. In this case, values will always remain below the primary energy requirements. The explicit limit values (■) will apply to $H_T'$. However, these values are only 11 percent lower than the old limit values, on average (this applies to both the mean value of the buildings under review, and the mean value of newly constructed buildings in Germany). The stricter requirements stipulated by EnEV with respect to the quality of the building's shell can thus be largely avoided by using renewable energy sources - which is actually demanded by EEWärmeG. However, this may be quite problematic because

- Heating systems have a significantly shorter life than the building's shell. The refurbishment measures concerning the building's shell define its final energy demand for many decades.
- Especially biomass is limited in supply. In order to largely replace other energy sources, it should be used in efficient applications.

Renewable energy has a more than average share in the reduction of the primary energy demand, where the improvement of the building shell accounts for a below-average share. Thus, the insulation measures that appear to be especially economic, given today's energy

2 The calculations were based on the draft version of EnEV from January 2009.

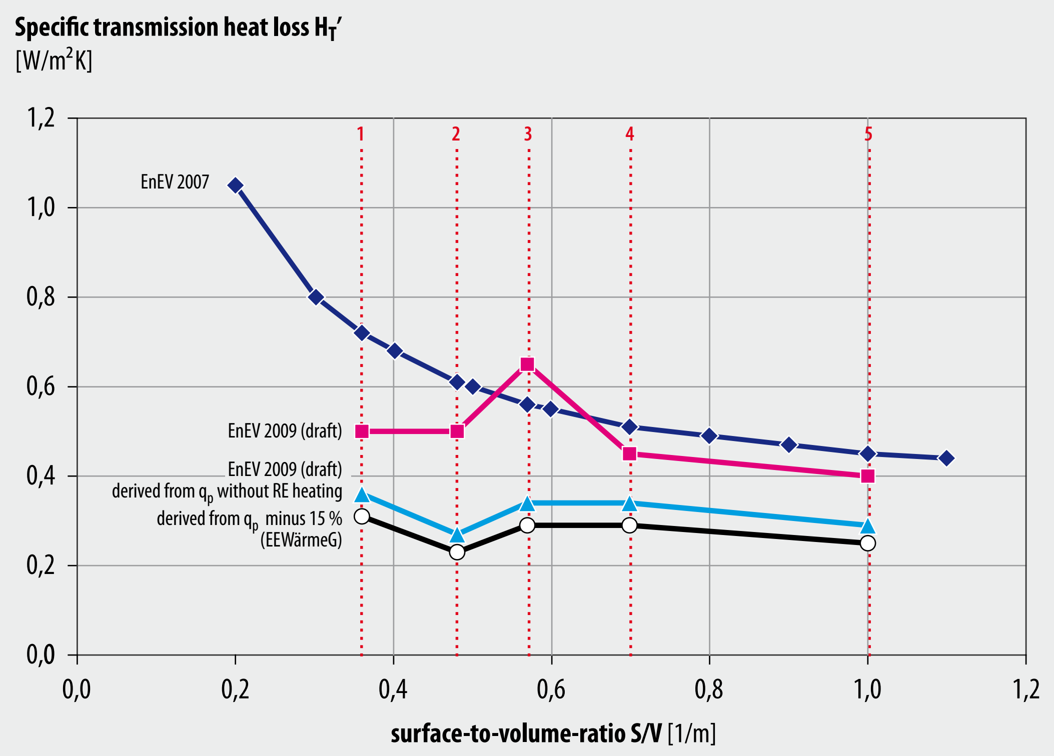



**Figure 10: Maximum transmission heat loss $H_T'$ as a function of the surface area/volume ratio (S/V) of the five model buildings**

- ◆ according to currently valid EnEV 2007
- ■ according to draft EnEV 2009
- ▲ that would have to be achieved in order to satisfy the primary energy requirements under the reference building method without using renewable energy
- ○ and in order to satisfy the primary energy requirements less 15 percent (requirement under EEWärmeG)

1: large residential building | 2: residential building | 3: terraced house | 4: semidetached house | 5: detached house

prices, are at a disadvantage. In addition, it becomes obvious that the circular reference made in the laws limits their transparency and understanding.

## Refurbishment of existing buildings

Even more obvious are the possibilities of mutual offsets if existing buildings are refurbished. In the framework of EnEV 2009 (as in EnEV 2007), there is the possibility of choosing between two approaches:

- compliance with the requirements on individual structural components to be refurbished (e.g. max. U value of walls, windows etc.), if more than 10 percent of the entire component surface is affected by changes, or
- compliance with the primary energy demands on newly constructed buildings (qP reference building) with a 40 percent markup.



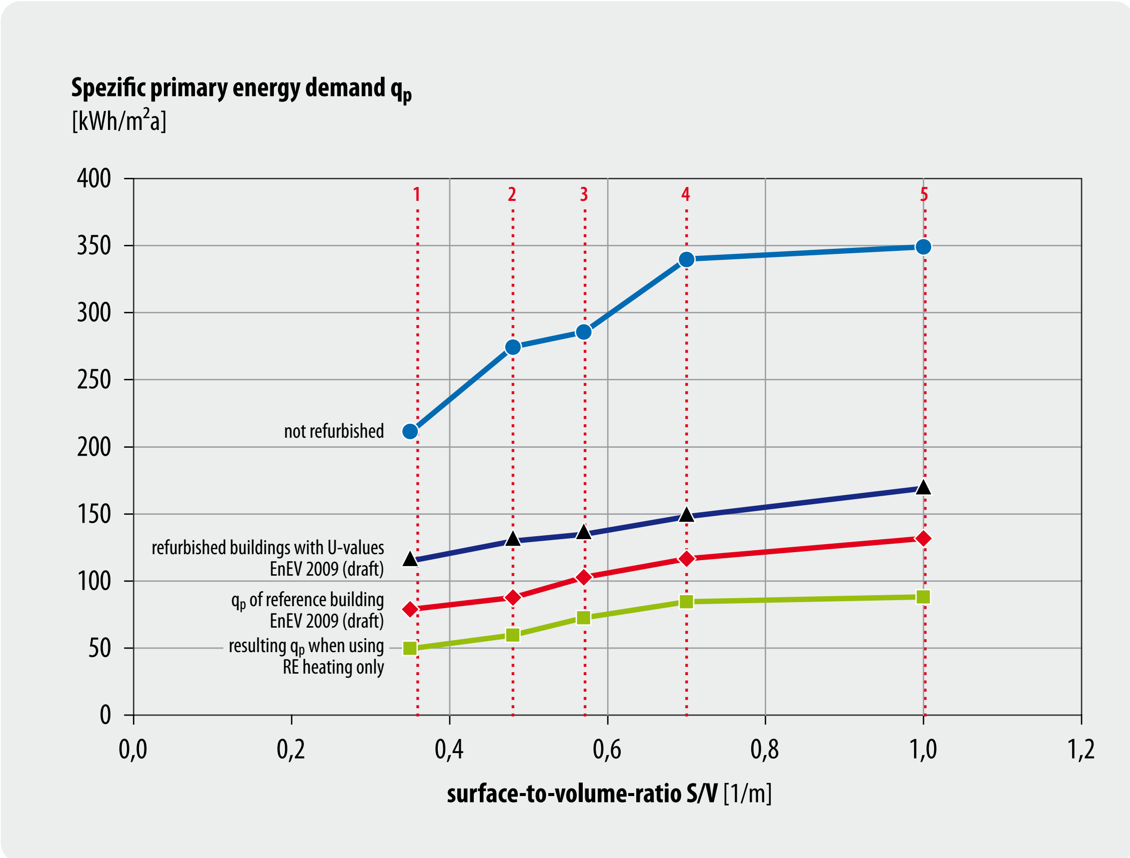



**Figure 11: Specific primary energy demand values for the building types under review**

- ● prior to refurbishment
- ▲ after refurbishment of all structural components under the structural component method of EnEV 2009 (without making any changes to the building technology)
- ◆ maximum value for refurbishment of existing buildings according to the reference building method
- ■ primary energy demand that can be achieved if only a wooden pellets boiler is installed (without improvements of the building shell)

1: large residential building | 2: residential building | 3: terraced house | 4: semidetached house | 5: detached house

No requirement has been stipulated in the draft EnEV 2009 regarding compliance with a minimum quality of the total building shell ($H_T$' limit value) of refurbished buildings.[3]

When using biomass, for example, it will be possible under the draft EnEV 2009 to comply with the primary energy demand limits without the need to further insulate the building since the secondary requirement concerning the quality of the building shell was omitted.

