

District Heating as an important Pillar of a Smart Urban Heating Supply System City of Graz/Austria

Christian Nussmueller

City of Graz / Austria

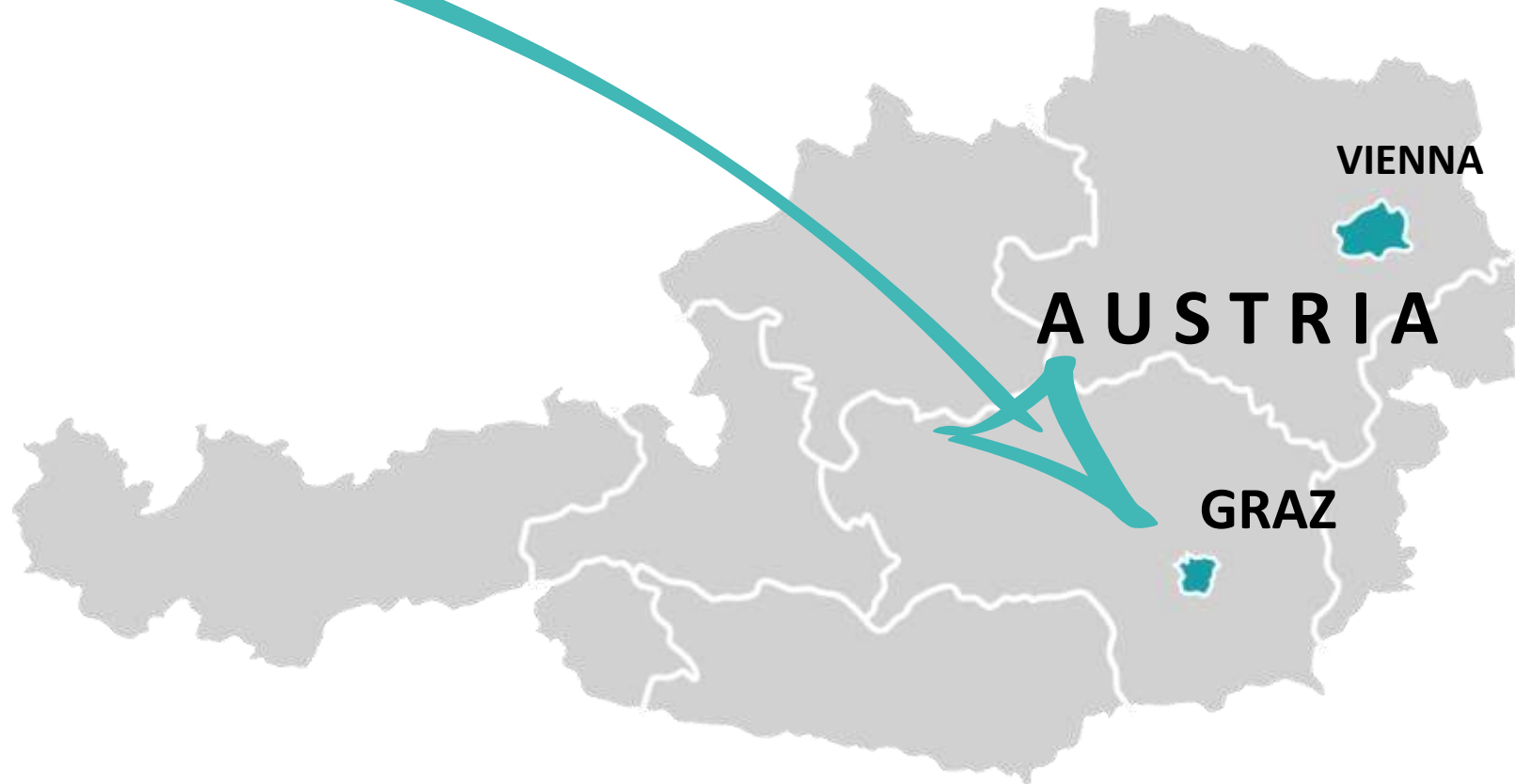
Executive Office for Urban Planning,
Development and Construction

**smart
city
graz**



Coordinates: 47°4'N 15°26'E

smart
city
graz



Graz – Austria's second largest City

Graz: 320.500 Inhabitants

(primary + secondary residence; 01/2017)

- **Non-self-employed workers: 171.600**
(01/2017)
- **Overnight stays : 1.080.000**
(year 2016)
- **Number of companies: 17.400**
(01/2017)

60.000 Students

(01/2017)

