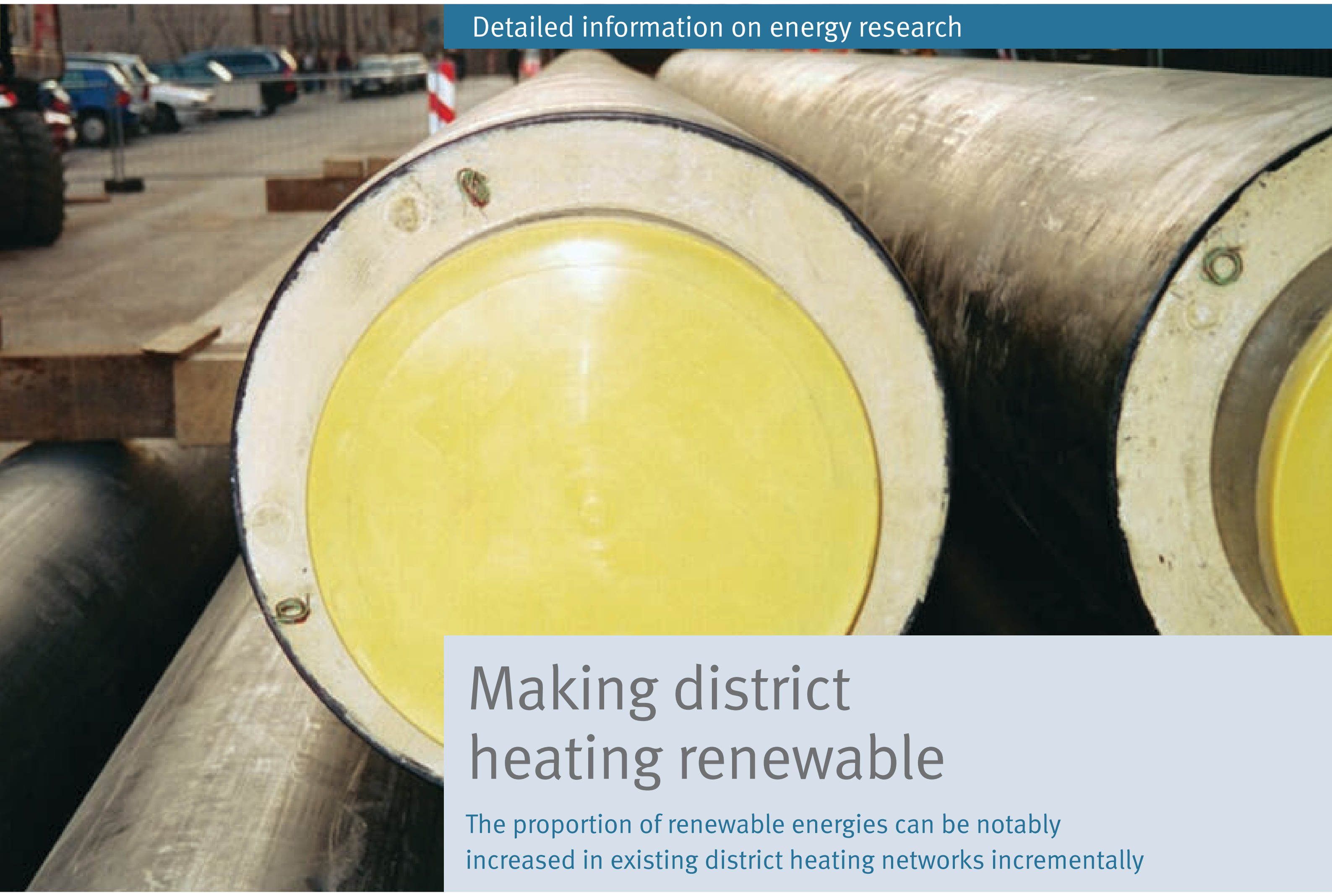
Detailed information on energy research



Making district heating renewable

The proportion of renewable energies can be notably increased in existing district heating networks incrementally

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Three research teams have investigated how the proportion of renewable energies can be increased in district heating networks. Custom strategies were developed in this respect for the model regions Jena and Ulm. The key lay in identifying the appropriate renewable energy sources and in understanding the potential these exhibit and the effect their inclusion would have on the efficiency of the networks. The project also comprises a survey of existing heat networks with best practice analyses.