Thus, this is the decisive chart to support arguments against intertwining the both instruments EnEV and EEWärmeG — the primary energy demand alone does not stipulate any requirements to save energy. Therefore, if interpreted accordingly, this provision may result in the omission of insulation measures or the use of bad material qualities in order to reduce investment cost.

3 The intention to limit the $H_T$' value was published after this paper went to press.

## Suggestions for further amendments to EnEV and EEWärmeG

Future amendments to these laws should refer to different aspects according to the authors:

**1. Disentanglement.** The policy example above shows that extreme intertwining of renewables and efficiency can also have disadvantages — first, insulation and renewable energy can be offset against each other, and second, the legal structure is very complicated.

A disentanglement of the goals and requirements could be supported by defining maximum heat values and final energy demand values instead of the $H_T$' limit values in the EnEV. Thus, the focus is placed first on thermal protection, and second on measures that increase the efficiency of the plant technology. The EEWärmeG would then be the only standard that stipulates requirements concerning the way in which energy demand is satisfied.

By distinguishing between shell, plant and energy source, clear rules can be adopted which exclude the possibility that builders and refurbishment specialists can buy their freedom from the obligation to properly insulate the building by using renewable energy. The primary purpose of the EnEV should be to limit the energy *demand* as a whole, whereas the EEWärmeG should stipulate *how* this energy demand is covered.

The flexibility required under the EEWärmeG to account for cases in which no renewable energy can be used could be ensured by establishing a **substitute *payment*** instead of a substitute measure. Only extremely well-insulated buildings well below EnEV-15 percent (e.g. passive house standard) should be excluded from the obligation to employ renewable heat.

**2. Simplification.** Especially in the area of residential buildings, where most different stakeholders are involved — from the owner up to the building or refurbishing contractor — substantial simplifications have to and can actually be made from the authors' point of view. This simplification would include not only the fundamental requirements (limit values) but also the calculation methods used.

**3. Stricter $H_T$' requirements.** As regards the envisaged requirements on new buildings, most of the tightening provisions are attributable to the solar plant and more efficient plant technology accounted for in the reference building. The tightening portion relating to the building shell remains below expectations compared to the economically feasible requirements. For this reason, tightening the $H_T$' requirements on new buildings further in 2009 would be desirable.

**4. Adjustment.** With respect to some energy sources, such as biomass, biooils or district heat, the current primary energy assessment must be seen as critical. In order to limit the tendency to compensate efficiency measures by renewable energy especially as regards biomass, which in itself is limited in supply, the primary energy factor of biomass should be changed. The same applies to the stipulation of primary energy factors for district heat.

However, if both instruments remain isolated, as is currently the case, intertwining them may even have negative consequences. Both the EnEV and the EEWärmeG may not be able to bring about their full climate protection effects. It is difficult to forecast the eventual effect of these instruments. Under purely economic aspects, the EEWärmeG could turn into an efficiency standard in the building sector because improved insulation as a substitute measure is normally cheaper than the use of renewable energy. This RE instrument could develop interesting dynamics which the EnEV has not been able to achieve so far due to the flexibilization options (crediting renewable energy towards insulation). However, if economic aspects are not the only decision-making criteria in new building construction, important efficiency potentials will not be exhausted for many years because the mandatory use of renewable energy allows builders to spend less on thermal insulation.

## The market efficiency programme — introducing efficiency elements in promotional programmes for renewable energy

Like heating systems based on fossil fuels, the generation of heat from renewable energy must be measured against its efficiency. Efficiency improvements are possible and reasonable for



**Energy consulting: Mediator between the worlds**

Energy consulting is a special opportunity for intertwining renewable energy and energy efficiency. The reason why energy consulting is especially important is shown by a few extracts from the IFEU evaluation of energy consulting on location: approx. 90 % of those receiving advice said that the main reason why they had accepted energy consulting on location were specific (refurbishment) projects, such as thermal insulation measures. Another reason for obtaining advice quoted by 60% of its recipients was their desire to reduce their heating and/or energy cost in the long term. Imminent heating modernization or conversion were quoted by about one-half of those advised. In addition, the evaluation has shown that local energy consulting has a decisive influence on the quality chosen for implementing the project (e.g. the insulation material thickness). Therefore, energy consultants are especially capable of contributing towards the implementation of high quality standards in the refurbishment of residential buildings.

And this is exactly the point where increased intertwining could add more potential — by pointing out to the possibility of achieving an excellent building standard (e.g. passive house or low-energy building standard) at low additional cost already at the advisory stage. Many people come because they want to modernize their heating system and leave the consultant's office with a comprehensive package of measures that also includes an improvement of the building shell. And conversely, of those who had sought advice in 2005 and installed a solar system with additional heating support and answered the question in the survey, one-half stated that local energy consulting had given a decisive impulse (18%) or important assistance (32%) for their decision to install a bigger solar plant for additional heating support.

Time plays an important role in "Energiebalance consulting", because refurbishment pays off in the long run and influences other decisions concerning energy supply. The positive effects of intertwining several concepts become more obvious. Renewable energy systems such as solar plants or heat pumps work more efficiently in buildings with a lower energy demand respectively a lower flow temperature of the heating system. The efficiency bonus in market incentive programmes also increases the subsidies granted for these plants in better insulated building structures. Thus, the energy consumption, and hence the costs, can be reduced in the long run by sustainable means.

all types of plants, especially since an increase in the efficiency of converting primary energy into useful energy also reduces the capital cost per installed power (which is often higher for renewable plants). A distinction must be made between

- solar energy plants and deep geothermal energy that do not need any additional fuel, except the auxiliary energy required for operating peripheral devices (pumps, control systems, etc.);
- heat pumps that require considerable amounts of gas or electricity in order to make use of geothermal heat, and
- biomass plants using a renewable and climate-friendly fuel, which is nevertheless available in limited quantities only.

The efficiency of renewable energy systems can be improved by increasing the primary energy utilization ratio, i.e. by changing from final energy resources requiring a lot of primary energy to less energy-intensive ones (e.g. electric heat pump → gas heat pump), by increasing the plant efficiency, e.g. by using condensing technology for biomass boilers or cogeneration, but also by reducing the auxiliary energy demand (e.g. efficient pumps for solar energy plants).

Providing heat from renewable energy is promoted under the so-called "Marktanreizprogramm" (market incentive programme, MAP) in Germany. The aim of this incentive programme is to increase the renewable energy fraction within the energy market especially in the field of heat supply. Promotion is granted for solar collector systems, biomass boilers, efficient heat pumps and local heat networks, among others, in the form of investment subsidies or low-interest loans with a redemption subsidy.

### Example of circulating and solar collector circuit pumps

Circulating and solar collector circuit pumps are an important element in the overall energy balance of a heating or collector circuit where high potential savings can be achieved over a short amortization time. In German households, approx. 14 million heating and 6 million water circulating pumps are in operation, which are currently able to convert only 10–15 percent of their power input into pumping output for technical reasons. In addition, these pumps are considerably oversized on average (panic surcharges) and often run at full power, even if heating operation has been reduced or interrupted.

**Figure 12: High efficient circulating pumps**
(Source: Grundfos)

For a number of years, pump manufacturers have also offered particularly efficiently controlled circulating pumps in permanent magnet technology. They consume up to 80 percent less electricity per year than "conventional" pumps. When the pumps are installed, a careful hydraulic adjustment has to be performed at the same time in order to ensure the full operating capability of the system. The hydraulic adjustment also reduces the heat loss of the system.

Similar to the heating circuit pumps, however, solar collector circuit pumps are normally oversized. Using these pumps, the primary energy savings that can be achieved in principle by solar collectors are reduced by 15 percent. This parasitic consumption can be reduced to 2–4 percent using high-efficiency pumps.

This particularly efficient type of pump has not yet become the established standard component for heating and collector systems on the market, however. The main impediments include significantly higher investments and the resulting preference of manufacturers to use regular pumps in compact systems and solar assemblies, reservations maintained by trade companies because of the complicated control adjustment, and a lack of information flow to the customer.

As a result, the Energiebalance project proposed promoting this type of particularly efficient pumps as part of the market incentive program. Under the current version of MAP, an investment subsidy of Euro 200 is provided for particularly efficient heating circulating pumps that comply with the conditions of the voluntary energy label class A. In addition, proof of the hydraulic adjustment has to be given. Especially efficient solar collector pumps are promoted by Euro 50 per pump.

