Heat Roadmap Europe 2050
A low-carbon heating and cooling strategy

AIT AUSTRIAN INSTITUTE OF TECHNOLOGY
TOMORROW TODAY

Sustainable heat supply strategies for district heating networks – tools and methodologies

3rd international conference on Smart Energy Systems and 4th generation district heating, Copenhagen, 12–13 September 2017

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DENMARK

4DH
4th Generation District Heating Technologies and Systems

BACKGROUND AND MOTIVATION

- **Current challenges for many district heating network operators:**
  - Changing market conditions (especially energy prices, regulative conditions and by trend decreasing final heat demand)
  - Increasing environmental targets (reducing CO2-emissions by reducing primary energy supply, increasing the share of renewable energy sources)

→ **Complex decision towards the future type and size of the supply units**

  - various uncertainties, new boundary conditions and conflicting requirements have to be considered!

CASE STUDY: CHEMNITZ (GERMANY)

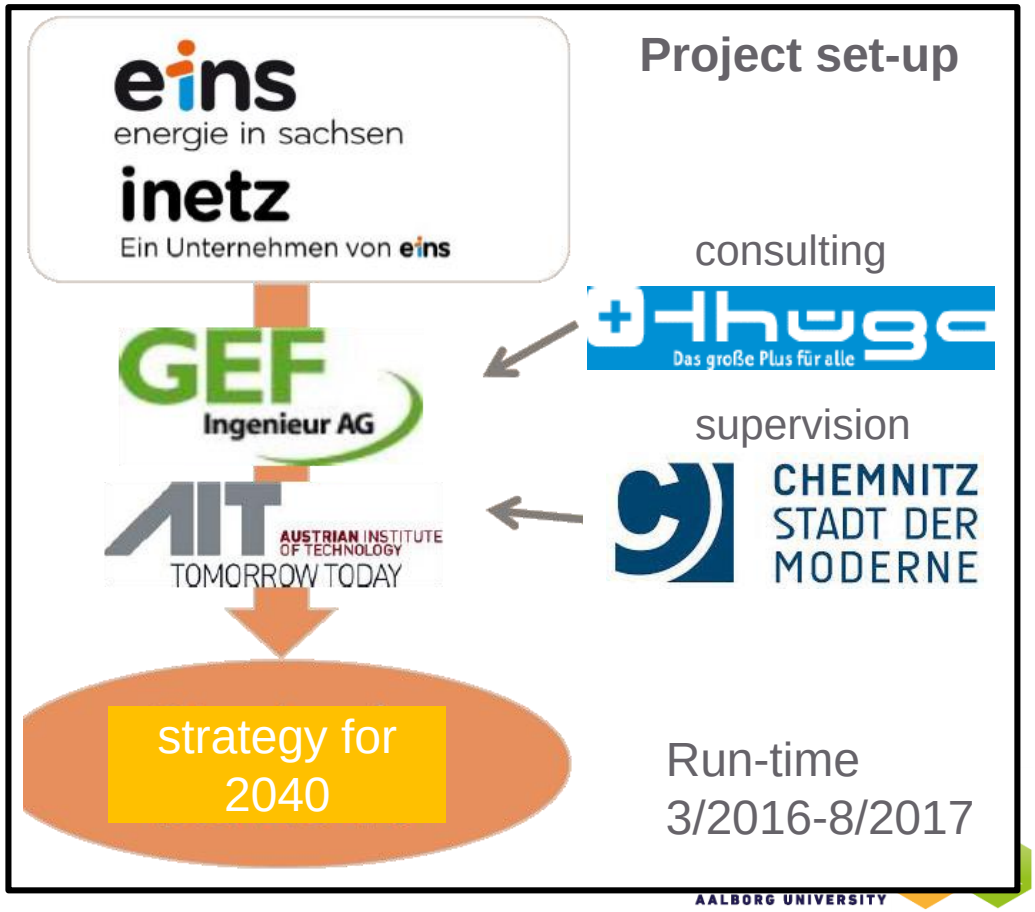
Source: www.ait.ac.at/fileadmin/mc/energy/downloads/News_and_Events/2016_11_15_2.Praxis_und_Wissensforum_FWK/B2_Patzig__161115_Praesentation_Waermeversorgungskonzept_eins.pdf