Nowadays, central district heating networks are usually supplied with heat via a small number of conventional generator plants on the basis of fossil fuels. In addition to heating plants, cogeneration plants with combined heat and power generation (CHP) are commonly involved. CHP plants demonstrate efficient fuel use and exploit waste heat sourced from power generation. The German government has set the target of covering 14 per cent of the heat market from renewable energy sources by 2020 in the German Renewable Energies Heat Act (EEWärmeG). This figure was 10.4 per cent in 2011. The reorganisation of district heating can make an important contribution in this regard. However, large-scale heat-led CHP plants are already under economic pressure with respect to electricity generation from EEG-funded renewable power. In order to increase the proportion of renewable energy sources in existing district heating networks on an economic and sustainable basis, it is important to understand the renewable energy sources available and the potential these offer, and to clarify their suitability in terms of technical and economic considerations. The IFEU institute, GEF Ingenieur AG and the AGFW (German Heat & Power Association) have scrutinised these issues in the “Transformation strategies for district heating supply” study.

This research project is funded by the

Federal Ministry for Economic Affairs and Energy (BMWi)

Which renewable energy sources are suitable?

The researchers investigated various renewable energy sources in a technical analysis. These included biomass from wood sources, biogas and biomethane, solar thermal and geothermal energy. Definitive characteristics were compiled and assessed in a comparative analysis for the identified sources. The investigations revealed the following: Many renewable energy sources, such as solar thermal and geothermal energy, though also low temperature waste heat in combination with heat pumps, were found to reach their capacity limits at supply temperatures greatly above 100 °C. The requirements of these energy sources with respect to the generator site too were found to differ somewhat to those of fossil fuel powered plants. The essential challenge when it comes to reconstructing large-scale district heating systems, however, lies in developing a strategy tailored to the conditions on the ground. The significant degree of individuality is likewise illustrated in the best practice examples prepared: The examples depict how it has already proven possible to successfully incorporate renewable energy sources in nine existing networks (Fig. 1). The best practice examples establish that the renewable energies are used in combination with fossil fuels for economic operation. Biomass of wood origin and geothermal energy were found to be the most used renewable energy sources in heat generation. Solar thermal energy, biogas and biomethane play a subordinate role.

Jena: 50 per cent of energy sources renewable by 2030

A new concept is currently in the works for the city of Jena's energy supply with the "Integrated energy and heating concept 2050". The Stadtwerke Energie Jena-Pößneck municipal utility companies hope to use the concept, among other things, to investigate whether it makes sense to replace the current monocentric district heat generation infrastructure with more flexible structures. An initial biogas CHP plant generating 1.4 MW_{th} was built in 2007. As the availability of wood as a fuel, according to the researchers' estimations, limits use beyond current volumes, they suggested constructing a biomethane CHP plant as an initial step in converting the local heat supply infrastructure. Biomethane is methane of non-fossil origin and can be produced from biomass gasification in a technical process involving a synthesis gas. The next step would be to lower the temperature level of the network, e.g. by replacing the steam network and reducing the temperature in the hot water network. The construction of further generator plants based on renewable energy sources should commence only once these conditions are in place. This can also be achieved by standard CHP plants or heat pumps (with supply temperatures not exceeding 100 °C). This can include, for instance, a second biogas plant, additional biomethane CHP plants and, if applicable, the integration of waste heat from waste water. With a base load from renewable energies of approx. 22 MW, a proportion of 50 % of heat generation from renewable energies is feasible for Jena by 2030 if the overall heat requirement falls due to refurbishments.