Even the pre-2007 versions of the market incentive programme already stipulated certain efficiency requirements with respect to the plants promoted, e.g. the "Solar Keymark" quality seal, a minimum yield of 525 kWh/m²a, a function control unit or a heat meter.

More efficiency elements were drawn up as part of the Energiebalance project which were implemented in the MAP, such as

- higher subsidies for especially good insulation of buildings,
- bonuses for optimized heating systems featuring particularly efficient pumps,
- subsidies for biogas micronetworks (cf. p. 34), or
- an improved promotion of local heat networks.



## Energy balance in the electricity sector

The expansion of renewable energy in the electricity sector is extremely dynamic. Within as little as ten years, the proportionate electricity share generated from sun, wind, water and biomass has almost tripled, from roughly five per cent to around 15 per cent of the gross electricity consumption. If the current dynamic growth continues in the future, the goals set for 2010 and 2020 will even be exceeded.

By contrast, electricity consumption has increased over the past 15 years and only dropped slightly in 2008. This consumption development is the result of a complex simultaneous occurrence of different effects. For example, while the electricity consumption as a function of the gross domestic product has generally decreased, an increasing number of electric appliances, product and demand shifts as well as changes in social structures (such as a decreasing average household size) resulted in a growing per-capita demand of the households.

In the building sector, renewables and efficiency are particularly closely intertwined. But not so in the electricity sector where intertwining RE and EE is not as direct and is not so closely linked to technical considerations, because in contrast to heat supply, electricity is almost exclusively supplied by cables, and the origin of the electricity plays no role for the end consumer in terms of technology.

The Energiebalance project examined the issue of intertwining efficiency and renewable energy in the electricity sector under two aspects:

- the question as to the efficiency *of* RE plants. This question is relevant both for the economic efficiency and the lifecycle assessment of the renewable energy plants (solar plants with a higher efficiency require a smaller module size; more efficient biomass plants consume less fuel, etc.). As regards biomass plants, one has to additionally bear in mind that the potential fuel supply is not unlimited, and that higher efficiency thus contributes towards mitigating competition for land and competing use. Combined heat and power generation (CHP) is a particularly important technical option for increasing the efficiency of renewable energy plants.
- *Learning from the renewables:* It appears to make sense to mutually learn from the experience made with the policy concepts and types of measures, the procedures, implementation processes and evaluation concepts applied. At an instrumental level, it is conceivable, for example, to transfer the successful mechanism of the Renewable Energy Act to efficiency elements.

### Using renewable energy more efficiently — the example of the Renewable Energy Act

The Renewable Energy Act was amended in the course of the Energiebalance project. For this reason, the project team was asked which efficiency requirements concerning renewable energy plants should be included in the amended Act.

The Renewable Energy Act (EEG) pursues the goal of sustainably increasing the proportionate share of renewable power generation. For this purpose, the Act sets forth rules concerning the preferential connection of systems generating power from renewable energy to the general supply network, its preferential purchase, transmission and remuneration and a nationwide balance of the electricity purchased and paid for. In addition, the law specifies fixed, segment-specific tariffs grid operators have to pay to the plant operators.

The Renewable Energy Act as amended in 2004 already set forth different kinds of efficiency levels/incentives for renewable energy plants. A distinction must be made between incentives rewarding increased efficiency, requirements calling for a certain amount of efficiency, and indirect efficiency effects generated as a result of the stipulations of the EEG.

- An *implicit incentive* consists in the amount of remuneration paid for the power generated which in itself stimulates certain optimization of the electricity yield.
- *Explicit incentives* are offered in the form of the CHP bonus or the technology bonus for innovative technologies and its combination with the CHP bonus.

- *Indirect efficiency effects* occur through a size graduation of the remuneration rates, often resulting in lower electrical efficiency yet higher overall efficiency.
- *Explicit efficiency requirements* are stipulated in the Biomass Regulation with respect to the minimum electrical efficiency of power plants.

An efficiency assessment has to take into account that the importance of efficiency varies to a great extent in the various sectors.

As regards wind and water power plants, efforts to improve the plant efficiency have been greatly exhausted based on the technological competition between manufacturers or (as regards water power) will be "automatically" developed in the course of technological progress made. In the case of wind power, the EEG stipulates an efficiency focus by excluding particularly inefficient locations from receiving remuneration. Wind power incentives should rather be given in the area of system integration and services.

"Energy efficiency" in the field of photovoltaics mainly refers to the energy required for the production of the plant and its degree of efficiency in operation. Depending on the technology (thin layer, mono- vs. polycrystalline), the type of support structure, the geographic and geometric arrangement of the system (location, shading, radiation angle, etc.), the raw materials used (solar silicon, which is less energy intensive in the production process, vs. electronic grade), the degree of recycling, etc. you can actually find major differences here. The energy return times of modern solar cells are in between two and five years for German locations.

For this reason, proposals have been made to define the EEG remuneration or an efficiency bonus subject to the cumulated energy consumption or a lifecycle assessment (per kW, per $m^2$ or similar) of the production process. While this basic idea appears quite interesting, the Energiebalance project team nevertheless proposed in the course of the EEG amendment 2008 not to additionally stipulate such a bonus. After all, it would not only make the EEG more complicated, the low significance of the energy required to produce PV in general would not justify such an approach for two reasons:

- *Environmental "import" from the conventional energy system.* In lifecycle assessments, it is assumed that the conventional energy system is used for the production of solar cells, i.e. the German electricity mix, for instance, is used for crystal pulling of the silicon wafers. However, it is not necessary to burden the lifecycle assessment of solar cells with the environmental impact of conventional electricity generation, because this would combine regenerative power supply with impacts from the fossil system. Another starting point would be a lifecycle assessment of electricity generation, e.g. 100 $kWh/m^2$*year in Germany, multiplied by a lifecycle of, say, 25 years, i.e. 2.5 MWh during the whole lifecycle. The amount of electricity needed for manufacturing the system could be deducted from this amount of electricity generated. The result would be a "net electricity generation".
- *Low environmental impacts.* Even when assuming a conventional background system for the production of PV, the environmental impacts of manufacturing modern solar cells are comparatively low, with $CO_2$ emissions amounting to 60 to 200 g/kWh only (for comparison: lignite electricity > 1000 g/kWh). For economic reasons (e.g. raw material availability), an endogenous process of improvement is already under way (e.g. solar silicon, low-loss wafer dicing methods, etc.)

In the field of geothermal power, promoting the heat utilization is of utmost importance. A proposal was made in this context as part of the EEG experience report that was included as a heat use bonus in EEG 2009 Sec. 28(2). The pump power demand is another issue.

In view of the significant yet limited potential availability of biogenic residuals and cultivable land for renewable fuels, the efficient use of biomass is to be given high priority. For this reason, the Energiebalance project placed special emphasis on biomass plants and examined the efficiency requirements to be made on biomass plants in order to enable them to maximally contribute to the reduction of exhaustible energy resources and the reduction of greenhouse gas emissions.



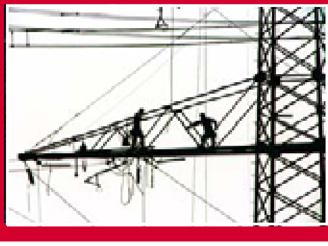
## Energy balance in the lifecycle by the example of biogas

In the course of the Energiebalance project, different biomass plants were examined on the basis of life cycle assessments of greenhouse gas emissions. Under this standard, the life cycle has to be assessed "from the cradle to the grave". The entire life cycle of biogas generation and use is included in the assessment accordingly.

If liquid manure from agricultural operations is used, the reductions amount to 150 g greenhouse gas per MJ of biogas compared to the conventional treatment of raw liquid manure. When using renewable raw materials (corn), as many as 40 g of greenhouse gas can still be saved (Figure 14). This significant reduction results from the amounts of electricity replaced and - in case of the manure plants - the reduction of emissions otherwise occurring when storing (methane) and distributing the manure (nitrous oxide). An increased heat utilization ratio compared to a typical plant (80 instead of 20%) results in a relevant improvement of the greenhouse gas life cycle assessment, which has no decisive influence on the result, however (Variant 2). A negative impact on the assessment was observed for the storage of the digestate where significant residual gas (methane) emissions may occur (Variant 3). As a viable measure, we therefore recommend imposing the requirement of a gas-tight cover and residual gas utilization, which also has the side effect of being a highly efficient means of reducing other emissions, such as ammonia.