8 Universities
2 Universities of Applied Sciences
2 Colleges

14 Scientific Centres
of Excellence

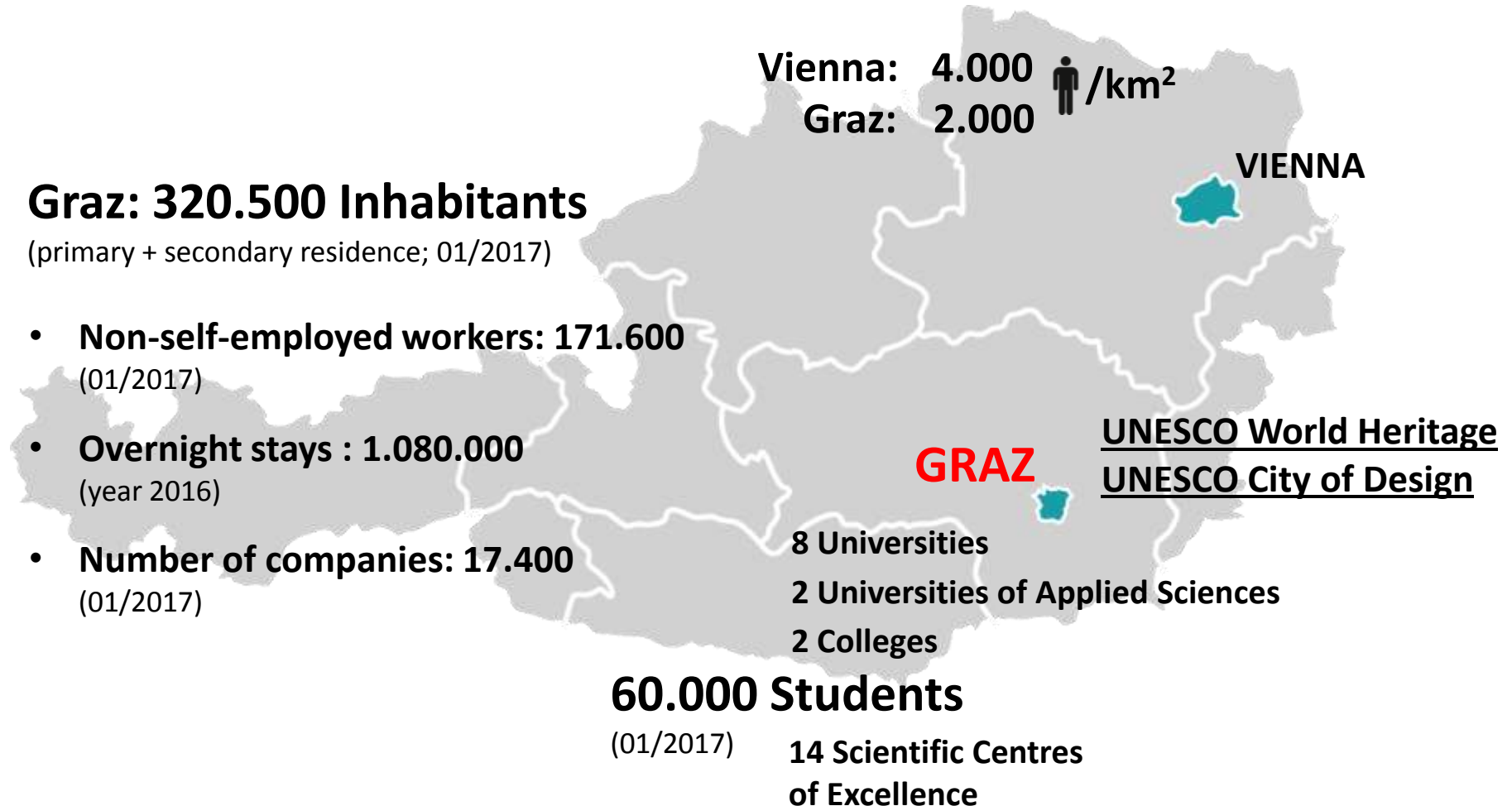
Vienna: 4.000 /km²
Graz: 2.000



VIENNA

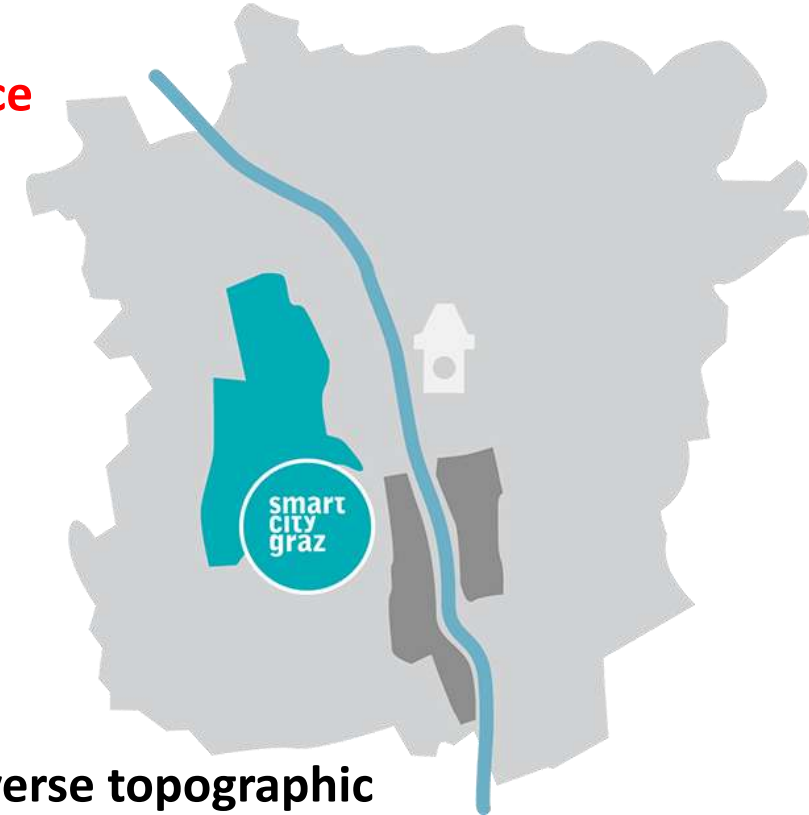
GRAZ

UNESCO World Heritage
UNESCO City of Design



Graz – Local Conditions and Challenges

- Primary residents: 286.686 (01/2017)
+50.000 since 2003 → strong demand for housing space
whole functional urban region Graz: 0.5 m
continually increasing
- Superficial area of 127 km²
thereof 50% zoned as green belt area
→ limited building land reserves
- **No** substantial building land reserves
of **public property**
- Local air quality and climate challenges because of adverse topographic
basin situation **→ Particulate Matter, Oxides of Nitrogen/NOx**
from motorised traffic, industrial emissions and domestic heating
(threat of legal action by EU)



Smart City Graz Strategy Development 2010-2013:

Vision for Graz in 2050 – General Objectives

- Dynamic city with compact building structures, an ideal urban mix of usage, attractive public spaces and a high quality of living.
- Consistent implementation of Smart City Strategy result in an energy-efficient, resource-conserving and low-emission city.
- Environmental friendly approach should be achieved by implementing sustainable concepts for energy consumption, mobility, and others.

Urban Development Concept 4.0

(legally binding, mandatory character since 2013)

10 Basic Principles:

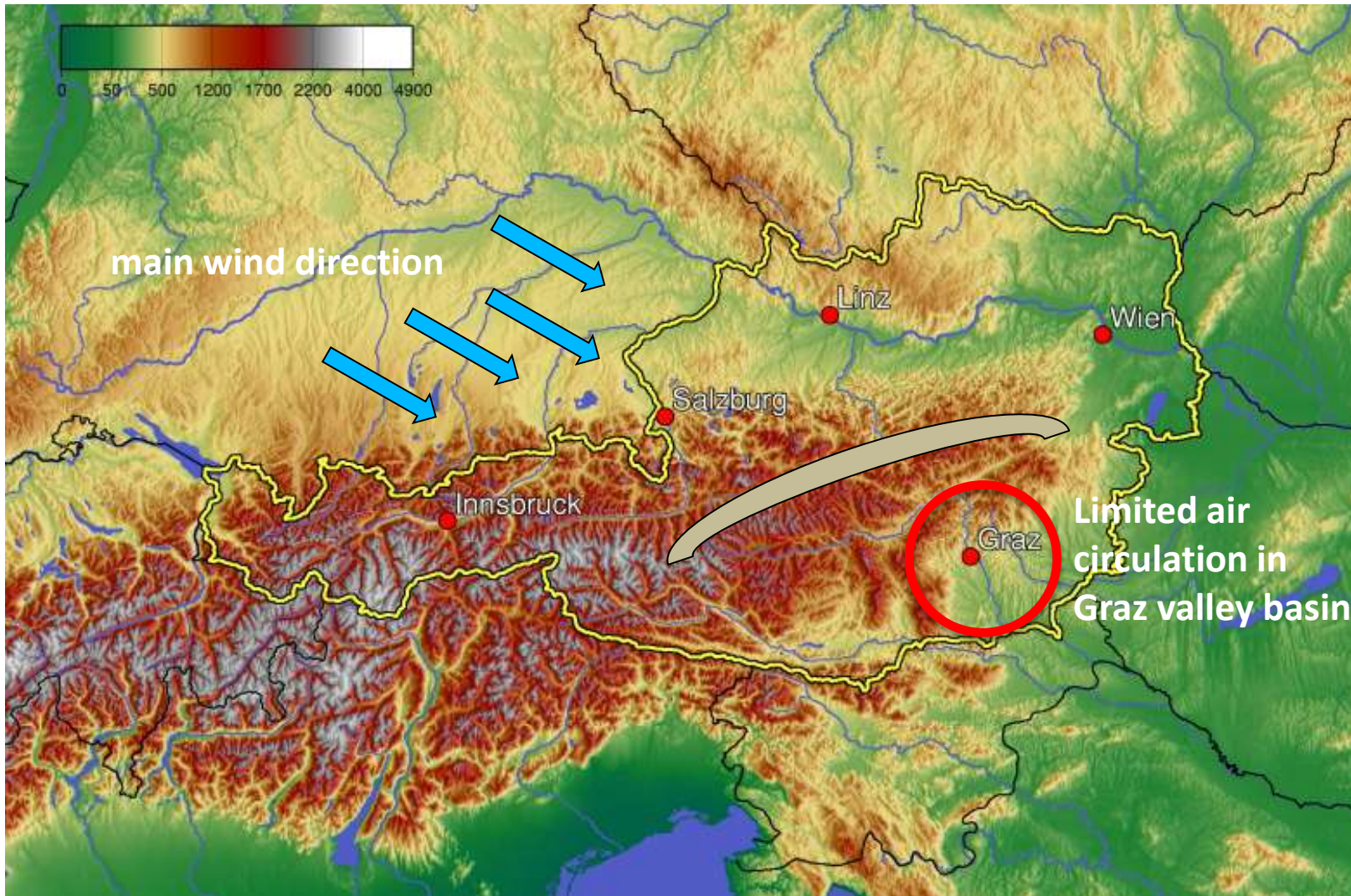
1.	Graz is developing into a „Smart City“
2.	Graz is considering itself as a significant player of regional development
3.	Graz represents a balanced integrated system
4.	Graz commits for an integrated urban planning approach
5.	Graz offers attractive living conditions for the whole city area
6.	Graz commits for high quality growth
7.	Graz offers both urbanity and diversity
8.	Graz is using any scope of action
9.	Graz commits for an applied building culture
10.	Graz commits for protecting its green space

City with
a high level
of quality of
life

Presentation Content

- 1. City of Graz - Local Conditions and Framework**
2. Basic Sources of Heat Supply for District Heating
3. Challenges and limits of the DH System and Sources
4. Since 2013: Large Scale DH-Strategy Process
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7. Conclusions - Messages for European Level

The Special Climatological Situation of FUA Graz Area



Quelle: https://upload.wikimedia.org/wikipedia/commons/4/4a/Oesterreich_topo.png

The Basin Situation in Graz

Atmospheric/thermal inversion in winter season

Main air pollutants:

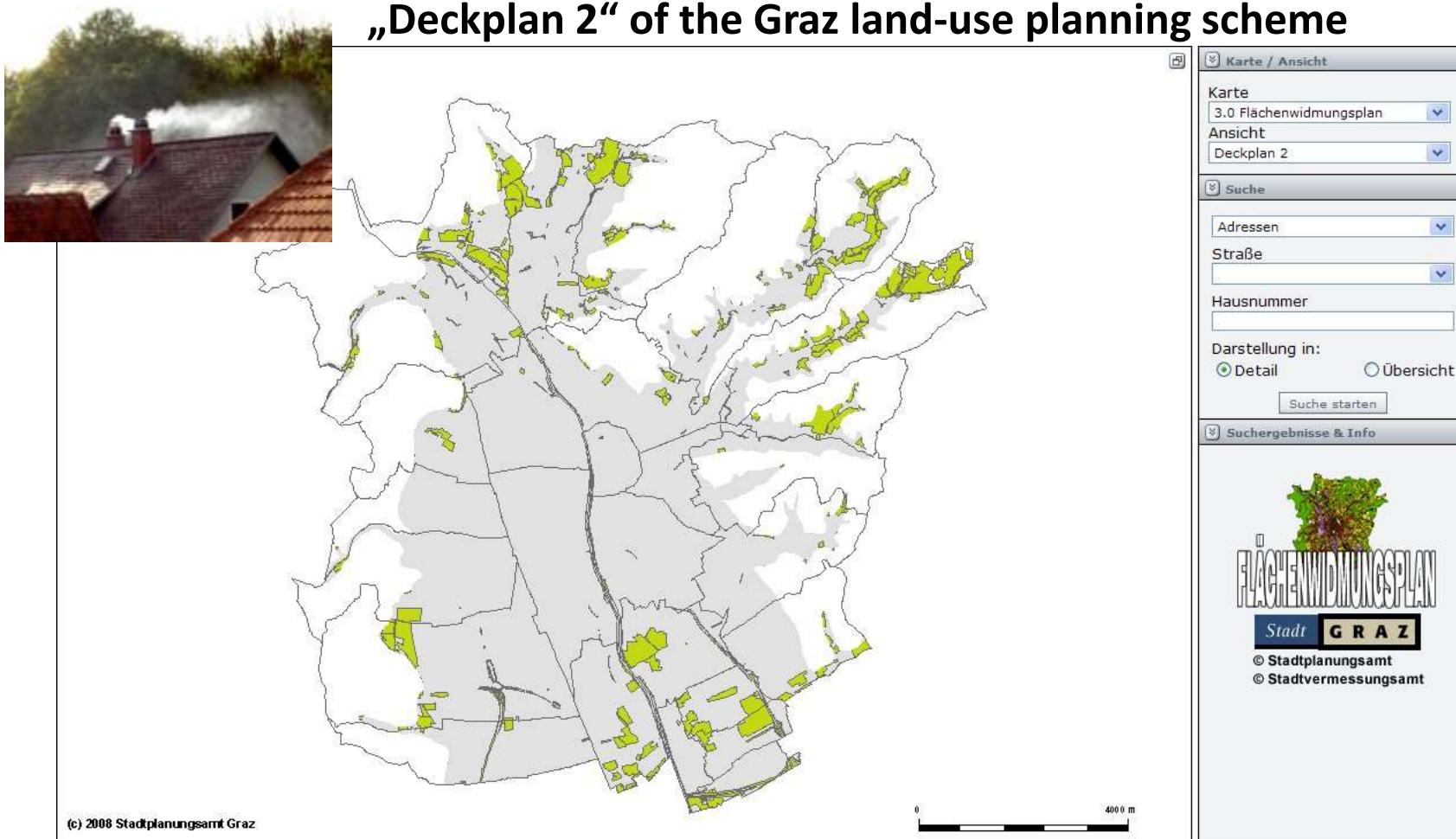
- PM₁₀
- NO₂
- BaP (Benzo(a)pyrene, a PAH)
- CO₂



Restriction Zones for Domestic Solid Fuel Heating

Mandatory preference areas for Central Heating

„Deckplan 2“ of the Graz land-use planning scheme



Dust concentration limit: 4,0 g / m² GFA and year

Other domestic heating action: Prohibition of redundant (solid fuel) heating systems

Smart City: „Existing Building Stock“ vs „New Stock“

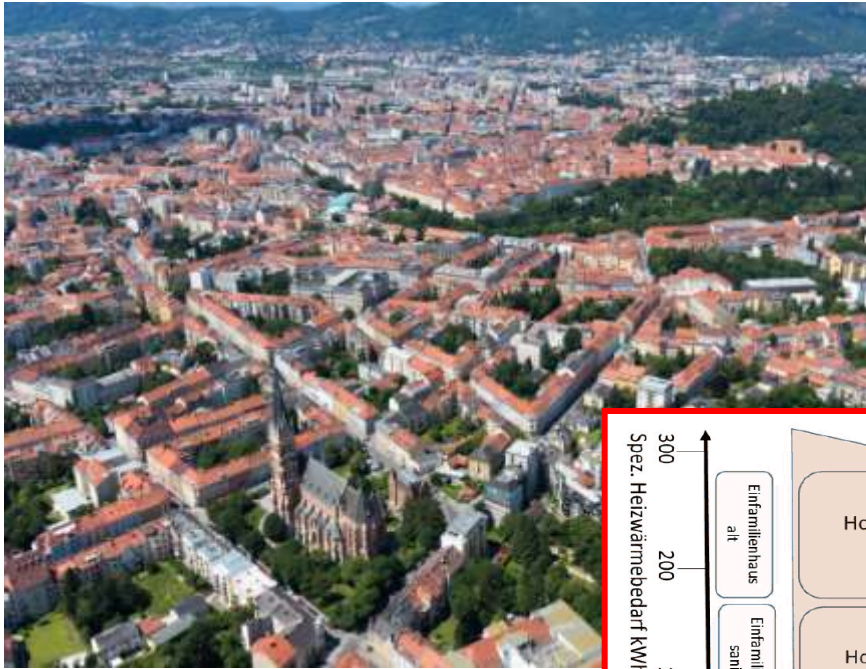


Foto: Graz Tourismus, Harry Schiffer



District Heating
definitely suitable for
„Existing Building
Stock“ !

**Combination with
Smart Grid District
Heating Networks
in Smart City Target Areas**
(innovative heat exchange
systems between buildings, etc.)

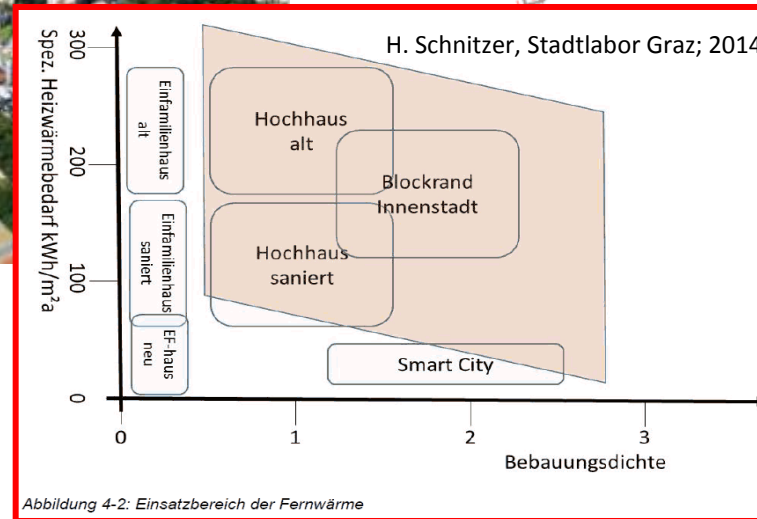
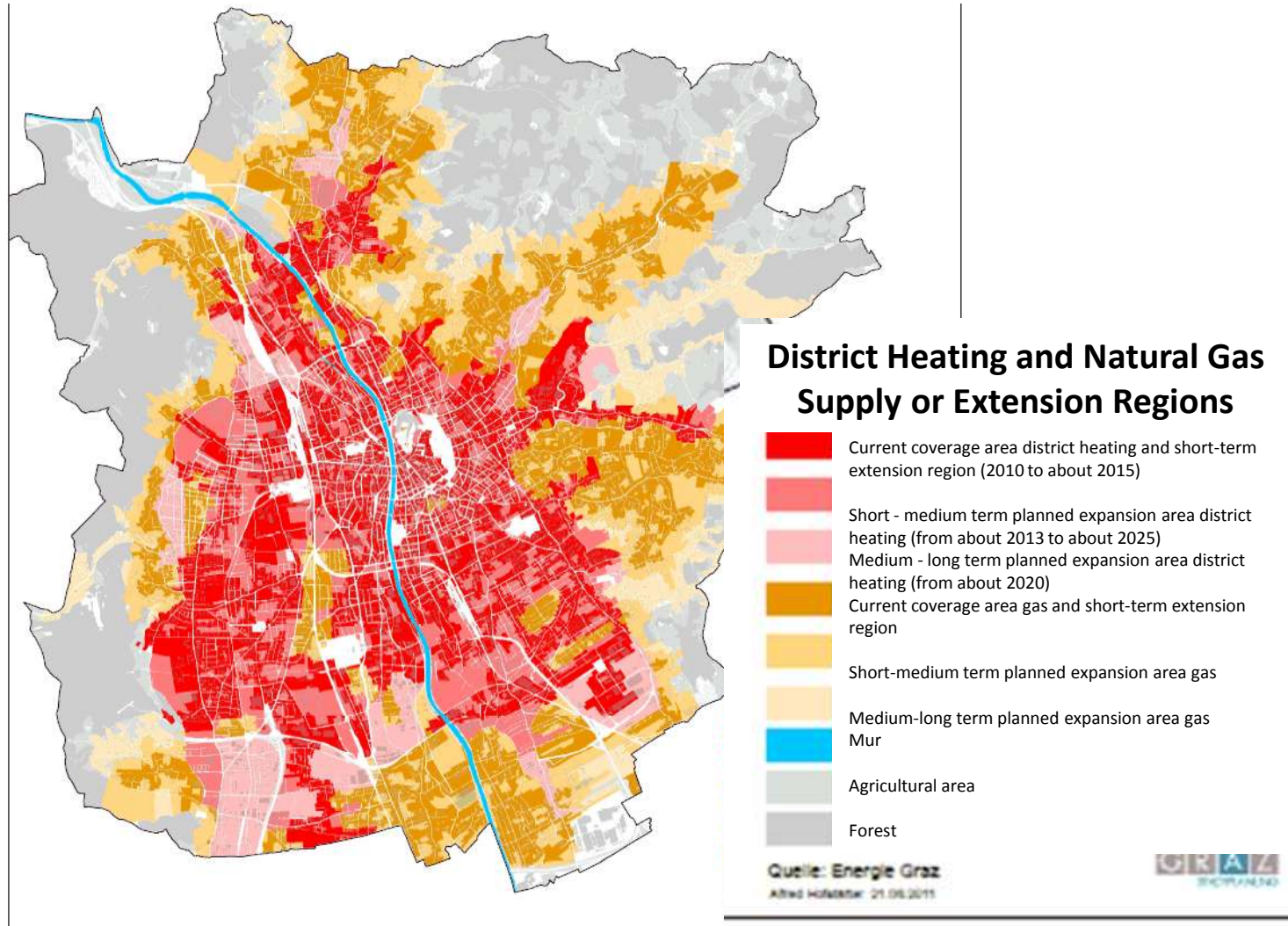