Initial situation

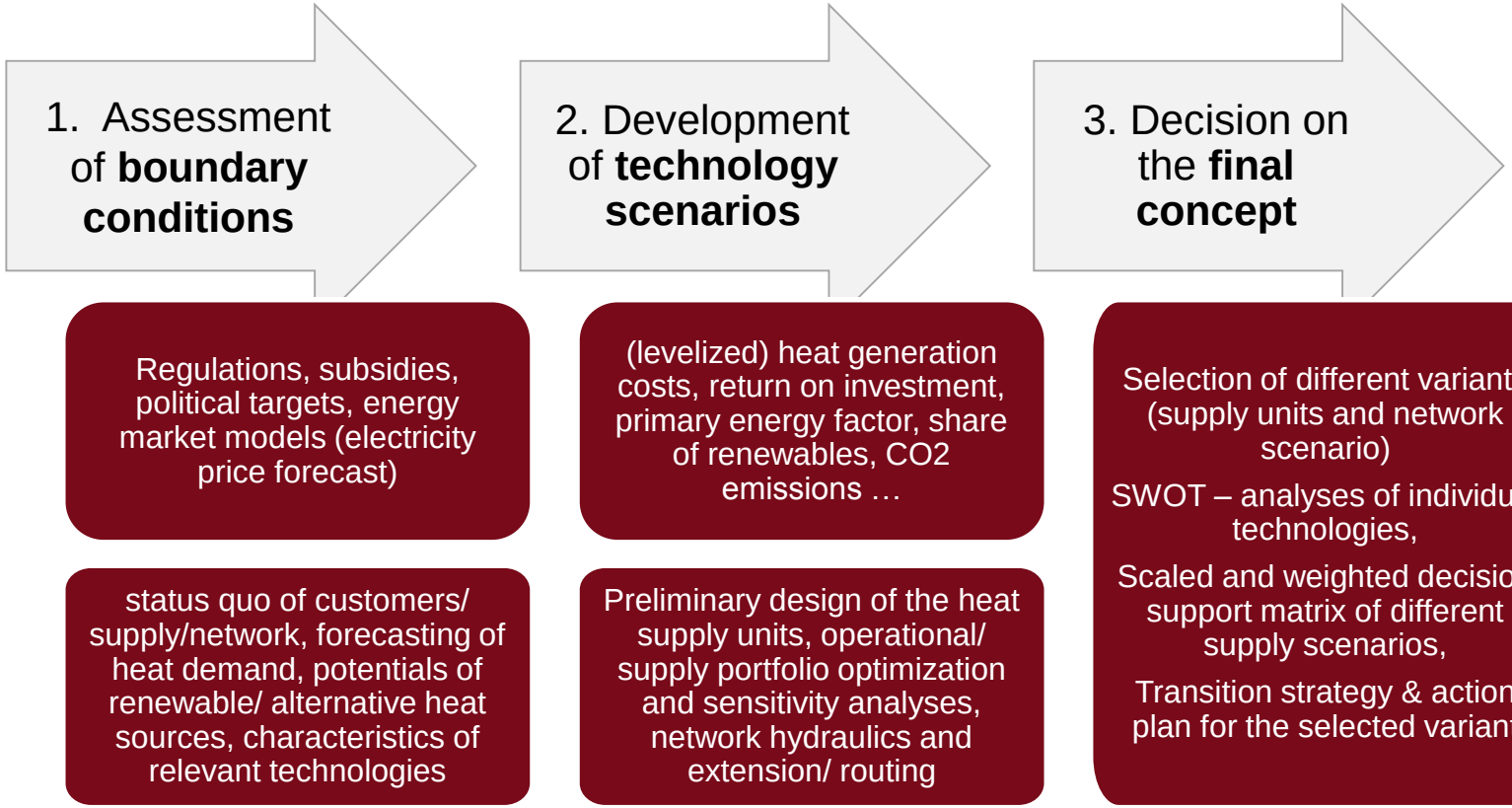
- 750 GWh/a heat demand
- 375 MW DH peak load
- CHP with gas + local lignite coal
- Decreasing heat demand and oversized distribution network
- Declining political and social acceptance of the use of coal

Objectives

- Development of a sustainable medium and long-term concept for a economic and ecological heat supply strategy for 2040



DECISION SUPPORT FOR NEW SUPPLY UNITS: OVERVIEW OF THE METHODOLOGY



1. ASSESSMENT OF BOUNDARY CONDITIONS

ELECTRICITY PRICE FORECAST

using a "**fundamental model**" of the European electricity system

Input and output for the simulation model

Input
- hourly: load, Wind, PV, Hydro import, ...
- Power plant data: Capacity, max. gradient, min. supply, emissions, efficiency, ...
- Power data (AC, DC, NTC, ...)
- Primary energy prices, CO_2 prices