Upgrading biogas to natural gas quality and feed-in into the natural gas system (Variants 4-9) result in additional environmental impacts - methane leakages to the atmosphere which are released during the upgrading process, and additional power and heat demand for gas upgrading and the necessary compaction. For this reason, biogas upgrading to natural gas quality and feed-in into the natural gas system were also investigated in the course of the Energiebalance project. Again, a reference system was defined consisting of a major plant including an upgrading plan


**Figure 13: Reduction of greenhouse gas emissions by a biogas plant (blue: liquid manure as charge material; brown: silage corn as charge material). Assumptions: 500 $kW_{el}$, reference case: external utilization of 20% of the heat produced. The electricity generated substitutes generation by so-called marginal power plants (70% hard coal, 30% natural gas) and heat from mixed generation comprising approx. 60% gas and 40% oil heating plants. For more assumptions, refer to main report.**



Variant 4, a biogas plant releasing 2 percent of the methane into the atmosphere during the upgrading process with an electricity demand of 0.3 kWh/m³ raw gas, while using 100 percent of the heat generated because the cogeneration station is located close to a heat sink, achieves slightly better results as regards overall greenhouse gas emissions than Variant 1. This noticeable improvement presupposes compliance with some basic requirements on the upgrading plant. For example, when assuming a higher power demand (Variant 5) or higher methane losses (Variant 7), no additional benefits are achieved compared to biogas use on location. For this reason, biogas injection into the gas system should always be associated with minimum requirements on the electricity/final energy demand as well as maximum methane losses and a regenerative coverage of the system's own heat demand.

These upgrading expenses and losses could be avoided by increasingly promoting biogas micronetworks. These biogas micronetworks allow for direct distribution of the biogas without separating other gas components.

When assuming that the biogas "only" replaces natural gas (Variants 8 and 9) rather than fuels with a higher carbon content in the substitution of electricity and heat described above, even lower credits are obtained because natural gas is the fossil fuel with the lowest energy-specific greenhouse gas emissions. The greenhouse gas emissions caused by the reference plant described here, such as methane losses resulting from biogas production and upgrading, would even be higher than the credit achievable for natural gas substitution. As a net result, Variant 8 with silage corn leads to greenhouse gas emissions. However, it would be sufficient to provide a gas-tight cover for the digestate store and to utilize the residual gas in order to revert the emissions into a reduction of greenhouse gas (Variant 9).

The Energiebalance project has contributed the recommendations derived from the above analysis — as well as a number of other suggestions made in the course of the project — to the process of amending the EEG (cf. p. 46). Many of these suggestions have now become part of the new EEG that came into force on 1/1/2009.

**Figure 14: Micro biogas pipeline:**
**In this system, the biogas is transported to the heat sink without upgrade and feed-in into the natural gas pipeline. Thus, the total efficiency is increased without energy intensive upgrading**
(Source: Stadtwerke Mosbach)



In the area of biomass promoted under the EEG, there are various process steps for which an optimization potential has been identified. The raw material input is included in the entire energy and greenhouse gas balance. The ecological "backpack" of energy crops is much higher than that of residuals, such as residues from landscape conservation and liquid manure. The various concepts of biomass utilization also differ as regards plant technology. Important parameters include the electrical and thermal efficiencies as well as the CHP ratio of the plant, the type of heat utilization, the type and amount of auxiliary energy demand and - for biogas systems - digestate covers, silage losses, methane losses of the gas system and possibly energy demand and methane emissions during preliminary treatment.

## Promoting efficiency under the EEG model: the Negawatt Feed Act (NEEG)

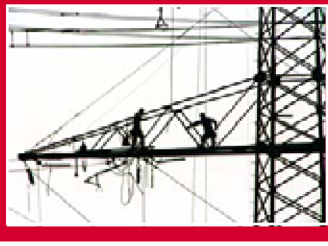
In Germany, the EEG is a proven instrument for the promotion of renewable energy (cf. p. 32). Can such a preferential provision concerning the infeed of electricity from renewable energy and the obligation of the electricity grid operators to pay technology-specific remuneration rates to electricity suppliers for each kWh of electricity fed into the grid be transferred to the efficiency segment?

In the course of the Energiebalance project, it was determined that in principle, the remuneration and new equalization scheme can be legally and practically transferred to the field of saving final energy. Analogous to the EEG, such a political instrument could be referred to as NEEG (NEgawatt Infeed Act). However, the fundamental problem in the field of saving energy remains the same, namely that procedures for evidencing the energy savings achieved have to be instituted, which give rise to additional transaction cost compared to electricity infeed meter readings. In addition, considerable pulling effects could occur, depending on the detailed stipulations of the NEEG.

The figure shows how such an NEEG could operate to promote energy efficiency technologies: The manufacturer or importer of an especially energy-efficient appliance gives evidence of compliance with defined efficiency criteria by his appliance to an energy efficiency body designated by the government, e.g., that it is at least 10 to 20 percent better than the best unit on the market. If the appliance is recognized as being worth promoting, the manufacturer or importer reports the number of devices complying with the specified energy efficiency criteria to the local grid operators in whose area its seat is located on an annual or monthly basis. The numbers are verified on a random basis on behalf of the transmission system operators. In order to determine the amount of premium to be paid, the grid operator performs a plausibility check of the figures reported and multiplies them by the verified energy saved per unit and the predefined duration of use and typical frequency of use. Afterwards, the local grid operator pays the premium to the manufacturers and importers concerned on an annual basis.

The leverage effect that can be achieved by manufacturer premiums supports the concept of paying premiums to manufacturers and importers instead of granting electricity bill credits or similar premiums to final users. And finally, the equalization and balancing mechanism stipulated by the EEG, which has been recognized under European law, has effects on the local grid operator as well as the higher-level system operators and electricity suppliers and down to the energy consumers. By contrast, if manufacturer premiums were paid by the government under a promotional programme, they would be voidable for constituting legally inadmissible subsidies.

Alternatively, the NEEG model could be tested by generally promoting the implementation of bundled energy-saving activities or programmes by their stakeholders by paying a certain lump-sum amount. This could initiate a creative competition for the most effective and efficient programmes for saving energy and services. Especially contracting firms, energy and climate protection agencies, local/regional energy and climate protection funds, consumer advice centres, energy consultants, social marketing experts, energy companies, industrial associations and non-governmental organisations are called upon to develop and offer energy-saving activities in this context. The search, discovery and optimising function of the market could thus be utilized to achieve additional energy savings over the general trend.