Abbildung: Pentaplan ZT GmbH

Legal framework: district heating supply area (DH)



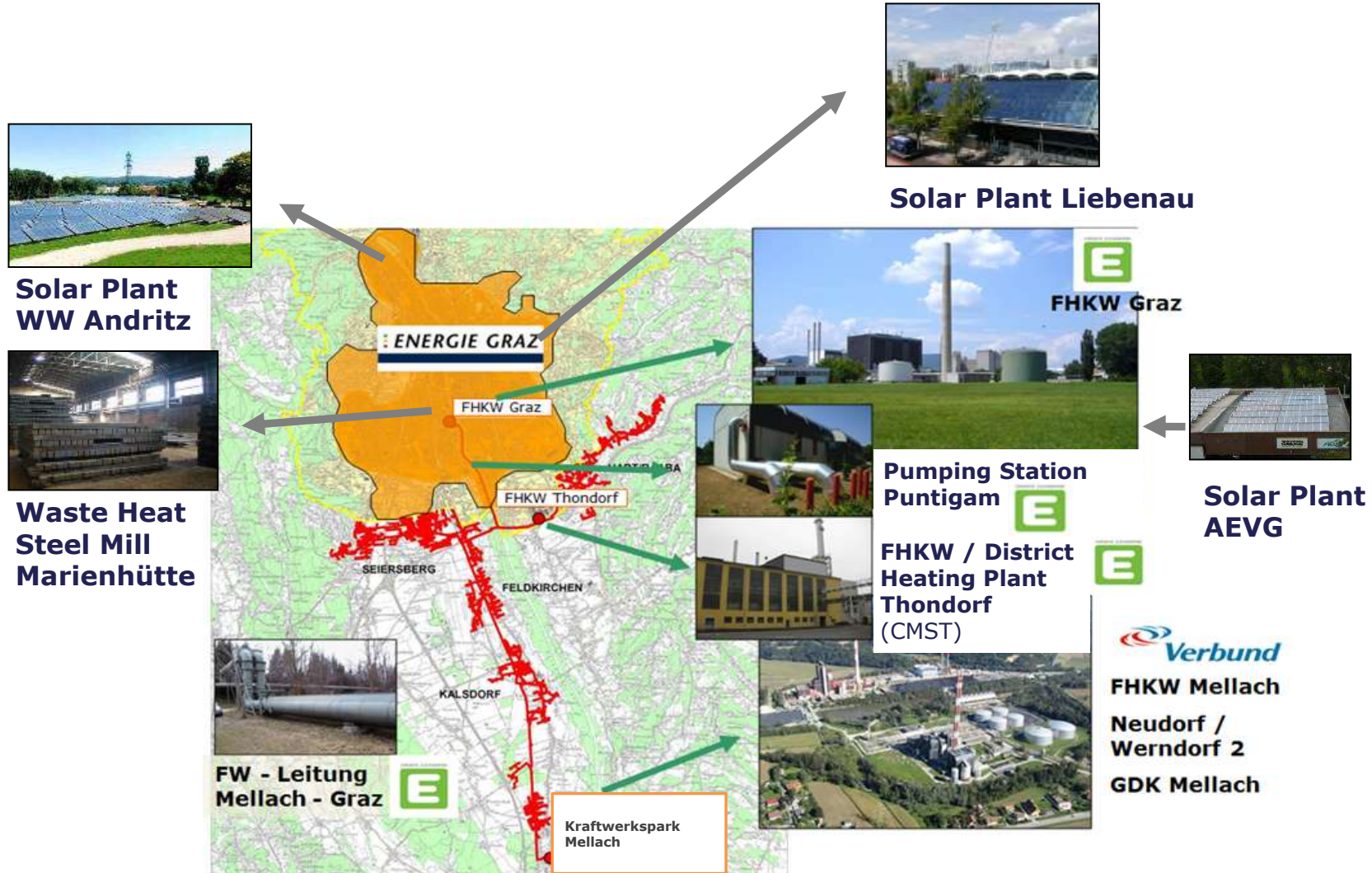
Obligation:
3-step legal process
by provincial regional planning
and building laws!
update Oct.2017

Percentage of DH:
36 % => up to 60 %
(for residential buildings)

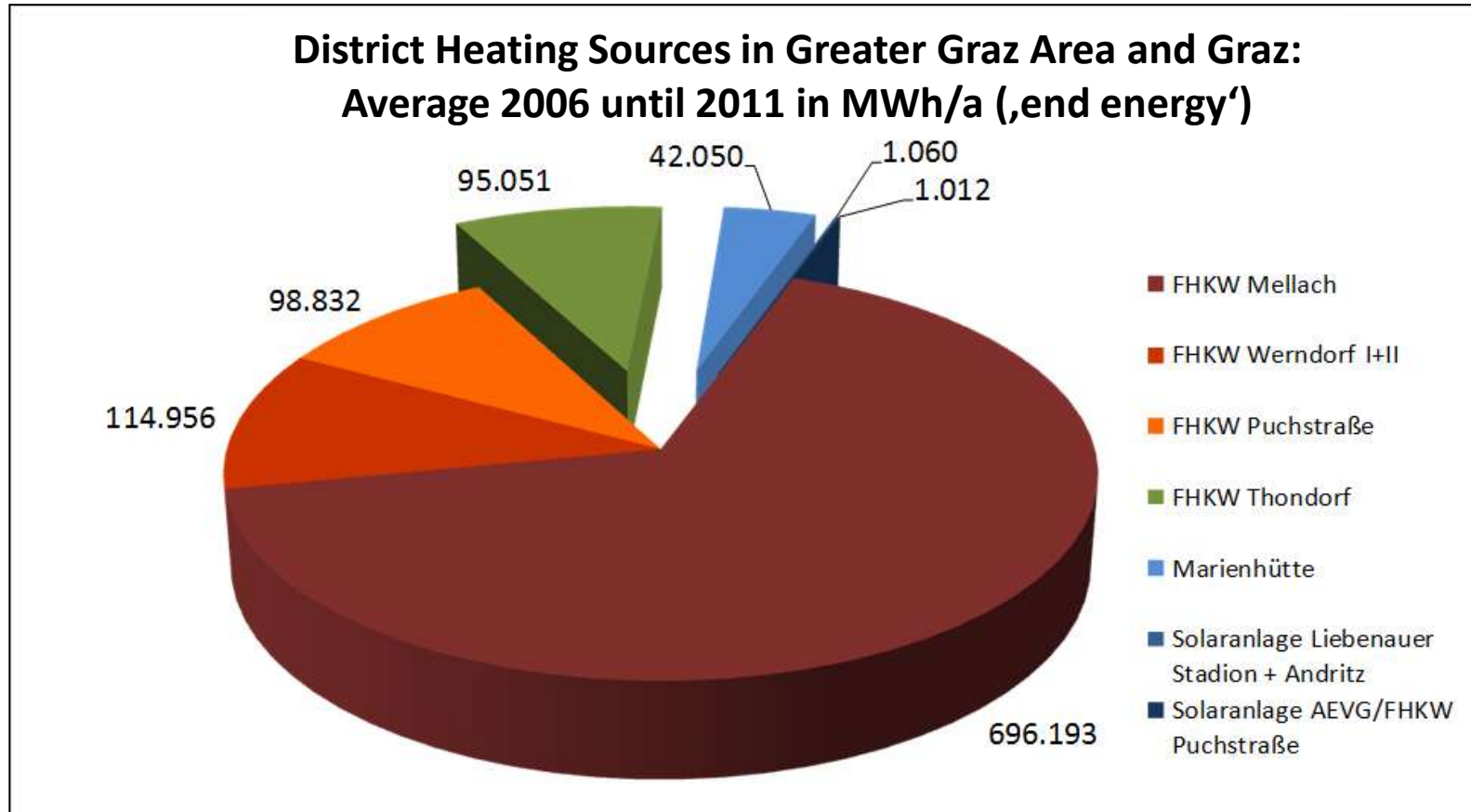
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Basic DH Sources - Situation of Graz



Initial DH Situation Graz – Sources (2006 – 2011)



Übersicht Wärmeerzeugung für Graz-Umgebung und Graz. Mittelwert 2006 bis 2011 in MWh/a (Basis Endenergie);

Source: Studie Emissionsreduktion durch die Fernwärme im Großraum Graz-Update 2012 im Auftrag der Energie Graz, Stadt Graz Umweltamt

Peak load: ca. 530 MW

Energy Deposition: ca. 1.200 GWh

Initial Situation ,istrict Heating Graz – facts & figures

- **DH peak load:** 530 MW, annual heat supply: **1,200 GWh***)
- Sources up to 2013: > 70 % from coal-fired CHP (cogeneration units)
- Brand new NG-fired CHP suffers from low prices for electricity
(D-Market: 70 Euro/MWh => 35 Euro/MWh)
- NG-boilers as „bridge-technology“
search for alternative heat-sources
- District heating system as a key factor for lowering emissions
- **Heating Graz** overall: approx. **2,300 GWh***)

