Green District Heating – Actual Developments of Deep Geothermal Energy in Germany

Buescher, Eckehard

Eckehard.buescher@geothermie.de

Keywords: Geothermal district heating, Germany, Europe, GDH, Munich, Ruhrgebiet,

ABSTRACT

In Germany the existing district heating systems mostly use conventional fossil fuels. They have been in operation for centuries; run by the waste heat of coal power plants. As the use of local heat is the fundamental idea behind modern district heating systems, the use of geothermal energy for DH becomes more and more relevant. Heat, cooling and fuel sources that normally would be lost remain in the local systems for both residential and non-residential sectors (including industries). Another important reason to use regional geothermal energy is the political target of German society to become more independent from external gas and oil resources.

1. INTRODUCTION

The heating and cooling sector plays an important role with respect to the primary energy demand, as in the EU and all over the world, heat and cooling demand accounts for about 50% of the total energy consumption. The potential of geothermal energy for this sector and not just for electricity supply is vast: The RHC (Renewable heating and cooling panel – European Technology Platform) estimates that in 2020, over 25% of heat consumed in the EU could be generated from renewable sources. By 2030, RHC technologies could supply over the half of the heat used in the EU. Besides geothermal energy, biomass and solar power are the basis of RHC. One of the reasons for an optimistic outlook into a renewable future in Germany is the increasing use of highly effective district heating systems with geothermal energy as a base load.

2. CURRENT STATE IN EUROPE AND GERMANY

In many countries in Europe, district heating systems using mostly conventional fossil fuels have been operating for centuries. Increasingly, the use of renewable energy like biomass, waste, or geothermal is becoming attractive. As the use of local heat is the fundamental idea behind modern district heating systems, they become more and more relevant. Heat, cooling and fuel sources that normally would be lost remain in the local systems for both residential and non-residential sectors (including industries). The use of geothermal district heating is already spread across Europe. Only 10 of 33 European states did not have geothermal district heating installed in 2012 (Figure 1).

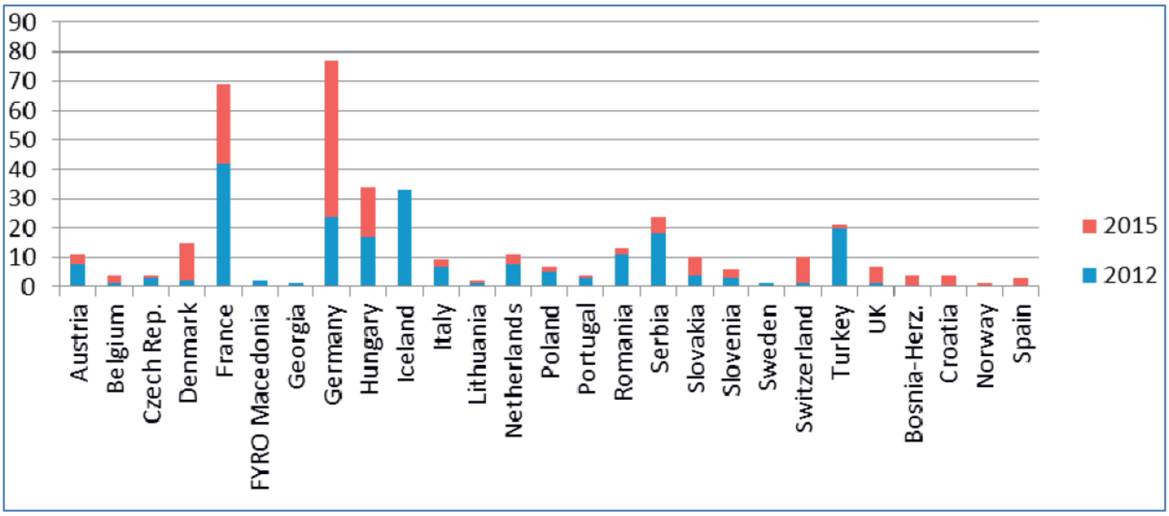

Figure 1: Development of Geothermal District Heating Systems in Europe in 2012 and 2015 [4]