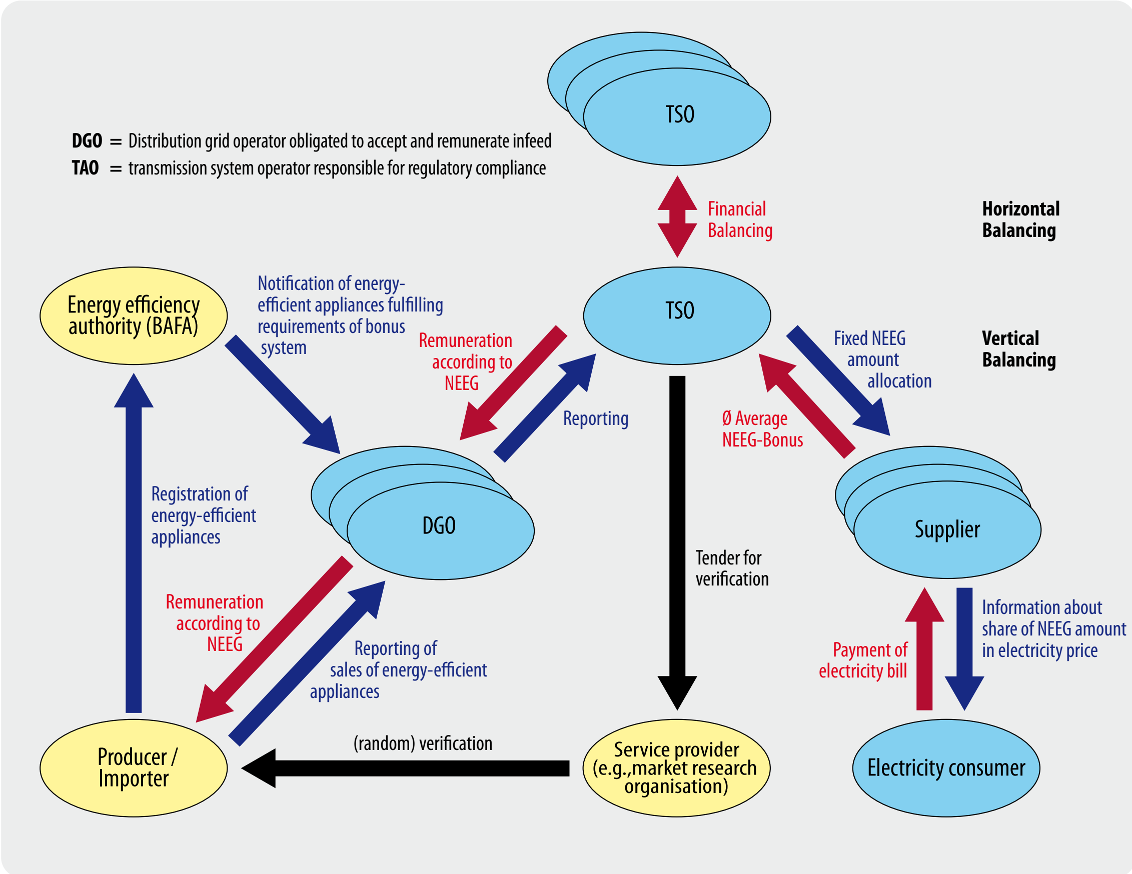



**Figure 15: Balancing scheme of the NEEG by the example of premiums for manufacturers and importers of energy-efficient appliances (simplified view, without physical balancing of the power "infeed" from savings).** Source: "Energiebalance" project based on VDN 2005

Under both NEEG models, there is a risk of promoting mainly standard measures or individual technologies, of developing only the most easily developed potential savings (taking the pick of the bunch) and of failing to optimise systems (lost opportunities). In any case, a future NEEG must be complemented by sectoral and/or technology-specific programmes that specifically address the implementation impediments identified and target system optimisation (e.g. by promoting a combination of advice, information/qualification and technology promotion, as suggested by a number of programmes for an EnergieSparFonds (Energy Saving Fund) proposed by the Wuppertal Institut).

For this reason, in a possible NEEG model to be introduced one would have to carefully check which technologies should be promoted through specific remuneration rates under the NEEG model, and which ones should rather be subsidized by promoting system optimisation (optimised planning with respect to the required use and its possible modification, system-optimised choice of components, device or plant settings) under specific energy-saving programmes.



## Energy balance in the traffic sector

The traffic sector is faced with the challenge to first break the growth trend of the passenger-miles before a sustainable reduction of the $CO_2$ emissions can be achieved. For this reason, measures to avoid traffic, transfer to environmentally friendly means of transport, and an improvement of the energy efficiency should have priority. However, this cannot only be achieved by technical means — such as more efficient drives — but also requires changing to more efficient modes of transport, target-specific urban planning and the targeted promotion of low-traffic infrastructures. Since increasing the efficiency automatically results in a higher renewables share in the energy consumed, it should have priority over measures for increasing the proportionate share of renewable energy in the traffic sector and intertwining without synergies.

In the course of the present study, two modes of transport — road traffic with a special focus on passenger cars and rail-bound traffic with special emphasis on the train traffic of Deutsche Bahn AG — were selected. First, because the vast majority of sectoral $CO_2$ emissions result from road traffic, most of which (or approx. 2/3) originate from passenger cars. Second, railway traffic is the only mode of transport that predominantly uses electricity as its driving force, which allows for other principles and approaches of an — integrated — use of renewable energy resources. Freight traffic was not reviewed because business management aspects already govern the efficiency of the vehicles. In view of the forecast increase in passenger-miles, strategies to avoid traffic and use other modes of transport will be much more important.

### Intertwining RE and EE in road traffic (passenger cars)

Energy efficiency is primarily and generally subject to the higher-level goals fixed by the European Commission. This plan for action also includes various measures for improving efficiency in traffic — with a special focus on technological improvements of passenger cars — which is to be indirectly controlled by making requirements on specific $CO_2$ emissions of new vehicles, expressed as $CO_2$ g/km, within a fleet.

Within the framework of the Integrated Energy and Climate Programme (IEKP), Germany relies on additional measures designed to offer an incentive for increasing efficiency in road traffic. Measures include a conversion of the car tax to $CO_2$ related rates, identifying the consumption of passenger cars and truck toll. Conversely, however, there still are strong incentives for high-consumption cars, such as the various tax privileges for company cars.

Renewable energy is used almost exclusively in the form of biofuel in the traffic sector today. Occasionally, RE electricity is also used in electric vehicles. As regards biofuels, however, the first critical limits have already been reached which are difficult to overcome. These include, for example, technical limits to biofuel additions for existing engines, as well as cultivation methods with sometimes negative impacts on the environment and the climate. For this reason, the biofuel objectives are adjusted both nationally and at the European level, and are tightened as regards the underlying sustainability demands.

Renewable energy and energy efficiency are not intertwined instrumentally in the traffic segment, with a single exception. This applies both at the European and the national level. Although there is a large number of measures on both levels, they either address renewable energy or mostly — in six out of nine cases under review — energy efficiency. Only at the European level, which thus also acts at the German level, the new '$CO_2$ Directive on fleet consumption' of passenger vehicles stipulates measures that provide for intertwining of renewable energy and energy efficiency at least in part or as an option.

Nevertheless, this intertwining element is a negative approach from the point of view of climate protection because the efficiency objective and its implementation are watered down by the optional biofuel credit stipulated without giving additional (demand) impulses for expanding renewable fuels where desired and useful. On the contrary, if fully achieved through biofuels, compensating the inferior vehicle efficiency would require almost the entire biofuel admixed today already in the

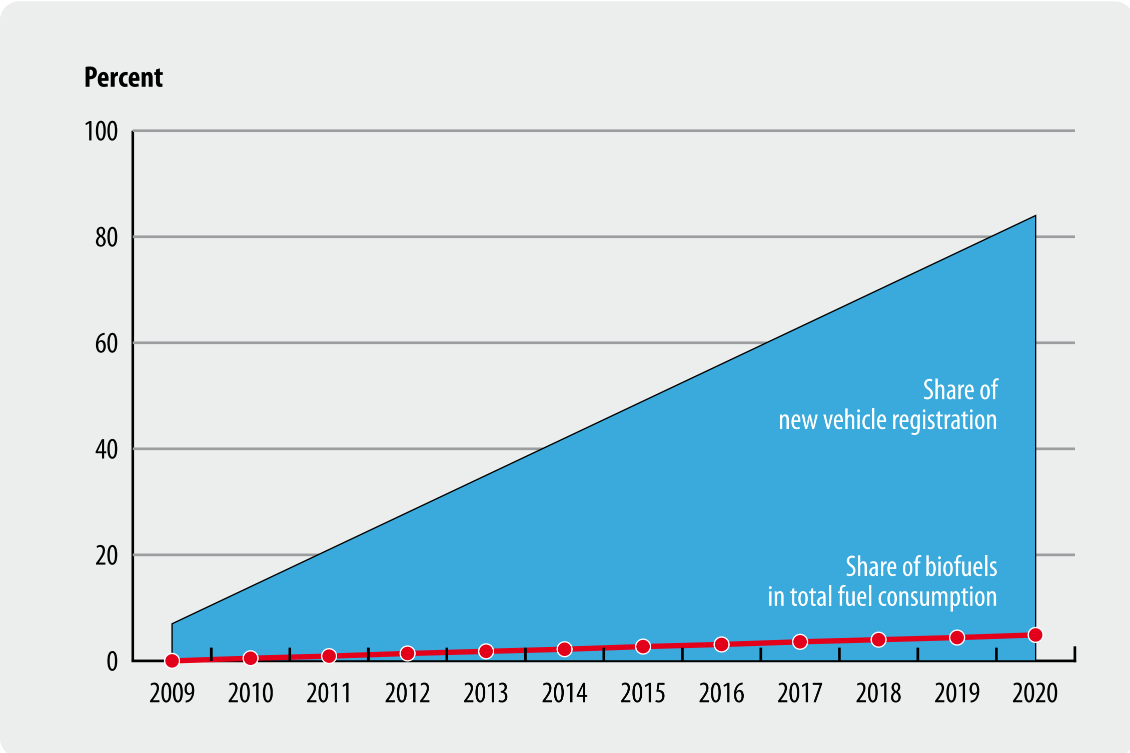



**Figure 16: Development of the biofuel share necessary to save 10g $CO_2$/km in new vehicles**

year 2019. As a result, the same amount of $CO_2$ would be additionally emitted that is saved every year by biofuels today.