*) average standardized value

Graz Solar Roof Cadastre - Theory and Reality



sehr gut geeignet
gut geeignet

Potential in theory

14 Mio m² Roof area overall

5 Mio m² Roof area suitable

=> Energy volume 2.000 GWh/a in theory

Intersection of roof areas with population figures regarding hot water requirements:

Potential real

(incl. historical city center)

156 GWh/a therm.

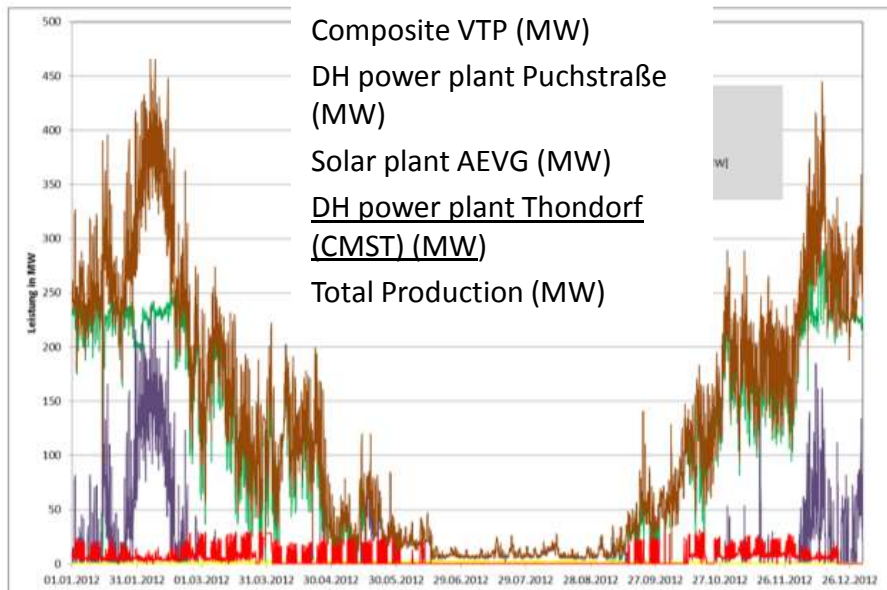
306 GWh/a PV

Presentation Content

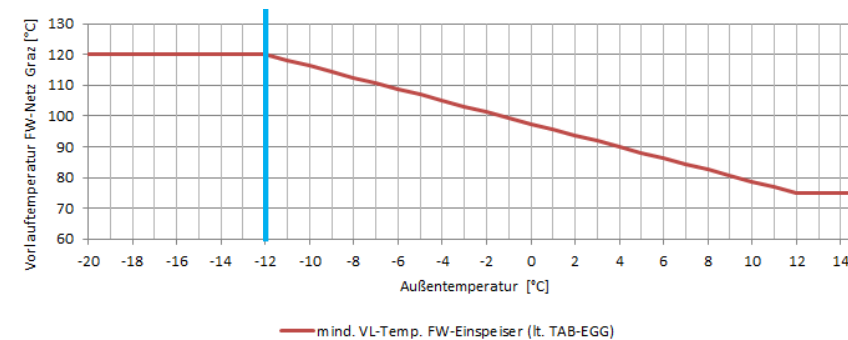
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RES – Challenges to meet

- Peak **demand** in winter time
(typical distribution in the summer/winter months: 1:10 to 1:20)
- **Temperature** level in the DH system vs. alternative energy supply
- **Volatility** of many renewable energy sources
- **Regional** availability, land availability for e.g. large solar plants (...)
- **Emission** situation in Graz as main limiting factor (PM10/NOx/BaP)



Jahreslastprofil/Load profile, District Heating Sources 2012;
Source: Steirische Gas-Wärme



Funded VL-minimum-temperature in the district heating feed in Graz
depending on the outside temperature
lt. Technical Connection Conditions of Energy Graz

Redesign of the DH- „Energy Mix“

RES Road map:
2017: 25 %
2025: 50 %
2040: 100 % ?

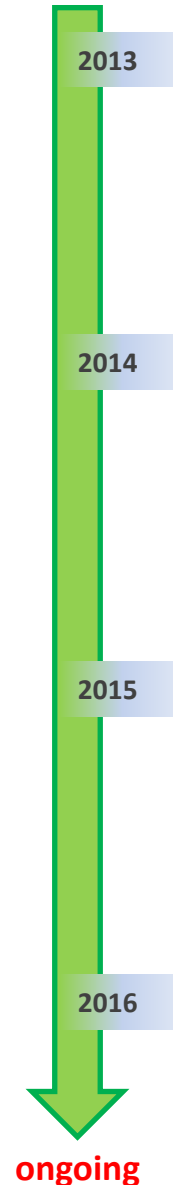
- Energy **Efficiency** first !
- **Biomass**: local potential 15 % of Graz-DH in Styria
If you want more => international pellets market...
- **Waste** heat (electric steel plant, paper factory,
waste water treatment plant: up to 30 % of Graz-DH)
- **Solar** energy: Existing approx. 20.000 m² for DH and
planned 450.000 m² with seasonal storage
(„BigSolarGraz“, up to 20 % of Graz-DH)
- **Manifold** sources - simulation of power feeds essential !
- Natural Gas as **bridging** technology ...

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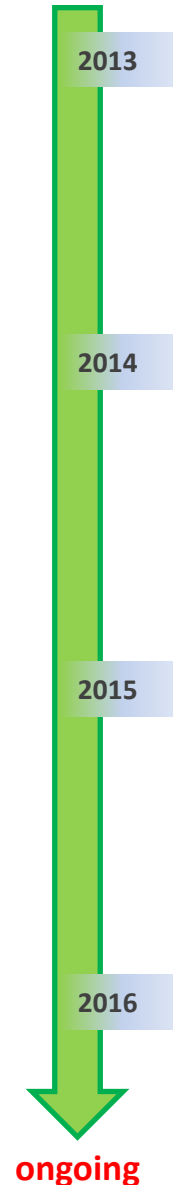
Since 2013: Large Scale DH-Strategy Process

- **CWG Core Work Group “Heat Supply Graz 2020/2030” established in 09/2013** (regional energy supply company Energy Steiermark, Energy Graz, Holding Graz, City of Graz/Environmental Department, Graz Energy Agency): **so far 42 workshops** of this Core Working Group CWG
- **Meetings of the Control Group** (decision makers): **6**
- **“Green Paper Heating Supplies Graz”**: inventory, data and facts with a outlook to 2020/2030
- **"Calls for Contributions"** definition of 13 subjects:
9 workshops with more than 150 experts
-> 38 action proposals



Since 2013: Large Scale DH-Strategy Process

- Detailed analysis of proposed measures: 16+
- Measures in preparation/implementation: 7+
- Event series “Graz Energy Talks”:
“The future of the Heat Supply in Graz”
(150 participants)
- Research projects: 3
- Excursions/Know How Transfer: 4
(Denmark, Switzerland, Germany, Sweden)
- **Simulation** of existing and future potential heat feeders



Heat Sources & Systems

A. Abwärme & Energieverbünde / Waste Heat & Energy Networks

B. „Smartes“ Fernwärmesystem / DH-System as a part of a Smart District Grid

Energy Model Graz Reininghaus

C. Biomasse / Biomass as Energy Source

D. Umweltwärme / Heat from groundwater and soil

E. Solarenergie / Solar Energy

F. Erdgasanlagen / Natural gas plants

... as necessary bridging technology

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Waste Heat & Energy Networks: Milestone Industrial Waste Heat Contract with SAPPI

- Neighboring municipality of Gratkorn to Graz/Andritz: **distance 9 km**
- **Peak load: up to 35 MW – total amount of heat: 150,000 MWh/a**
(=ca. **15% of DH in Graz!**)
- Contractual Challenge: contingent liability now covered by new established intermediate company



sappi

Fernwärme – DI (FH) P. Schlemmer / DI S.
Scheibner

bioenergie⁺
Ihr Plus in Wärme.