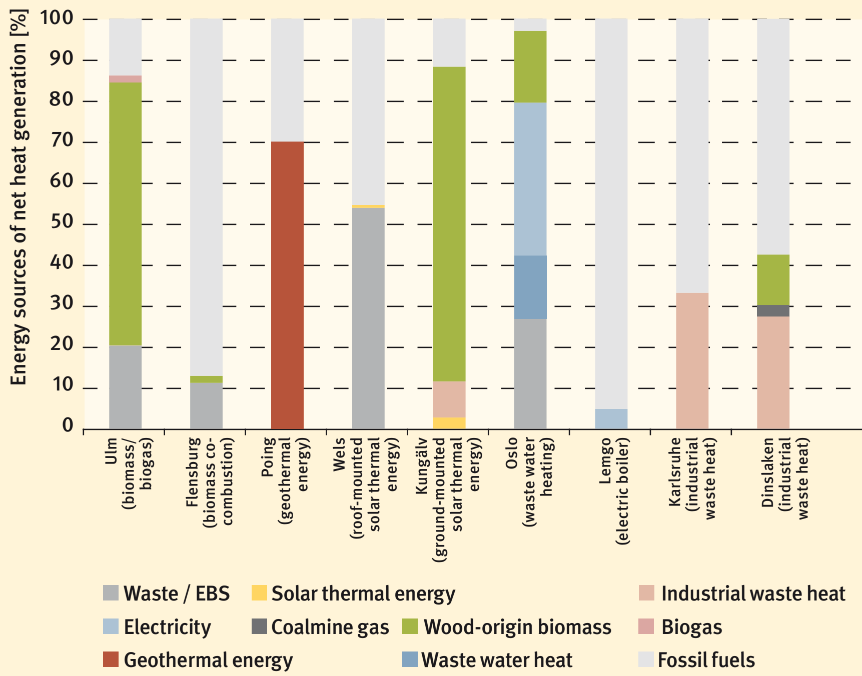

Fig. 1 *Overview of energy sources including renewable energies in best practice examples*

Energy source	*Wood-origin biomass*			*Biomass co-combustion*	
	Boiler	*CHP*		*Boiler*	*CHP*
Erzeugertyp		*Steam pow. process*	*ORC/KC*	*In coal boiling*	*Coal steam power process*
Thermal performance class					
Up to 1 MW	✓		✓		
1 to 5 MW	✓		✓		
5 to 10 MW	✓		✓		
10 to 20 MW	✓	✓	✓	✓	✓
› 20 MW	✓	✓		✓	✓
Electrical performance class					
Up to 1 MW			✓		
1 to 5 MW			✓		
5 to 10 MW		✓			✓
10 to 20 MW		✓			✓
› 20 MW		✓			✓
Load type					
Peak load	(✓)			(✓)	
Base load	✓	✓	✓	✓	✓
Summer load					
Temperature level					
Steam network	✓	✓		✓	✓
High-temperature network (T_{Vl} › 140 °C)	✓	✓		✓	✓
Hot water networks (140 °C › T_{Vl} › 110 °C)	✓	✓		✓	✓
110 °C › T_{VL} › 90 °C	✓	✓		✓	✓
Low-Ex network	✓	✓	✓	✓	✓

Fig. 2 *Selected options for integrating renewable energies in district heating (green: available; red: not available/not expedient; white: not applicable)*

Recommendations for conversion strategies: What needs to be done?

The advisability and success of integrating renewable energies in district heating depend heavily on the specifics of the network. The researchers consequently have developed a decision tree that helps district heating operators review the steps expected to increase the proportion of renewable energies in their supply systems. The model regions investigated and the best practice examples of the study illustrate transformation steps under economic conditions that are also transferable to other networks (Fig. 4). The issue of reducing the network temperature for in-

Fig. 3 *Inside the municipal utility company's heat transfer station in Jena: The plant transfers the heat from steam to hot water.*

Integration of renewable energies plants	Network optimisation	Consumption trend	Contribution to renewable energies/electricity system integration
Geothermal energy	Temperature level reduction	Higher proportion of renewable energies owing to reduced sales volume	Connection of electric boiler to renewable energies surplus electricity
Biomass CHP / peak load	Construction of secondary networks	Harmonisation of annual load duration curve	Thermal storage system for boosting current volatility of CHP
Biogas and biomethane CHP	Integration of thermal storage systems		
Biomass co-combustion	Return supply		
Solar thermal energy			
Heat pumps (LT heat)			
Industrial waste heat			

Fig. 4 *Transformation columns of district heating systems for higher proportions of renewable energies*

Ulm: Pioneer at the very forefront.

District heating company Fernwärme Ulm GmbH (FUG) supplies district heating to a total of 15,000 residential units. With a connected load of 390 MW_{th}, the network already exhibits a proportion of heat generated from renewable sources in excess of 50 %. This heat for the most part is supplied by biomass CHP plants and a waste-fuelled power plant. Heat is furthermore supplied to the network by four CHP plants of external suppliers (three biogas plants, one vegetable oil CHP plant). This makes Ulm a true pioneer when it comes to integrating renewable energies into large-scale district heating systems and the city is now at a stage in its development that Jena would be expected to reach around 2030 based on the transformation strategy developed. For Ulm therefore, minds are now focussed on exploring necessary options to boost the proportion of renewable energies yet further. In light of the positive history of the biomass CHP plant I operated in the western part of Ulm since 2004, a second plant (biomass CHP plant II) was ultimately commissioned in 2012. Further investment on this scale is not expected to follow suit in the coming years due to energy industry boundary constraints. The study revealed in consideration of economic factors therefore that the district heating system belonging to FUG integrates close to the optimum proportion of renewable energies. Any further integration of new regenerative plants currently would reduce the economic viability of heat generation.