The existing intertwining between EE and RE set forth in the EU Directive on fleet consumption should be removed as soon as possible for this reason without raising the existing EE objective (120 g $CO_2$/km) for new vehicles and without further delaying its practical implementation.

Technological approaches for intertwining efficiency and renewables in road traffic are seldom, not considering the use of biofuels in adapted motors and the non-mobile portion, such as the traffic areas etc. Only an integrated use of solar energy through photo-voltaics for generating on-board electricity appears to be viable. In view of the high expenditure to be made concerning technical integration, possible rebound effects and the expected relatively high additional cost, using renewable energy for this purpose in vehicles is not really recommended.

In this connection, and in preparation of possible intertwining with solar on-board power generation, a realignment of the current standard measuring cycle is proposed on the basis of the “New European Driving Cycle” (NEDC) with respect to the type-related consumption measurement including the auxiliary systems of the respective most recent car model. For this purpose, measurements should be performed with and without the auxiliary systems at least once, each, in order to separately detect the fuel consumption by the auxiliary systems. On this basis, e.g, the maximum fuel share to be consumed by — certain or all — auxiliary systems in proportion to the total fuel consumption could be stipulated by a legal requirement.



## Intertwining RE and EE in rail-bound traffic

Energy consumption in rail-bound traffic[4] has been strongly reduced since the 1960s by reducing train connections, shutting down secondary lines, conversion to modern electric and diesel locomotives and expansion of light-weight construction. Between 1990 and 2006, German Rail was able to reduce its absolute primary energy consumption by an additional 19.5 percent to 151 PJ, however, 54 percent alone resulted from the stationary segment until 2005. This reduction was brought about not only by a conversion to natural gas, but also by the sale and shut-down of railway stations and the cutback in administrative tasks. The savings were based on an energy thrift campaign dating back to the year 1994 under which the enterprise committed itself to reducing the specific primary energy consumption per person transported or per ton of goods transported by 25 percent. This objective was achieved.

In 2006, greenhouse gas emissions amounted to approx. 8.4 million tons of $CO_2$ (DB AG 2007), of which approx. 84 percent were attributable to the entire traction segment, including 71 percent to the use of electricity. As a result, the integration of renewable energy is generally a viable option. The **proportionate share of renewable energy** which amounted to slightly over eight percent in 1990 rose to 13.3 percent in 2007, including nine percent or the vast majority of electricity being generated by water power in a total of 12 plants and thus existing installations, because the water power potentials are virtually exhausted in Germany. With over 13 percent, rail-bound traffic has a significantly higher renewable energy share than road traffic, however, it is faced with the great challenge to make up for its nuclear energy share of almost 30 percent, which will no longer be available in the future, by the most $CO_2$ efficient technologies possible in order to achieve its self-defined objective to reduce its specific $CO_2$ emissions by 20 percent until 2020 compared to 2002 levels. According to recent planning, carbon-generated electricity will be used for economic reasons, increasing the $CO_2$ emissions of German rail by a minimum of approx. 3.6 million tons or 60 percent compared to present levels, according to their own calculations. This applies in the case of a constant electricity consumption, whereas emissions would increase accordingly if consumption was about to rise further. For this reason, both renewable energy and especially also energy efficiency are of special importance.

Detailed technological and/or instrumental intertwining of RE and EE does not exist in the rail-bound/train traffic according to the known facts and state of affairs. Only the commitment to reduce $CO_2$ can be considered a general approach to intertwining leaving scope for measures both in the field of renewables and efficiency. Otherwise, independent boundary conditions are currently being prepared with a generally positive influence on an increase in energy efficiency. Especially recent tax legislation as well as the no longer free award of $CO_2$ emission rights are expected to provide economic incentives to save energy in all areas of the rail-bound systems.

Relevant new incentives for increasing the use of RE power may result from the current draft of the new EU Directive on Renewable Energy which for the first time stipulates targets for the entire traffic sector including (traffic) electricity and in connection with the challenge outlined above to abandon the use of nuclear energy without affecting the $CO_2$ balance.

In the field of political instruments, however, there is more scope for new instrumental intertwining approaches.

1. **RE objectives:** The specification of — dynamic — goals for the proportionate RE traction current, such as 100 percent in 2020. With this value, the traction current could maximally contribute to the EU goal (10 percent in 2020) concerning the RE share in the traffic segment, thus reducing the otherwise necessary quantity of biofuels. More biomass would be available for the stationary segment, which can be used more efficiently here than in the traffic sector. In addition, specifying an ambitious goal could specifically contribute to low-$CO_2$ substitutes for the nuclear power abandoned.
2. **Best Available Technology approach:** Introducing rules for consumption standards in analogy to passenger vehicles would

4 For the present study, mainly the rail-bound traffic (including suburban lines) of Deutsche Bahn AG was reviewed because it dominates the energy consumption by rail-bound traffic by approx. 70 percent and the Federal Government plays a special role as the owner of the system.

be one possible approach to increasing efficiency. However, more profound analyses should be conducted beforehand, and EU provisions should be awaited because stand-alone solutions of the member states are not realistic in the single market.

3. **Climate protection focus in invitations to tender:** Public procurement policies can influence the efficiency of the railway fleet already today by drawing up the corresponding public invitations to tender. This should be accounted for more strongly by the federal states in the future. In general, efficiency and renewable energy can also be coupled in procurement policies. However, it is important to avoid neglecting efficiency measures when expanding regenerative energies resulting in negative intertwining effects of the type currently experienced in the passenger car segment.

Although new approaches for intertwining RE and EE in rail-bound traffic could be identified, these approaches are not expected to yield additional synergies from today's point of view, with the exception of RE objectives for traction current. Intertwining RE and EE in rail-bound traffic is of limited importance for this reason, and can be recommended to a limited extent only.

## Electromobility

Electromobility is a measure for increasing the efficiency of the drive train - which is defined as the final energy needed per passenger-mile since the tank-wheel efficiency of this drive is significantly higher than that of a vehicle with an internal combustion engine. Electric vehicles are considered free from $CO_2$ in the European


**Figure 17: Electric vehicles intertwine renewables and efficiency — if the boundary conditions are right** (Source: Daimler)



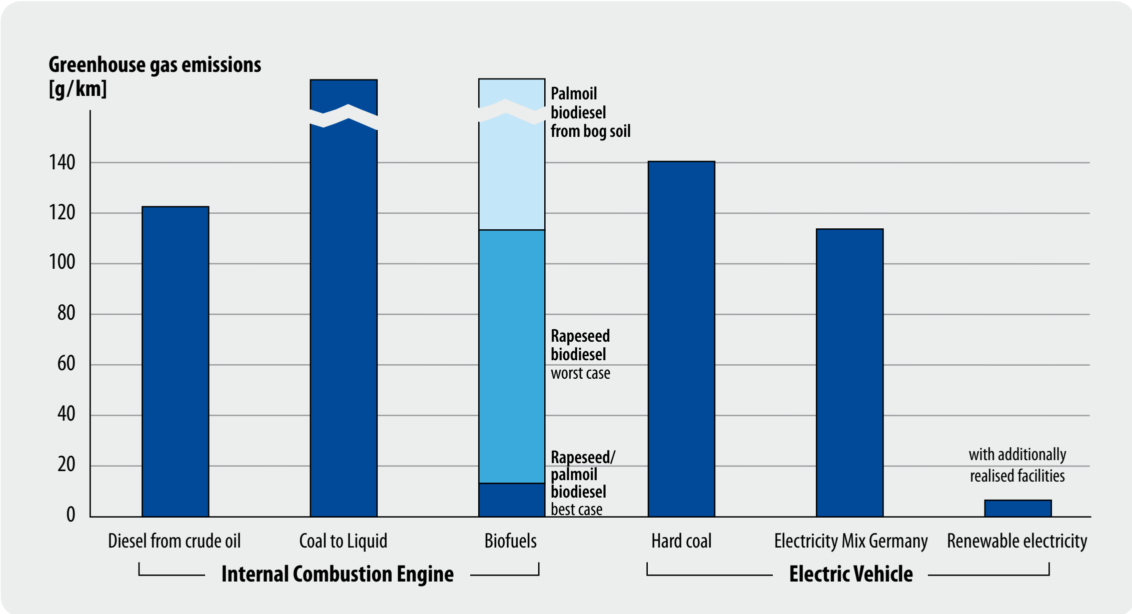



**Figure 18: Greenhouse gas emissions of various future vehicle concepts based on a lifecycle assessment (with fuel chain, without vehicle manufacture).**

$CO_2$ Regulation for passenger cars, regardless of the electricity mix used. In principle, this no-$CO_2$ credit (which is even granted multiple times during the first years) may constitute a financial incentive for a manufacturer to offer electric vehicles on the market. However, this incentive only works if the average of this manufacturer's relevant fleet is significantly above the limit value. Due to the graduated introduction and other exemptions (pooling, "eco-innovations", etc.) this is not to be expected or will be limited to a few cases only. For this reason, subsidizing electric vehicles must be independent of penalties.