A large number of geothermal district heating systems can be found in France (~42 systems, 250 MW_{th}), Iceland (~32 systems, 2,300 MW_{th}) and Germany (~27 systems, 250 MW_{th}). Right now the installed geothermal capacity of Europe adds up to 4,900 MW_{th}. 1,700 MW_{th} of this capacity is in EU-member states. It is estimated that the number of geothermal district heating systems in Europe will increase extensively in these years. By 2015 four more states are expected to be equipped with GDH systems. Specifically, the number of GDH systems as in Germany, France and Hungary will increase about 80.

Table 1: Actual Deep Geothermal Projects in Germany [1]

Tiefe Geothermieprojekte in Deutschland									
Projekte in Betrieb									
Status	**Name**	**Bundesland**	**Art der Nutzung**	**MW_{therm}**	**MW_{el}**	**max. Temperatur in °C**	**Teufe in m**	**Förderrate (l/s)**	**Jahr d. Inbetrieb-nahme**
27 Projekte in Betrieb	Arnsberg	Nordrhein-Westfalen	Sonde	0,35	0	55	2.835	5,6	2012
	Aschheim, Feldkirchen, Kirchheim	Bayern	Hydrogeothermie	19	0	85	2.630	75	2009
	Bruchsal	Baden-Württemberg	Hydrogeothermie	5,5	0,55	120	2.542	24	2009
	Dürrnhaar	Bayern	Hydrogeothermie	0	7	141	3.926	130	2013
	Erding	Bayern	Hydrogeothermie	9,7	0	65	2.200	55	1998/2008
	Garching	Bayern	Hydrogeothermie	6	0	74	2.100	100	2010
	Heubach/Groß-Umstadt	Hessen	Sonde	0,09	0	38	800	0	2012
	Insheim	Rheinland-Pfalz	Hydrogeothermie	0	4,8	165	3.300	85	2012
	Ismaning	Bayern	Hydrogeothermie	7	0	77	1.906	85	2013
	Kirchstockach	Bayern	Hydrogeothermie	0	7	139	3.882	130	2013
	Landau	Rheinland-Pfalz	Hydrogeothermie	5	3,6	160	3.340	70	2007
	München-Riem	Bayern	Hydrogeothermie	10	0	93	2.746	75	2004
	Neubrandenburg	Mecklenburg Vorpommern	Hydrogeothermie	3,8	0	53	1.267	28	1987
	Neuruppin	Brandenburg	Hydrogeothermie	2,1	0	64	1.700	13,9	2007
	Neustadt Glewe	Mecklenburg Vorpommern	Hydrogeothermie	7	0	99	2.320	35	1994
	Oberhaching-Laufzorn / Grünwald	Bayern	Hydrogeothermie	40	3,8**	127	4.083	140	2011
	Poing	Bayern	Hydrogeothermie	7	0	76	3.000	100	2011
	Prenzlau	Brandenburg	Sonde	0,15	0	108	2.790	k.A.	1994
	Pullach	Bayern	Hydrogeothermie	15	0	107	3.445	105	2005/2012
	Sauerlach	Bayern	Hydrogeothermie	4	5	140	5.567	110	2013
	Simbach/Braunau	Bayern	Hydrogeothermie	9	0	90	1.942	90	2001
	Straubing	Bayern	Hydrogeothermie	4,1	0	36	800	45	1999
	Unterföhring	Bayern	Hydrogeothermie	10	0	85	2.512	85	2009
	Unterhaching	Bayern	Hydrogeothermie	38	3,36	122	3.350	150	2007
	Unterschleißheim	Bayern	Hydrogeothermie	30,81	0	79	1.960	100	2003
	Waldkraiburg*	Bayern	Hydrogeothermie	13,5	k.A.	108	2.650	65	2012
	Waren	Mecklenburg Vorpommern	Hydrogeothermie	1,3	0	63	1.566	17	1984
	SUMME			**248,4**	**31,31**				
	*Leistung bei Vollendung des Wärmenetzes								
	**Kraftwerk in Bau								