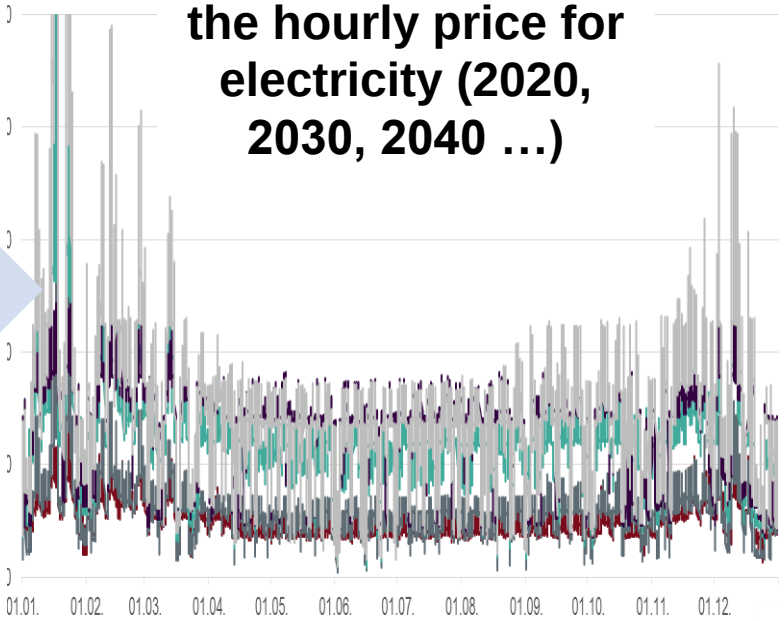
Marked Model
Minimization of the total generation costs
Technical boundary conditions

Solving the model (Gurobi -Solver)

Output
Electricity prices, utilization of power plants, costs, hydro-generation, Import/Export, load flows, level of the storage, etc.

Model EDisOn = **E**lectricity **Dis**patch **O**ptimizatio**n**: Lineares Optimierungs Problem der **TU Wien, EEG**

Result: forecast of the hourly price for electricity (2020, 2030, 2040 …)



HEAT DEMAND ASSESSMENT USING 3D CITY MODELS & ENERGY PLUS*

* TOOL HAS NOT BEEN USED IN CHEMNITZ, SINCE THE HEAT DEMAND FORECAST WAS DONE BY GEF Ingenieur AG

Heat Emission

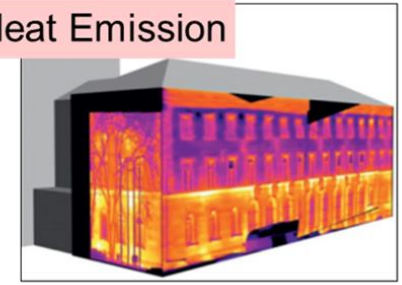
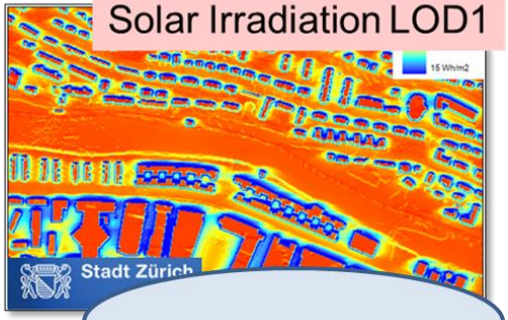
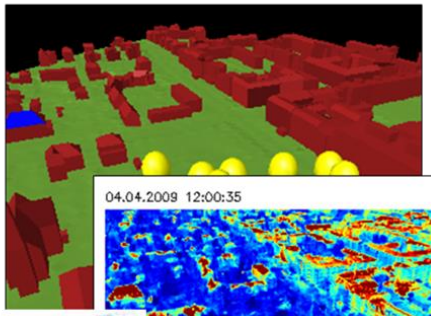