Article 3 of the EU Directive On the Promotion of the Use of Energy from Renewable Sources dated December 2008 furthermore stipulates that the renewable energy consumed by electric vehicles shall be considered to be 2.5 times of electricity input with respect to the 10 percent renewables goal in transport. However, the RE electricity input will be proportionately recognized towards the 10 percent goal only until 2011. Member states may freely choose between their own and the EU share of renewable electricity in the mix. By late 2011, the EU Commission must submit a proposal as to the method to be used to credit renewable electricity that exceeds these average values to the 10 percent objective.

The final energy consumption, and thus the efficiency of an electric vehicle, depends on a variety of factors ranging from the type of battery and its inherent consumption to the efficiency of the charger and up to the size of the vehicle, the driving speed, the route used (because of brake energy regeneration) and the use pattern (frequency of use, length of rides, days of inactivity). The charging process is another essential loss item. The "Rügen test" conducted by BMBF until the mid-1990s demonstrated that electric vehicles of the Golf class of that time could be operated at a final energy consumption (i.e. from the power outlet) of approx. 20 kWh/100 km. This power consumption corresponds to the same fossil primary energy consumption of a vehicle operated with fossil energy that consumes approx. 5 to 6 litres of diesel/petrol per 100 km. By building up a new consumption segment, electric vehicles may also be responsible for the installation of new power plant capacity in the future. For the next few years, it is mainly planned to build a large number of additional coal fired power plants. When taking 20 kWh/100 km as a basis, the greenhouse gas emissions of an electric vehicle with an assumed hard coal charge are the same as those of a vehicle with an internal combustion engine (Figure 18).

Since the climate and energy balance (with respect to non-regenerative energy sources) of electric vehicles offers robust benefits over cars running on petrol or diesel only if they are supplied with renewable energies, making the promotion of electromobility — e.g. by tax exemptions or market incentive programmes - subject to power supply from additional regenerative sources will contribute to the desired goal.

The climate balance of electric vehicles has to consider the interaction with the instrument of emissions trading. Shifting the final energy consumed by cars from the traffic sector — which is not subject to emissions trading — to the electricity market will basically result in the electricity consumption being subject to the emissions cap. It would also be conceivable, however, to adjust the cap by these "migrating" amounts of electricity, which must be excluded by political means.

The focus of promotion should initially be on optimizing efficiency as a whole when developing new vehicles. Especially the emerging stage of a market for electric vehicles is a good opportunity to develop the still high EE potentials in this area, and thus for specifying ambitious EE goals which will then have direct impacts on research and development.

The preparation of such a coupling mechanism should distinguish between the early market entry stage of electric vehicles and a long-term perspective. The authors believe that during the market entry stage, government promotion of electromobility should be causally linked to renewable energy while making sure that additional power must be produced from renewable sources. When promoting vehicles by tax a relief or market incentive programme, a pragmatic mechanism should demand that they are fuelled with ecopower. During the first years of developing electric vehicles, this intrinsic link should be as simple as possible, given the small amounts of electricity, cause the lowest possible transaction cost and permit refuelling not only at the customer's own power outlet, but also at any other one. During these initial years, the aspect of simultaneous supply is not decisive, either.

This pragmatic mechanism could make government subsidies subject to the procurement of ecopower with a high share of new power plants. For this purpose, a meter would have to be installed in the electric vehicle.

In the long-term perspective, a second characteristic of electric vehicles will gain in relevance in view of the increasing quantities of fluctuating renewable power generation from wind and solar systems: the possibility of deliberately charging and discharging the battery. The time flexibility in charging electric vehicles is not only a possibility, but also a technical necessity because otherwise grid restrictions could take effect, especially in the distribution network. A cogeneration bonus that is currently being envisaged under an EEG Decree will have to account for electric vehicles as movable loads.

The integration of electric vehicles in the power grid also offers the long-term opportunity to provide special network services. Especially in the decentralized networks of the future, electric vehicles may provide energy storage and standard power. However, the questions of acceptance and of battery wear caused by regeneration would then have to be clarified.

## Selected Recommendations of the "Energy Balance" Project for Intertwining Energy Efficiency and Renewable Energy

| Problem | Implemented? | Note |
|---|---|---|
| **Target concepts** | | |
| ***Promotion of "Energiebalance communities/regions"*** | | |
| Energy efficiency measures are accounted for to a lesser extent in regional and communal target concepts → promoting the strategic preparation of climate protection activities in communities and regions while equally accounting for potential efficiency, savings and renewables (energy balance communities). | ✓ | Included in Promotion Guidelines of the climate protection initiative dated 18/06/2008. |
| The institutionalization of a "caretaker" in the community/the region is the central success factor for the implementation of climate protection measures → promotion of a central body in the administration or in a newly established firm with public participation. | (✓) | Included in Promotion Guidelines of the climate protection initiative dated 18/06/2008 as start-up subsidy. |
| Description of various measures for implementing RE and EE projects in communities and regions, of "new" financing schemes (e.g. venture capital) and of recent legal frameworks, user-friendly design as part of an updated climate protection guideline for communities. | (✓) | |
| **EnEV and energy consulting** | | |
| *Aim* | | |
| There is no relative or absolute savings objective as regards heating or final energy demand of buildings, nor a long-term outlook within the framework of EnEV → definition of an absolute savings objective for the building sector, additional definition of a specific target value for heating energy consumption per m² of residential floor space. | ✗ | |
| No investment is made in education and training, skills enhancement of personnel and technical plants unless planning security is granted → integration of a concrete objective (passive house standard in new building construction as of 2015 and EnEV 2007 less 40 percent for existing buildings) in EnEV and/or EnEG. | ✗ | |
| *Disentanglement* | | |
| Overlapping contents should be avoided when defining the purpose of the relevant instruments. Currently, there are multiple overlaps between the requirements of the existing instruments → EnEV: Limitation of the heating and final energy demand of a building; EEWärmeG: requirements as to the use of renewable energy. | ✗ | |
| *Simplification* | | |
| Simplification of the requirements (from $H_T$' to heating energy demand) and the assessment procedure (not to DIN 18599). | ✗ | |

# Recommendations

| Problem | Implemented? | Note |
|---|---|---|
| *Tightening* | | |
| In the draft version used, the EnEV provides for a "compensation" of thermal insulation by the use of renewable energy → tightening of $H_T$' requirements (or the specific maximum heat demand for heating) on new buildings. | ✗ | |
| In the draft EnEV version, no building shell-specific limit values were stipulated for fundamental refurbishment measures → re-enactment of a $H_T$' limit value for existing buildings. | ✗ | |
| Some of the energy requirements on heat distribution / control / pump operation do not comply with the state of the art. Sec. 14 of the EnEV provides for additional tightening opportunities (e.g. increasing energy requirements on circulating pumps / integration of detailed requirements on hydraulic adjustment). | ✗[5] | |
| *Adjustment* | | |
| Adjustment of the calculation methods for the primary energy factors of district heat and biomass. | ✗ | |
| *Energy consulting* | | |
| Any measures in the building sector (RE and EE) can hardly be assessed on their own account; they rather have to be related in time to any measures that have already been implemented or are planned → presentation of a technically and economically feasible sequence of measures in the reports of the consulting provided on location, publication of sample reports as well as proposals for the presentation of the time axes and the assessment of the economic efficiency, detailed framework data and information on the state of the art from an "energy balance perspective". | ✗ | |
| Long-term economic efficiency assessments are an essential foundation for the builder's decision-making process. Nevertheless, short-term assessments are often preferred → development of tools for economic efficiency calculations. | (✓) | |
| **Technologies for the supply of passive houses (individual supply)** | | |
| In passive houses, compact heat pump units do not reach the same annual operating hours as in other buildings, however, they consume less electricity due to good insulation → subsidies for compact heat pump units for use in passive houses. | (✓) | Implemented as part of the new KfW promotion. |
| Solar plants can be ideally used in conjunction with especially energy-saving buildings, such as passive houses. For this reason, subsidies for small plants should be considerably increased → higher subsidy rates for solar-thermal plants for passive houses. | ✗ | |
| **Comparison of supply options at the neighbourhood level** | | |
| Cold local heat networks are a potentially interesting infrastructure option. However, empirical knowledge of existing systems is limited → evaluation of existing "cold local heat" projects. | ✗ | |