Most of the existing and under construction DH-projects in Germany are in the south; either in the Molasse basin north of the Alps or in the upper Rhine valley. Both areas offer appropriate conditions for the use of deep geothermal energy. With typical temperatures between 80-95°C at depths of 2,600 to 3,000 meters and more than 120 to 150° expected deeper than 4,000 meters, both geothermal electricity production (ORC or Kalina) and direct heating systems may be possible. For the production of electricity by geothermal energy, it is important to know that there is a feed-in-tariff for geothermal electricity of 25€ct/kWh (34$ct/kWh). This price is ambitious but seems to be sufficient. The number of geothermal power plants in Germany will rise from the current number of 7 to 18 when those that are under construction or planned are completed. All of these plants use and will use the geothermal heat to deliver regional heating systems. Most of the German deep geothermal projects will be for direct use applications and will not produce electricity.

3. PROJECT EXAMPLES:GREEN DISTRICT HEATING

3.1 Heating of the City of Munich

The city of Munichh has a population of more than 2 million, and therefore it has ambitious targets on its future energy supply. Munichh seeks to become the first CO_2-free capital of the world. 100% of the electricity would be produced from renewable sources by 2025. Munichh seeks to generate 100% of its heat demand from renewable sources with biomass and geothermal energy by 2040. [4]. At present, the district heating network has a length of 800 km and will be expended in the next years, as can be seen in Figure 2.