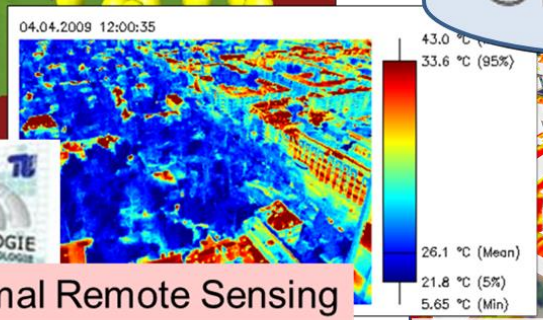
Image: Hoegner / Stilla, TU München

Solar Irradiation LOD1



Utility Networks





Thermal Remote Sensing

CityGML

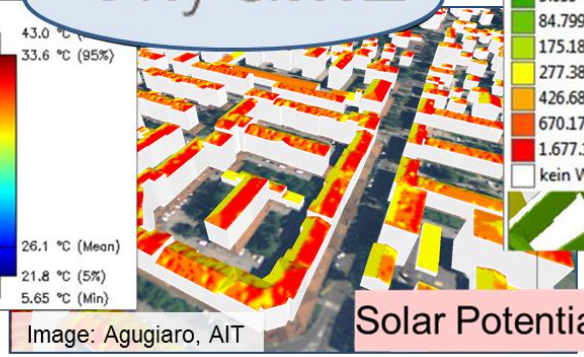


Image: Agugiaro, AIT

Solar Potential

Heating Energy Requirements

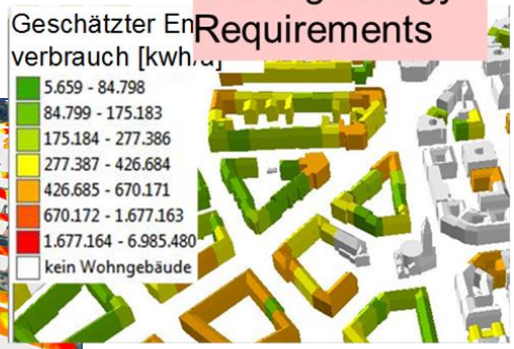


Image: Kolbe et al., TU Berlin

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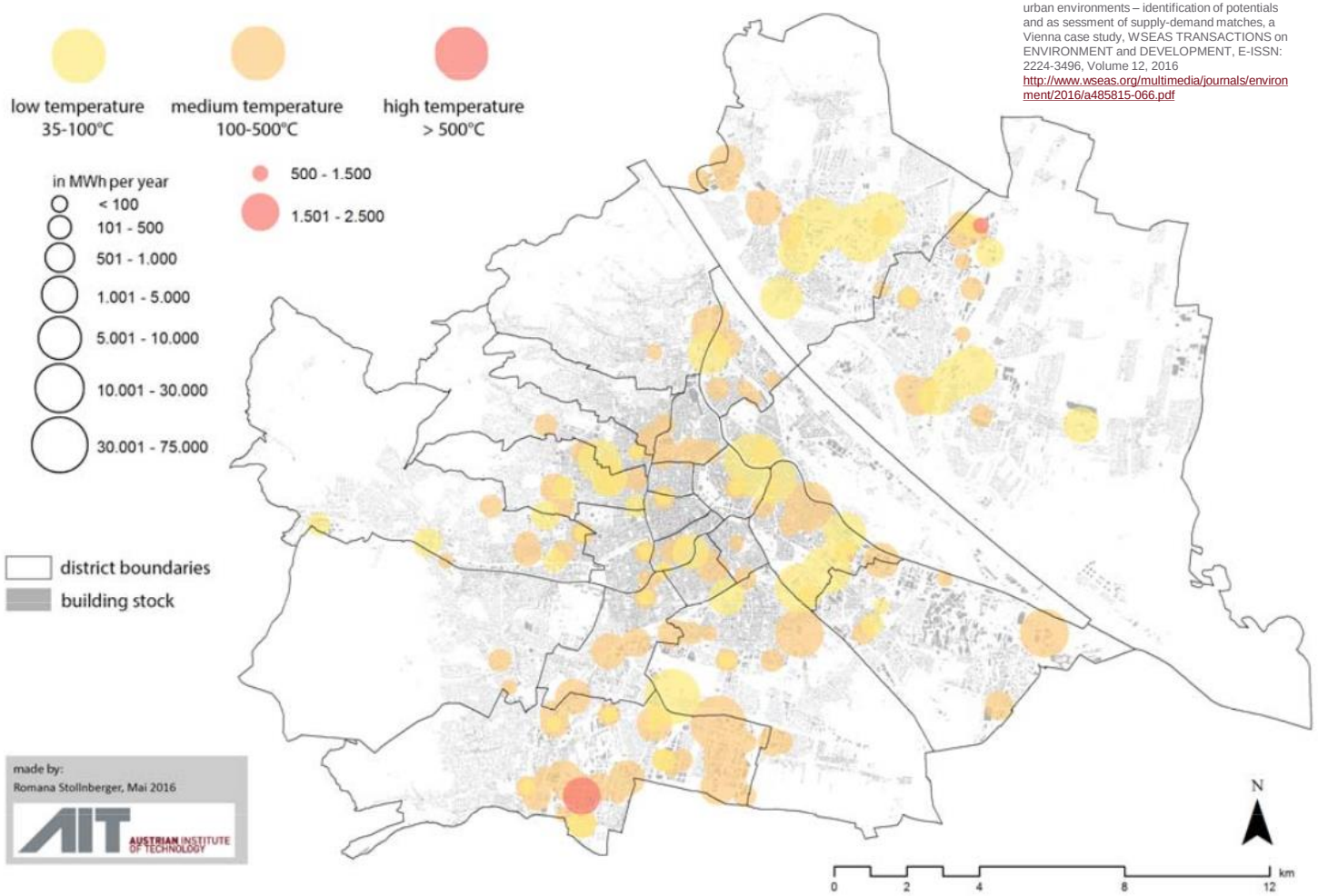
reINVEST