SAPPI Gratkorn: Pulp and Paper
ca. 1 Mio t paper / a

Fotos: Bioenergie - Jakob Edler (links) und Stadt Graz/Fischer (rechts)

Waste Heat & Energy Networks / other Examples, Outlook

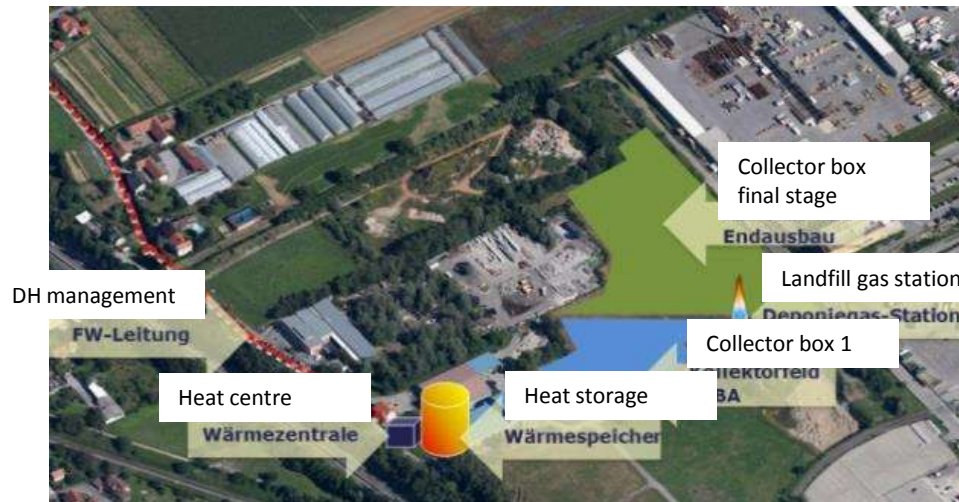


Marienhütte heat pump in completion (01/2016);
Source: Energie Graz GmbH&Co KG

- **utilisation of waste heat with heat pumps located in the steel mill “Marienhütte”**
(6.6 MW, approximately 3.5% of the year-DH-demand) – Smart District Heating Reininghaus
- **Waste heat recovery “Indoor Ice Rink Liebenau” (0.7 MW):** use of waste heat from refrigerating machines by use of heat pump; surplus feeds DH-grid
- Next step: consideration of energy flows between building structures and on district level (urban development areas)
-> in future: implementation of **local heating supply concepts**
- **temperature level often not sufficient** for existing DH-system

„Smart“ District Heating System

- Integration storage, Power to Heat (P2H)- and hybrid solutions
- Intelligent IKT (control feeder, weather forecasts, tariffs)
- Partnerships with customers (temperature levels, energy efficiency, load management, as ‚prosumers‘ ...)
- New urban development areas: low temperature district heating sys with integration of alternative energies sources such as solar plants, heat pumps...

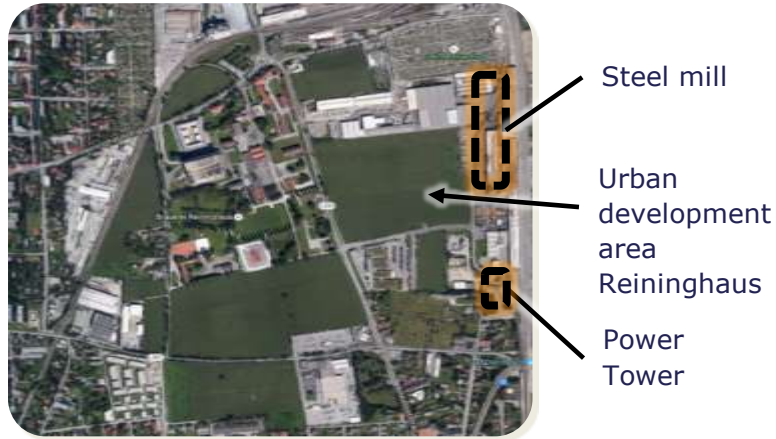


Source: Google Maps, Energy Graz - Graz Energy conversations 4.5.2015

Solar storage project

„HELIOS“ new paths (discharge power up to 10 MW, solar panels 2.000 – 10.000m² in combination with landfill gas cogeneration landfill gas-CHP and P2H)

Energy Model ,Graz Reininghaus‘



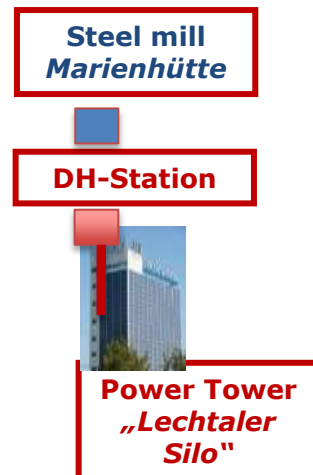
New urban development area:

Area: approx. 54 ha

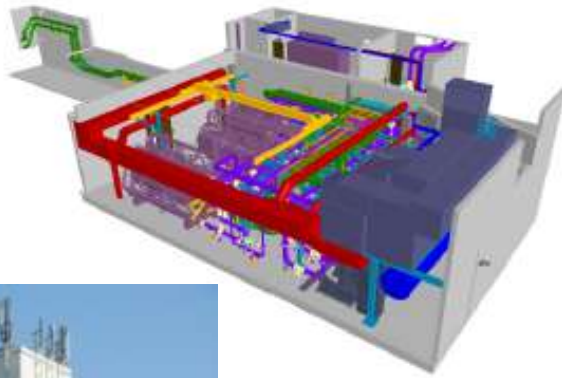
- Final stage of construction: approx. **10,000 to 12,000 residents**
- Construction of the first building in 2015
- Final stage of construction roughly finished by 2045

Goals of the energy model ,G-Reininghaus‘:

- Much lower CO₂ emissions
- Utilisation of existing **waste heat sources** (industry)
- Highly efficient **industrial heat pumps**
- Feed in LT-local-Network (69°C) and HT-DH-Network (up to 95°C)
- Integration of **heat storage units**



Energy Model ,Graz Reininghaus‘



Quelle: Bilfinger VAM, Energie Graz

- Highly efficient large heat pumps:
2 WP with each 3.3 and 5.75 Mw^{therm}
- Own local PV-System (85 kWp) and use of ‘natural power’
- Modular energy storage of up to 1,800 m³ (daily/weekly storage)
- Heat supply for the district heating network of Graz (at 75 up to 95°C): approx. 35 - 46 GWh/a
- Construction work to be completed
- Start of the trial operation of heat supply: June/July 2016
- Commissioning LT local network planned for 2017

Smart City School Campus in a decentral urban energy system

Energy concept

Local geothermal energy

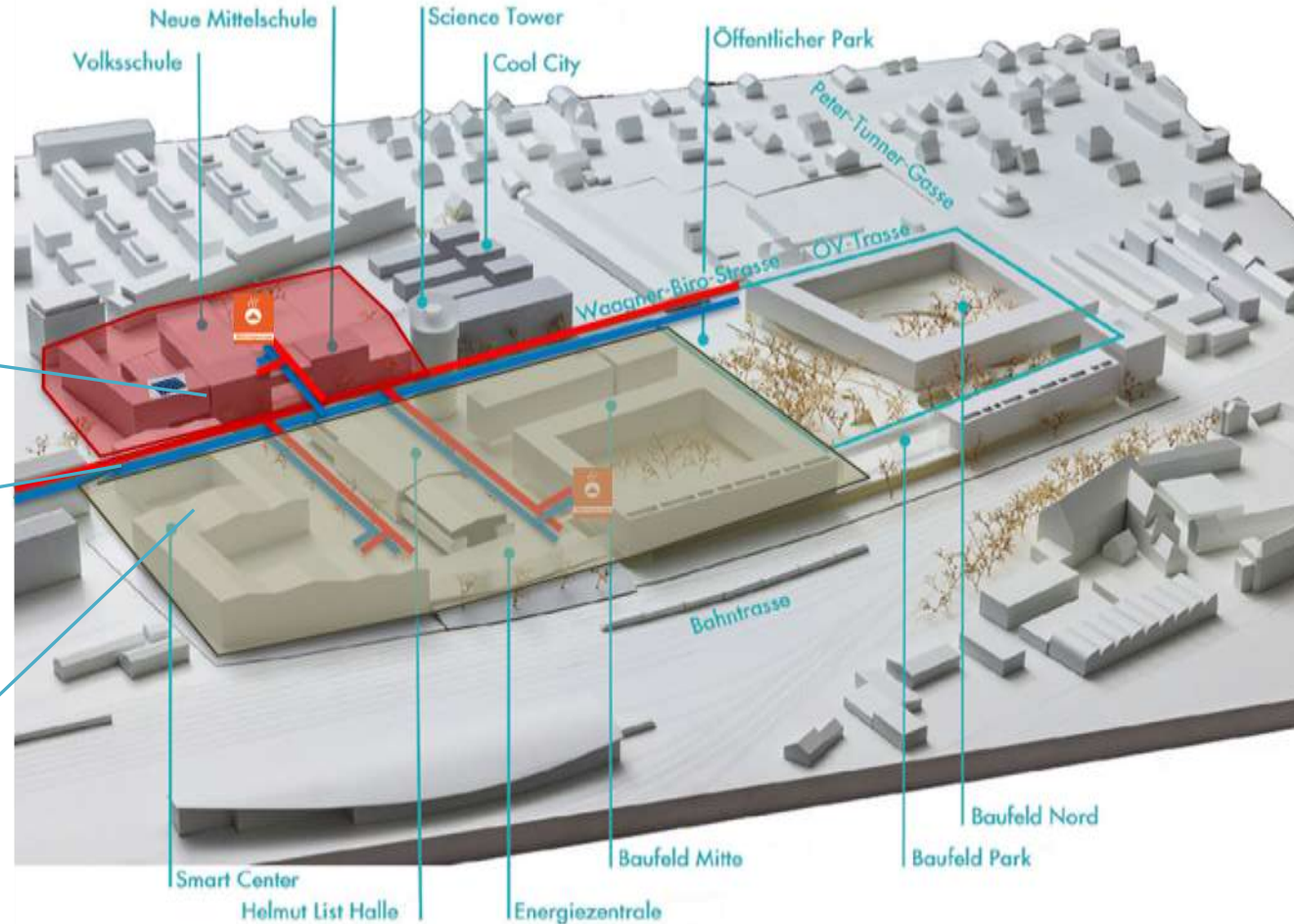
+Heat pump

Local and regional electric energy

+PV plant

Local industrial waste heat

LT-local heat network



Smart City – Demo area



Smart City – School campus (VS and NMS)

Biomass

- Potential of regional supply: **up** to approx. **30 MW / 150 GWh/a**
 - (corresponding study in progress of University of Graz)
- Need of more „international“ market for pellets (commodity prices)?
- **Emissions** PM 10 et.al . set of **problems** – filter systems?
- **Biomasse unit**, kind of **wood chips**, regional supply (contracting), location: Hart/Raaba (5 MW, approx. 2% of yearly DH-demand)
- **DH supply** from company **FARINA-Mühle** (flour production mill)(0.25 MW)
waste heat of combustor with organic (mill) waste
- **More potentials** – future prospects:
- More Biomasse plants - fed with wood chips from regional supply
- Usage of „torrefication“ of Pellet at Power Station Mellach ?