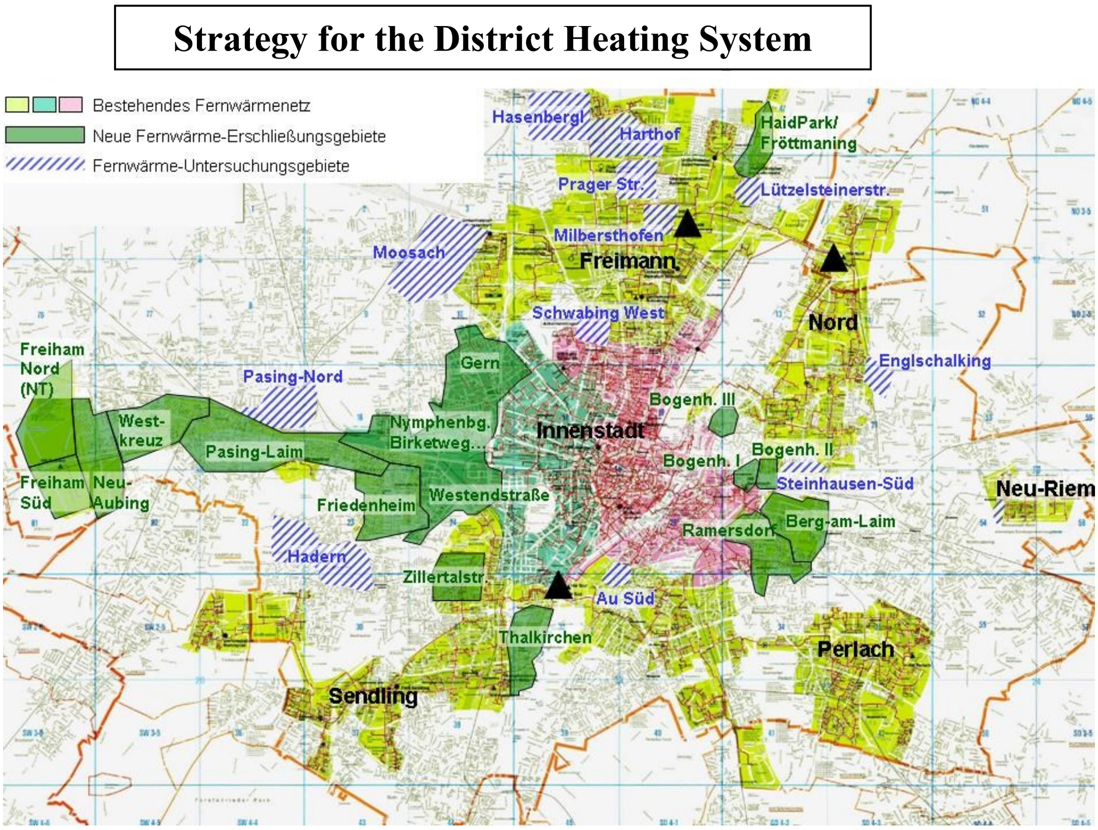

Figure 2: Future Development of Green District heating in Munich

In many smaller cities all around Munichh, such as Ismaning, Kirchweidach, Sauerlach, about 3,000m deep wells are being drilled to contribute to the heat supply for Munichh's district heating system. The number of potential sites for for the geothermal district heating projects is up to16.

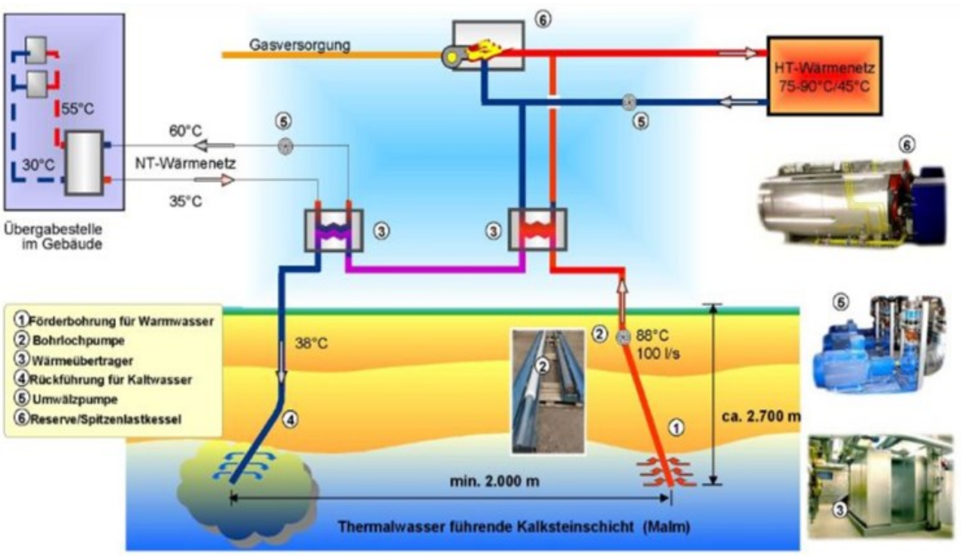

Figure 3: Functional Chart of one of the Munich Geothermal Heating Systems [2]

On the area of the former airport München-Riem, the city of Munich constructed the fairgrounds for Messe München. This area is the location of one of the first geothermal plants. The relevant data for Riem are described in Table 2.

Table 2: Data of Geothermal Heat Plant of München-Riem

Drilling:	Dublette
Thermalwater temperature:	80 °C
Depth:	2.600 bzw. 3.000m
Installed geothermal Capacity:	8 MW
Implementation Date	2004

Table 3: Data of Geothermal Power and Heat Plant of Sauerlach near Munich

Drilling depth:	Th1: 4.757 m Th2: 5.060 m Th3: 5.567 m
Temperature Thermalwater:	140 °C
Yield:	110 l/s
Electrical capacity	5 MW
Annual Power Production	40 Mio. kWh
Max. Heat Capacity and porduction	4 MW / 4 Mio. kWh/year (enough for 16,000 households)
Annual CO_2-reduction	35.000 tons