5 A limit value was introduced for existing buildings after this paper went to press.

## Recommendations

| Problem | Implemented? | Note |
|---|---|---|
| Existing steam networks should successively be converted to hot water networks. Any projects that have been completed should be better publicized in expert circles (utility companies) → development of suitable incentives for decentralized steam generation or conversion to hot water networks. | ✗ | |
| Local heat systems connect their flow lines to the return lines of district heat systems → promotion of R&D measures for viable district heat supply systems, e.g. utilisation of return flow. | ✗ | |
| Cost reduction in local heat supply → far-sighted planning, accounting for infrastructural channels, loop-through opportunities, etc., at an early stage. | ✗ | |
| **Renewable Energy Heat Act** (The present proposals were made by the Energiebalance project prior to the implementation of the EEWärmeG.) | | |
| Reduction of the 20% requirement for the use of solar heat to 15%. | ✓ | Was implemented by the current EEWärmeG |
| If there is a possibility of connecting to a local or district heat network with highly efficient CHP, there should be no obligation to use RE. | ✓ | Was implemented by the current EEWärmeG |
| The possibility of a substitute payment offers higher flexibility in the EEWärmeG. | ✗ | |
| **Market incentive programme** | | |
| Bonus for especially efficient solar circulating pumps in solar collector plants promoted under market incentive programmes (MAP). | ✓ | |
| Bonus for especially efficient circulating pumps and hydraulic adjustment in MAP-promoted plants. | ✓ | |
| Efficiency requirement on local heat network → minimum heat sale of 500 kWh per pipeline meter. Quality requirements on heat production. | ✓ | |
| Bonus for MAP-promoted plants in well-insulated buildings. | ✓ | BMU proposal, endorsed by the project team |
| Introducing promotion of biogas micronetworks. | ✓ | |
| Minimum requirements on biogas upgrading (power demand, methane losses, procurement of process heat). | ✓ | |
| **EEG** | | |
| *Total Biogas* | | |
| Biogas contributes to climate protection and must generally be made more attractive → increasing biogas remuneration. | ✓ | |
| *Liquid manure* | | |
| Liquid manure has a significantly better GHG LCA than regenerative resources and avoids competing use. Manure potential is insufficiently exploited → improved promotion of small plants below 75 kWel and liquid manure ratio. | ✗ | No new performance class, but higher promotion for plants < 150 kWel (EEG Sec. 27(1)); EEG Annex 2 VI No. 2 b). Increased biomass bonus for manure ratio >30% in small plants (4 Ct/kWh < 150 kW, 1 Ct/kWh < 500 kW). |

# Recommendations

| Problem | Implemented? | Note |
|---|---|---|
| *Landscape management residues, biowaste* | | |
| Landscape management residues have a significantly better GHG balance and avoid competing use → bonus for landscape management residues. | ✓ | EEG Annex 2 VI No. 2 b) — Increased biomass bonus for small plants < 500 kW (2 Ct/kWh) using landscape management residues. |
| Biowaste has a significantly better GHG balance and avoids competing use → promoting the retrofit of fermenting stage to compost works. | ✓ | Retrofit plants receive technology bonus (EEG Annex 1 II No. 1 i). Promotion of retrofits under MAP is under discussion. |
| *CHP* | | |
| CHP increases climate benefits without being sine qua non → increased CHP bonus, but CHP not mandatory for plants < 5 MW. | ✓ | EEG Sec. 27(4) No. 3 |
| CHP bonus for existing plants. | ✓ | Generally for plants < 500 kW, otherwise for first-time CHP use after 31/12/2008 only (EEG Sec. 66(1) No. 3). |
| Higher CHP bonus will increase risk of abuse → list of pros and cons or proof of climatic benefit. | ✓ | EEG Annex 3 |
| *Covering digestate* | | |
| Requirement of covering the digestate store. | (✓) | For plants requiring approval under BImSchG, covering the digestate store is a precondition for receiving the biomass bonus (EEG Annex 2). For other plants: Power to enact secondary legislation, EEG Sec. 64. |
| *Biogas upgrading* | | |
| Only makes sense with complete heat utilization → CHP use mandatory. | ✓ | EEG Sec. 27(3) No. 3 |
| Only makes sense if upgrading losses are not too high → minimum requirements on power demand, methane losses, process heat coverage. | ✓ | Annex 1 I No. 1 |
| *Biogas micronetworks* | | |
| Avoid upgrading yet provide for transport to heat sinks → technology bonus to be granted to biogas micronetworks or inclusion in the market incentive programme. | ✓ | Inclusion in Promotion Guidelines for Market Incentive Programme dated 5/12/2007. |
| **„NEEG" Negawatt Infeed Act** | | |
| *Premiums for manufacturers and importers of efficient technologies* | | |
| Promoting the development and market launch of specially energy-efficient technology which relies less on system optimization but rather on the efficiency of the actual product → system of premiums in analogy to EEG: premiums paid to manufacturers and importers of especially efficient technologies are allocated to the electricity price. | (×) | A similar proposal providing for electricity bill credits for final customers instead of manufacturers' premiums was already presented by BMU as part of a concept paper on ecological industrial policy. |
| *Sector- and/or technology-specific programmes* | | |
| EnergieSparFonds (energy saving fund) with EE programmes promoting a combination of consulting, energy analyses and EE technology, and thus especially system optimization → implementation of an EnergieSparFonds programme as proposed by WI. | (×) | Individual elements have already been taken up when amending MAP and KfW promotional programmes and in the communal promotional guidelines of the national climate protection initiative. |

# Recommendations

| Problem | Implemented? | Note |
|---|---|---|
| *NEEG test programme* | | |
| Lump-sum remuneration for major EE activities or programmes as of a minimum quantity of electricity saved in the amount of, e.g., 1 GWh/a → implementation of an EnergieSparFonds. | ✗ | |
| *Amendment to Incentive Regulation intended to stimulate competition (Anreizregulierungsverordnung, ARegV)* | | |
| This Regulation results in lacking efficiency, because the cost of energy loss is passed on to customers → improvement of the Regulation or specific promotional programme for reducing energy loss in the grid. | ✗ | Also refer to the current discussion among regulating agencies at the EU level |
| **Road/passenger vehicle traffic** | | |
| *Amendment of the EU Directive on fleet consumption* | | |
| Biofuel credits (10g $CO_2$/km) result in dewatering and a delayed EE increase → cancellation of credits for biofuel/RE fuel and other technical measures for achieving efficiency goals. | ✗ | |
| *Expansion of the NEDC measuring cycle; introduction of EE objectives for auxiliary systems* | | |
| The auxiliary systems and their fuel consumption are not covered by the measurement → measuring cycle should be performed with and without auxiliary systems. | ✗ | |
| So far, no efficiency requirements have been stipulated for auxiliary systems, such as air conditioning → introduction of separate, technology-specific EE objectives for auxiliary systems of passenger cars. | ✗ | |
| *Development of adequate and pragmatic approaches to the link between electric vehicles/renewables* | | |
| Promotion of additional renewable energy plants for covering the demand of electric vehicles → a simple mechanism should be included in government promotion that provides for the purchase of ecopower from additional plants and incentives for load management. | ✓ | "Work in progress" |
| Refuelling of electric vehicles to be included in load management for system integration of renewable energy → to be accounted for as part of the EEG cogeneration bonus. | (✓) | "Work in progress" |
| **Rail-bound/train traffic** | | |
| *RE goals for traction current* | | |
| So far, no specific investments have been made in RE plants; nuclear power portion to be replaced with carbon power → definition of targets for traction current (e.g. 100 % RE current by 2020). | ✗ | |
| *Extension of public invitations to tender* | | |
| RE and EE have so far played an insignificant role in invitations to tender → introduction of mandatory EE and RE goals and criteria in public invitations to tender for passenger miles by the federal states. | ✗ | |

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