IDENTIFICATION OF WASTE HEAT POTENTIALS USING OPEN AVAILABLE DATA*

* ANALYSES HAS NOT BEEN DONE IN CHEMNITZ, SINCE THE POTENTIAL WAS ESTIMATED TO BE RATHER LOW

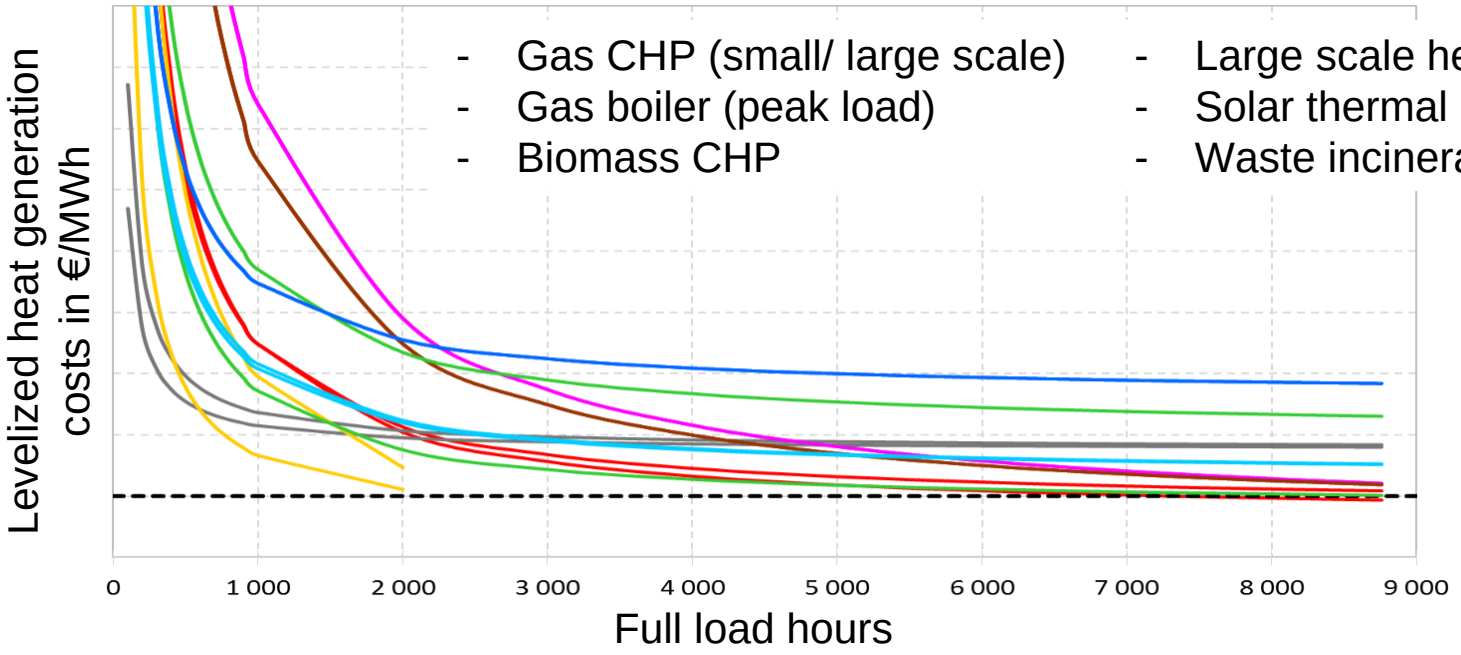
Example Vienna

- Top-down: utilization of available GIS and company data
- Bottom-up: Interviews and side surveys