3.2 Future District Heating of the Ruhrgebiet

The highly industrialized and very densely populated Ruhrgebiet (area of the river Ruhr) in North-Rhine Westphalia is home to about 6 million people. The former coal mining area has a lot of experience and knowledge in mining techniques, thermal power plants and all kinds of renewable energies. Due to guidelines of the European Commission the coal mining in this area will have to phase out until 2018. Then the last of the coal pits, going down to more than 1,000 meters, will have to finish its activities. For two reasons this is a chance for geothermal energy:

1. Using of the mine water with a temperature of about 30-40°, which is already done in some projects in the Ruhrgebiet
2. Conversion of the existing district heating systems from coal to renewable energies as geothermal, biomass and “windgas”

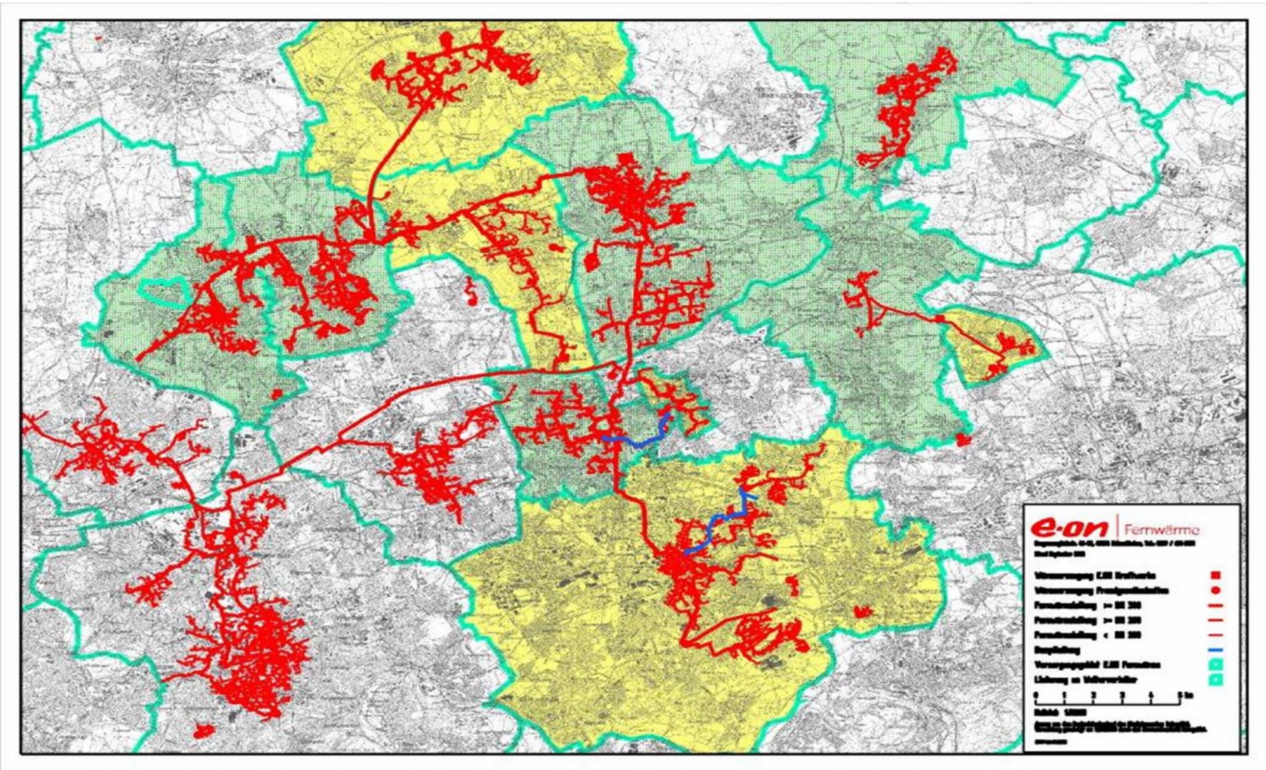

Figure 4: Main district heating lines in the Ruhrgebiet [3]

Bott investigated in 2013 the geothermal potential of this densely crowded area [8]. He calculated a theoretical potential of 841 EJ and the technical potential in a distance of 1.5 km to the existing main DH lines of 38 EJ (10,500). This is big enough to serve the existing heat demand of about 6,000 GWh/a.