Solar Energy: Feasibility Study „BIG Solar Graz“

Developed by a core team
from June to December 2015



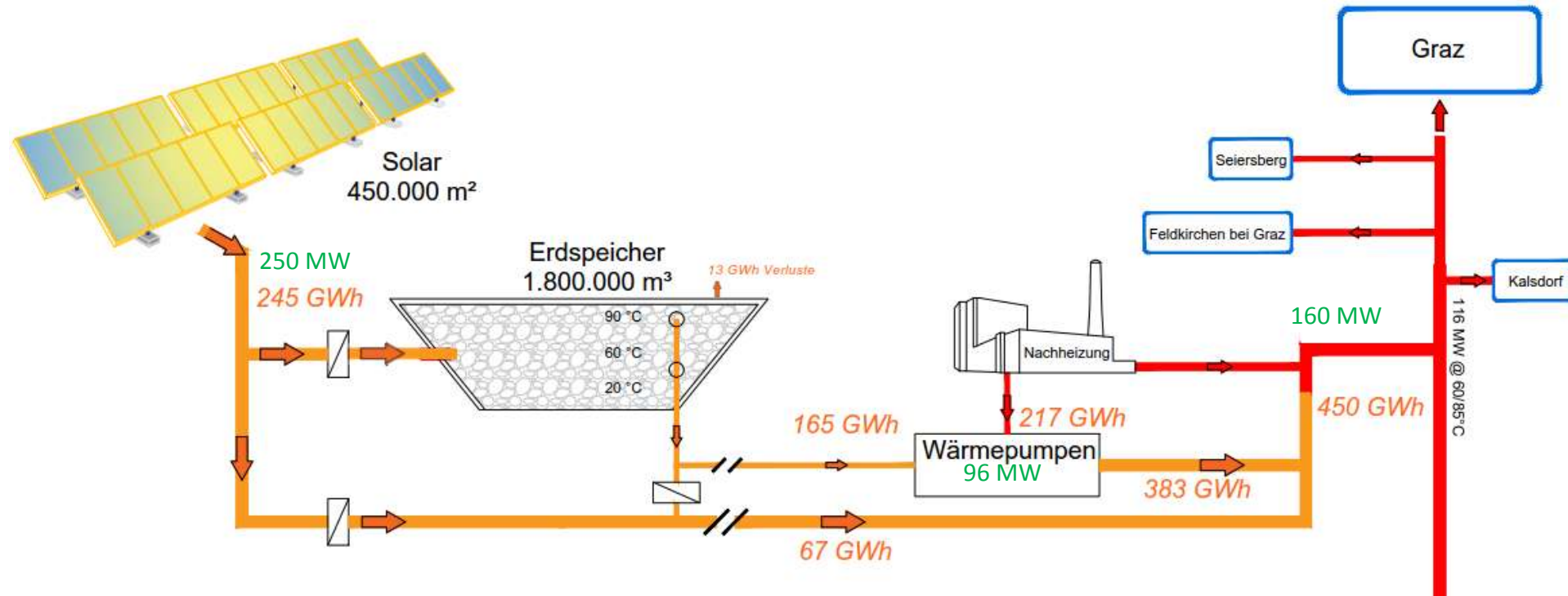
Supported by



Co-Financed by national, regional and local level



„BIG Solar Graz“ - System concept -optimum scenario as a city-wide Decarbonization measure of DH

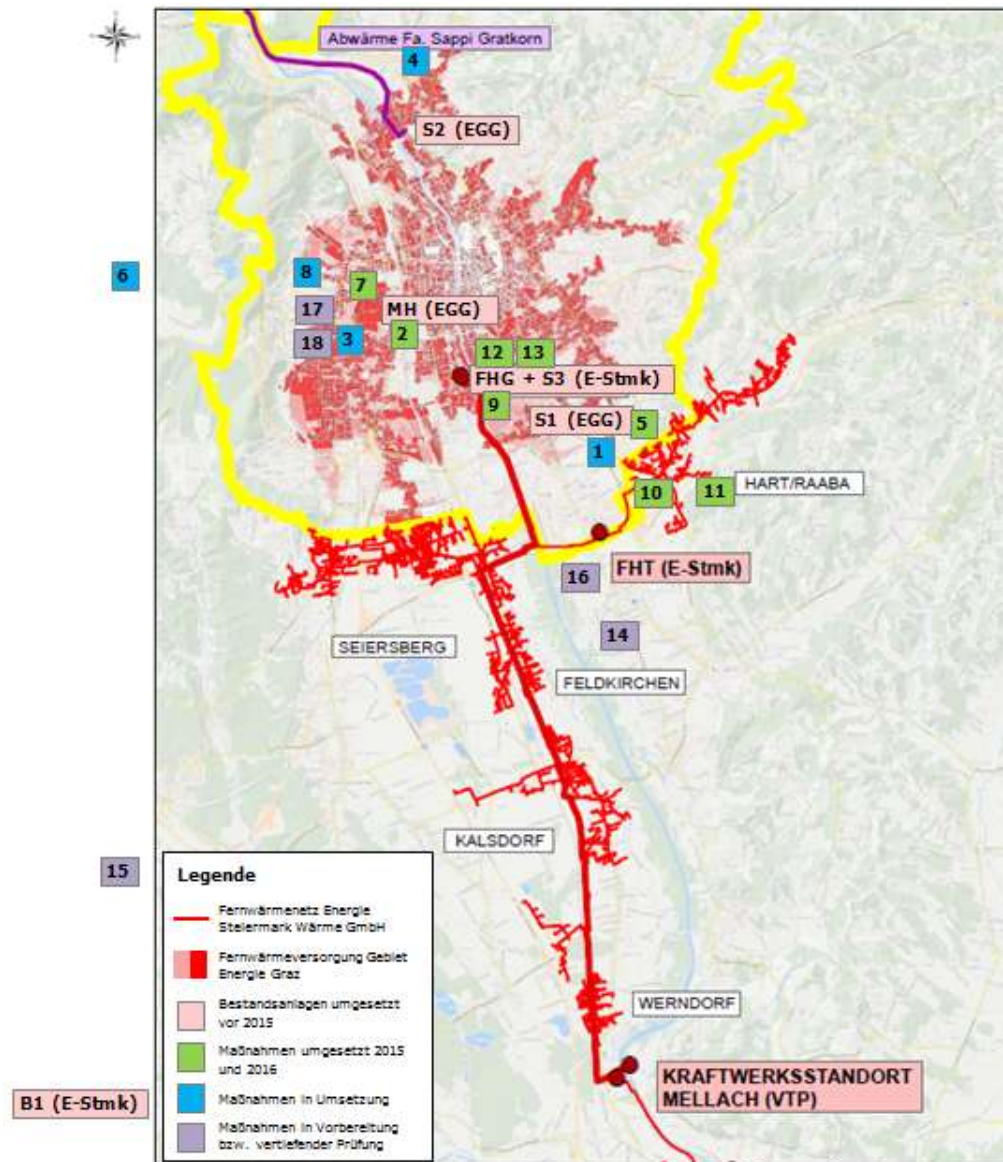


- Effect: Solar coverage DH-system: ca. 20 %
- Total investment: ca. 200 Mio. EUR
- Current challenge: finding enough areas for solar park

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Measures in Implementation / detailed evaluation



- 1 **HELIOS** - solares Speicherprojekt Neufeldweg
- 2 Weitere Abwärmenutzung mit Wärmepumpen in der **Marienhütte**
- 3 Energiemodell **Reininghaus**
- 4 Abwärmenutzung aus Papier- und Zellstoffwerk **Sappi**
- 5 Abwärmenutzung **Eishalle** Graz
- 6 **Energie-Effizienzmaßnahmen** im FW-System
- 7 Adaptierung der **Heizzentrale** Waagner-Biro Straße
- 8 Energiemodell **Campus Eggenberg**
- 9 Ausbau der **Solaranlage** am Areal der FW-Zentrale Graz
- 10 Wärmeeinspeisung **FARINA-Mühle**
- 11 Hackgut - **Biomasseanlage** in Hart
- 12 Erneuerung der „**Heißwasser-Container**“ in der FW-Zentrale
- 13 Errichtung von erdgasbefeuelten **Kesselanlagen** in der FW-Zentrale Graz – Ausfallsreserve Puchstraße
- 14 **Abwärmenutzung Kläranlage** der Stadt Graz in Gössendorf
- 15 **Big Solar Graz**
- 16 **Power to Heat** Anlage Gössendorf
- 17 **Smart City** – Energiemodell Volksschule/Neue Mittelschule
- 18 Abwärmenutzung **Linde Gas**