Source: Loibl W.; Stollnberger, R.; Österreicher D.: Waste-heat re-use from commercial sources in urban environments – identification of potentials and as sessment of supply-demand matches, a Vienna case study, WSEAS TRANSACTIONS on ENVIRONMENT and DEVELOPMENT, E-ISSN: 2224-3496, Volume 12, 2016
http://www.wseas.org/multimedia/journals/environment/2016/a485815-066.pdf

CHARACTERISTICS OF RELEVANT SUPPLY TECHNOLOGIES



Cost functions of the relevant supply technologies, based on

- investment & maintenance costs
- fuel and electricity prices
- taxes and subsidies
- efficiencies and CO2 emissions
- …

Ralf-Roman Schmidt: Sustainable heat supply strategies for district heating networks – tools and methodologies, 3rd international conference on Smart Energy Systems and 4th generation district heating, Copenhagen, 12–13 September 2017

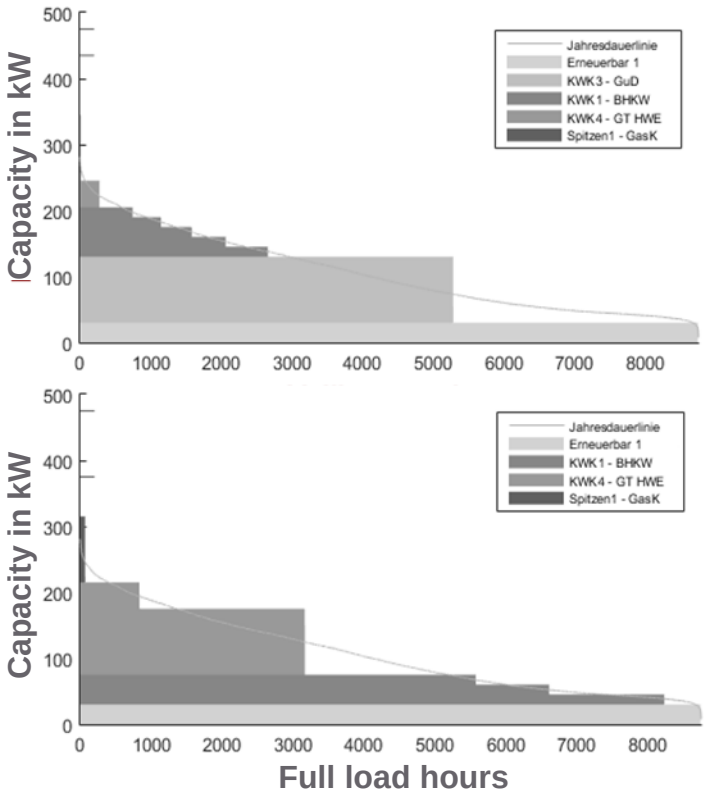
2. DEVELOPMENT OF TECHNOLOGY SCENARIOS

PRELIMINARY DESIGN OF THE HEAT SUPPLY UNITS

- Optimization algorithm to cover the load duration cost minimum costs
  - Based on the cost functions of the relevant supply technologies
- Large number of parameter variations possible, e.g.
  - (average) energy price scenarios
  - Head demand scenarios
  - Regulatory boundary conditions