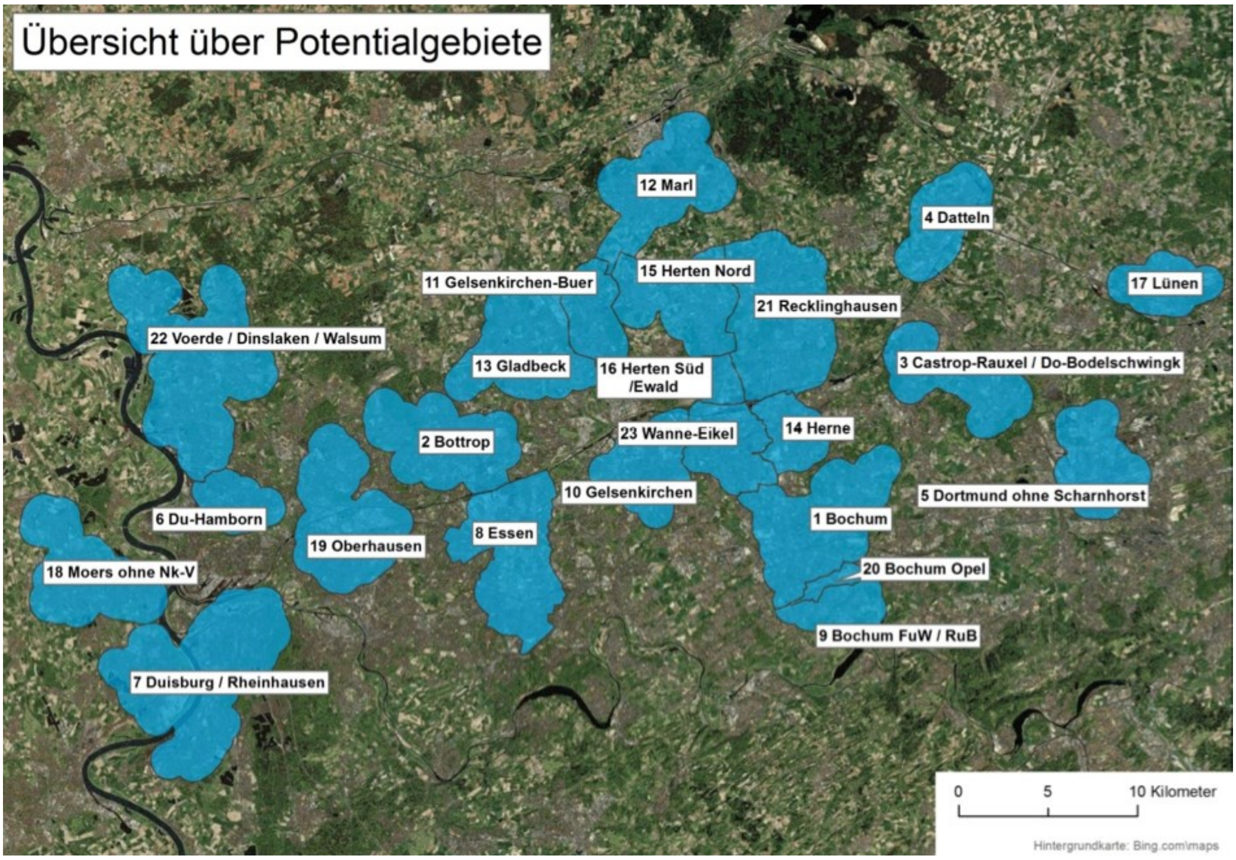

Figure 5: (Geothermal) District Heating Areas in the Ruhrgebiet [3]

4. FUTURE DEVELOPMENT IN EUROPE AND GERMANY

The first phase of German Energiewende focused on renewable electricity. Meanwhile, more than 25% of German electricity is produced mainly by wind and photovoltaic and the phase-out of nuclear power will be managed without power cuts. Meanwhile, Germany is still exporting electricity. Now is the time to concentrate on sustainable development within the heating sector, which accounts for more than 50% of energy consumption (electricity is just 16%) [7].