stance is greatly significant. If renewable energy sources cannot be procured nationwide, potential identified at regional level limits the development of renewable district heating – beyond technical and economic benefits.
Further findings: It is not necessary to replace centralised high-output fossil fuel-powered CHP plants with renewable energy plants of the same output if economic leeway exists for these to relinquish some of the base load. Furthermore, the operation of renewable CHP plants complicates the integration of solar thermal and geothermal energy in the base load. To ensure, however, that renewable heat is not lost, the integration of large-scale short-term heat storage tanks with daily or multi-day charging and discharging cycles has proven of value.
Renewable proportions of 50 % of network supply appear achievable overall through an incremental approach, even under less optimal framework conditions. Whether large-scale heating networks in future can source 100 % of their thermal energy needs from renewable sources is doubtful. The study's model calculations revealed there to be significant difficulty associated with achieving a very high renewable energies proportion while keeping end customer pricing at a reasonable level.
Political instruments developed by the researchers are aimed at supporting individual optimisation solutions. Proposals include a support programme for the development and implementation of measures for network transformation and promotion of solar thermal energy in order to gain more experience in Germany in the implementation of solar power-supplied district heating networks.
In terms of the German Renewable Energy Sources Act (EEG), proposals include modifying the former exclusivity regulation specific to biomass, subject to certain conditions such as adherence to sustainability criteria. This would better serve the implementation of biomass co-combustion and busbar CHP plants. The 2014 amendment to the EEG, however, has worsened the conditions for the economic operation of CHP plants with biomethane and solid biomass. The amendment has made the replacement or extension of such plants more difficult, in Jena, Ulm and elsewhere.

Research for energy-efficient heating networks

The EnEff:Wärme research initiative of the German Federal Ministry for Economic Affairs and Energy supports concepts for new adaptive cooling and heating networks that also create potential avenues for the integration of renewable energies. Essentially, however, it‘s all about boosting efficiency. EnEff:Wärme promotes specific network optimisation with the aim of further increasing the share of local and district heating and integrating less densely populated areas into the supply network. This could be the future of central heat supply systems. District heating networks, or smart grids, are to become central building blocks in local energy management. “Low-exergy technologies” (LowEx) help reduce transmission losses. Two example projects:

Decentralised feed of solar heat into local and district heating networks

The multifunctional use of district and local heating networks could already make a notable contribution to realising low-emission heat supplies in the short to medium term. However, until now there has been a lack of detailed thermohydraulic investigations into the network and system technology at the interfaces of decentralised feed-in units/district heating networks and storage systems/district heating networks. Researchers at the AGFW, Dresden University of Technology and the Solites Steinbeis Institute are investigating the technical and ecological implications in this regard of decentralised supply with the aid of coupled simulations. On the basis of the simulation results, the researchers define requirements for system components and develop corresponding technologies and system solutions. To support the project, a new house connection and grid feed-in station (HANEST) has already been developed and tested by the Dresden University of Technology.

Thermal storage systems for improved flexibility of CHP plants

Flexible operation of CHP plants can be achieved by integrating thermal storage systems in district heating networks, as this would allow for a decoupling of electricity and heat supply in terms of time. In an EnEff:Wärme project, researchers at TU Berlin are investigating the conditions under which investments in the construction of a storage system are economically viable, and which improvements would be the result from an environmental policy perspective. Alongside TU Berlin, Leipzig University, the Hanover University of Applied Sciences and various industry partners are involved in the research project, which is expected to run until 2016.

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Links and literature (in German)

- www.eneff-waerme.info/en
- AGFW, Frankfurt am Main (Hrsg.): Transformationsstrategien Fernwärme. TRAFO – Ein Gemeinschaftsprojekt von ifeu-Institut, GEF Ingenieur AG und AGFW. Abschlussbericht. FKZ 0325184. April 2014. 292 S. Forschung und Entwicklung. H. 24
- Huther H., Paar A., Richter S., Ochse, S.: Transformation statt Wende – Wie kann in Fernwärmenetzen der Anteil erneuerbarer Wärme erhöht werden? In: EuroHeat & Power. Jg. 42 (2013), H. 6, S. 26 – 31

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Imprint

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Project number
0325184

ISSN
0937 - 8367

Publisher
FIZ Karlsruhe · Leibniz Institute for Information Infrastructure GmbH
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A service from FIZ Karlsruhe

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Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag

Concept and design: iserundschmidt GmbH, Bonn – Berlin, Germany · Layout: KERSTIN CONRADI · Mediengestaltung, Berlin, Germany