→ **Calculation allows *rough* estimate of the suitable supply units**

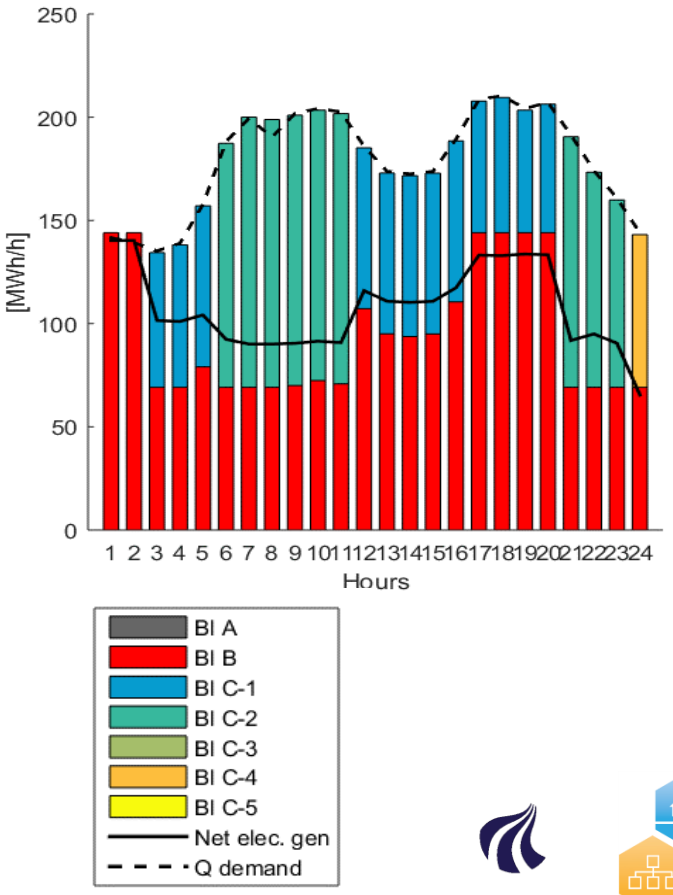
→ **Hourly fluctuations of demand and electricity prices are not considered!**



OPERATIONAL/ SUPPLY PORTFOLIO OPTIMIZATION

- Optimization of the scheduling of all supply units (and storages) on hourly basis
- Method: Mixed integer linear programming
- Target function: minimization of OPEX for electricity and heat production
- Main boundary conditions:
  - Heat demand,
  - Electricity prices,
  - Hydraulic limitations …

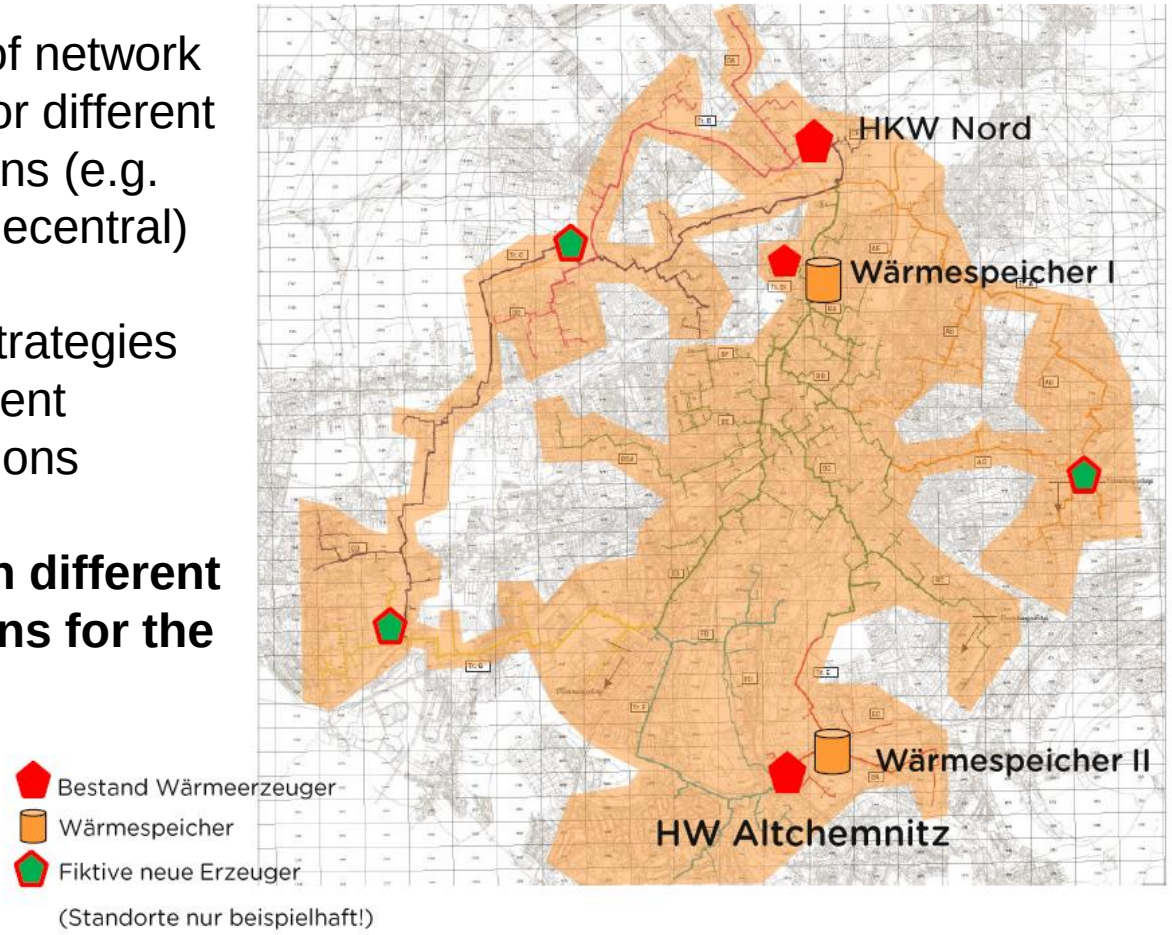
→ Decision on different suitable options for the supply units