This projected development uses the advantage that geothermal district heating is efficient with respect to costs and environmental impact (low CO_2 emissions). Furthermore, geothermal energy is a renewable heat source which has a high security of supply because it is not affected by outside temperature, season or time of day and can be installed in nearly every European state.

Another aspect is the urbanization taking place all over the world. In the future, an increasing number of people will need heating and cooling in highly populated urban areas. Geothermal energy has good potential to meet this demand for heating and cooling of homes, offices and factories in an effective and sustainable matter.

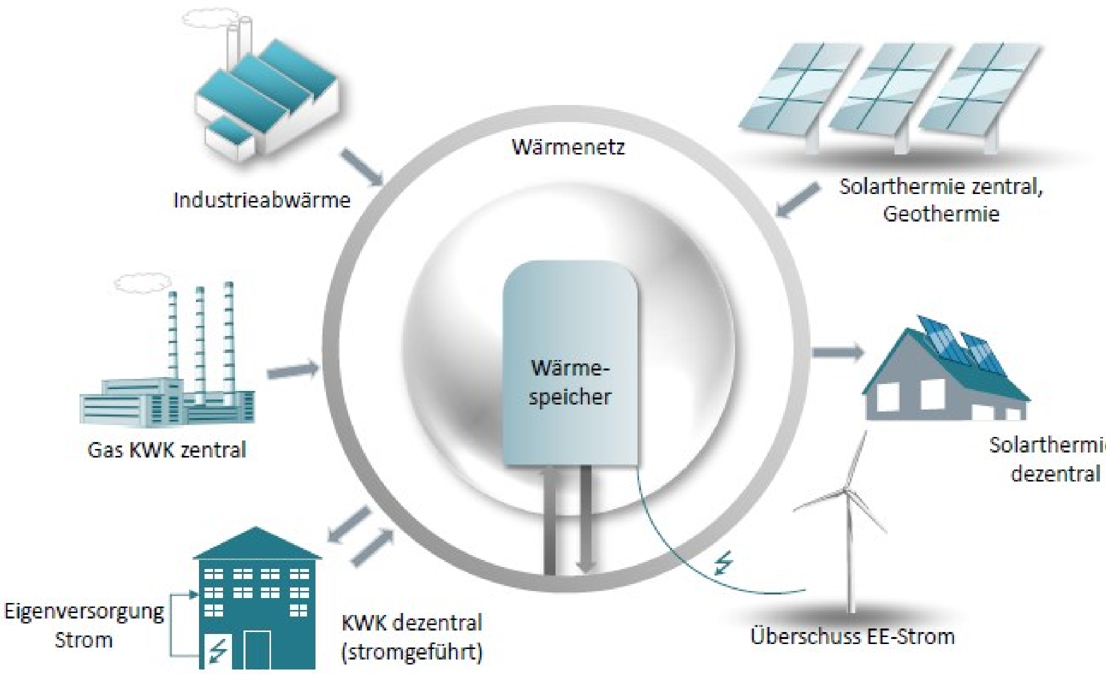

Figure 6: Intelligent Heating Network [7]

In the future, a sophisticated system combining different renewable energy resources will help to reach the targets of "Energiewende", which must not focus just on electricity. An intelligent combination of improved energy efficiency and renewable heat sources will help to reach the ambitious climate protection targets. Renewable energy sources could be as follows:

- geothermal
- solar
- biomass
- "windgas" (power to gas and power to heat)
- underground heat storage
- combined heat and power
- industrial heat

There is huge potential for geothermal energy and for climate protection by using intelligent networks.

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