District Heating Sources Greater Area of Graz 2018

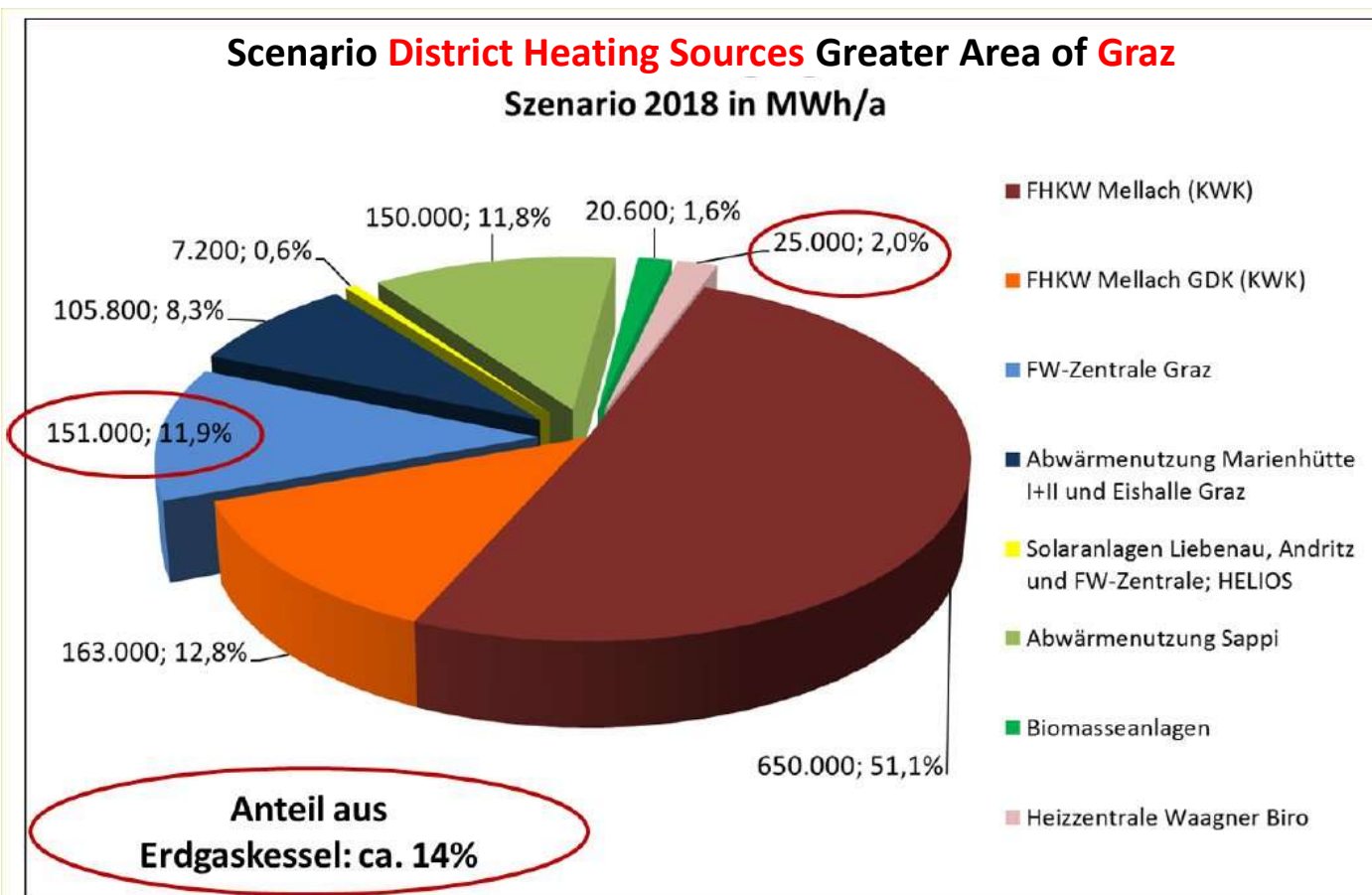


Abbildung 2: Fernwärme-Erzeugung im Großraum Graz – Szenario 2018 mit Markierung des Anteils der Wärmeaufbringung aus Erdgaskesselanlagen

Das Szenario 2018 setzt sich demnach wie folgt zusammen:

- Ca. 64% Wärme aus hocheffizienten KWK-Anlagen
- Ca. 22% Wärme aus sonstigen erneuerbaren Quellen
- Ca. 14% Wärme aus Erdgaskesseln

(CHP)

(CHP)

gas-steam power plant

(RES)

(RES)

(RES)

(RES)

(RES)

(RES)

(CHP)

(RES)

(NG)

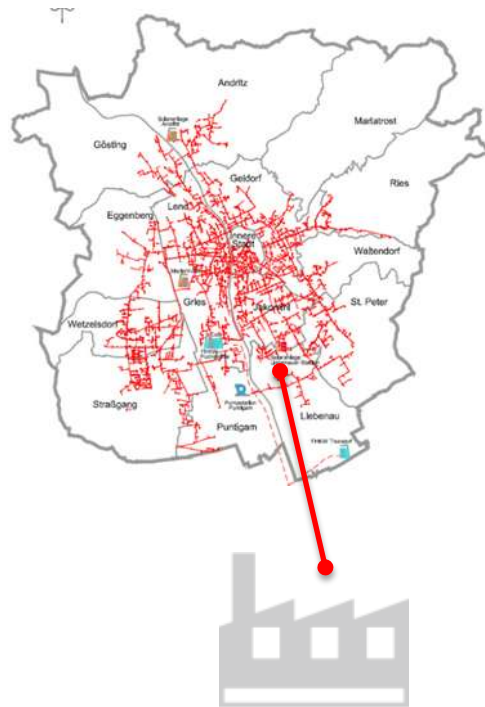
Source: Grazer Energieagentur
06 10 2017,
Wärmebereitstellung für die
fernwärmeversorgten Objekte
im Großraum Graz **Szenario
2018**

System Change „District Heating Graz“

More suppliers > more challenging implementation!

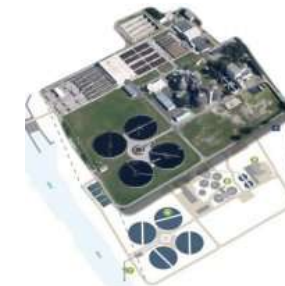
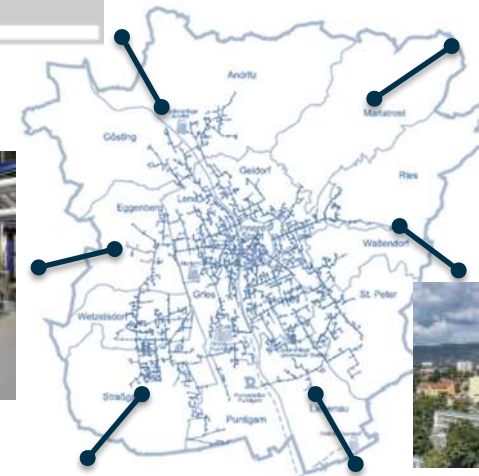
up to now:

Ca. 70 % from 1 key supplier



in future:

approx. 20 suppliers ...



Energy Efficiency Measures – Customer related

1. Building Stock:

- **Efficiency improvements of existing buildings**, i.e. modernising insulation of buildings -> **reduces heating cost for customers**

2. District Heating System:

- **Energy efficiency measures in the district heating at level customer installation units** incl. lowering response temperatures and reducing power peaks -> **reduces heating cost for customers**
- **Network: reducing losses and optimising feeders/storage**
- **Use of different temperature levels ('closed loops') and the district heating return flow** (low temp., despite 'supply flow'...)

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Conclusions for City of Graz

- The first step towards heat supply from renewable energy sources RES or waste heat sources has been successfully set!
- The process for the future heat supply system in 2030 has only just started and will
- take time!
- Affordable Smart City heating is definitely an issue – but challenging!



Conclusions - Messages for European Level /1

- For the “already built” (historical) European cities, which due to the building structure/facade design, etc. cannot be extensively renovated, a district heating network is incessant (e.g. heat demand of such areas in Graz: roughly 850 GWh of 1000 GWh total heat quantity).
- An (existing) district heating network is the basis to decarbonise tens of thousands of flats/buildings in one go (without having to negotiate with thousands of owners).
- This would require a specific funding program at EU level!

Conclusions - Messages for European Level /2

- In new built Smart City development areas, a grid-connected supply network is very advantageous in order to have an energy exchange between buildings or on district level.
- “Heat change” has to be seen as an integral part of the discussion about the current “Electricity change” in Europe (PV, wind energy etc)!
- Industrial waste heat: new innovative business models for cooperation of "municipalities" (long-term planning) with "industry" (short-term market-oriented planning and not-want-to-bind ...) needed.

Thank you for your kind attention.
See you in Graz ...

www.smartcitygraz.at

GER

[Bilingual Smart City Graz-Folder](#)

www.umwelt.graz.at

[3D-Model](#) (only Firefox or Chrome)

[Image Video Graz - Tourism](#)

[Image Video Graz - Business Location](#)

[Graz Dashboard](#) GER





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**For further details please get in contact with
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**Dr. Werner PRUTSCH
(Head of Department)**

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