NETWORK HYDRAULICS AND EXTENSION

- Evaluation of network hydraulics for different supply options (e.g. central vs. decentral)
- retrofitting strategies for the different network options

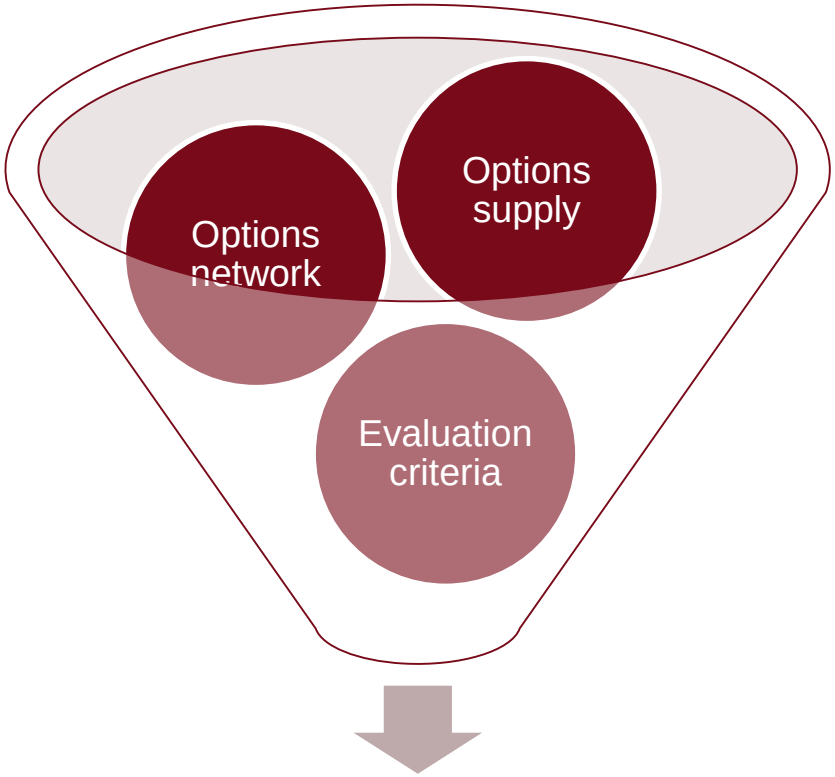
→ Decision on different suitable options for the network



Source: www.ait.ac.at/fileadmin/mc/energy/downloads/News_and_Events/2016_11_15_2.Praxis_und_Wissensforum_FWK/B2_Patzig__161115_Praesentation_Waermeversorgungskonzept_eins.pdf

3. DECISION ON THE FINAL CONCEPT

SELECTION OF DIFFERENT VARIANTS



Checking compatibility and **composition of different variants V_1, V_2, … V_n**

SWOT ANALYSES FOR RELEVANT TECHNOLOGIES

Example: solar thermal energy	
Strengths • Small running costs and no risks • No CO2 emissions • Local technology suppliers	*Weaknesses* • High specific investment costs • Competition to base load supply • Long term storages not economically viable
Opportunities • By trend decreasing temperature levels in the network • Increasing need for reducing CO2 & subsidies for renewables	*Threats* • Collectors can be damaged (e.g. natural disasters) • Long payback times reduce flexibility

Existing plants

Large scale CHP (Combined cycle gas turbine)

Small scale CHP

Biomass

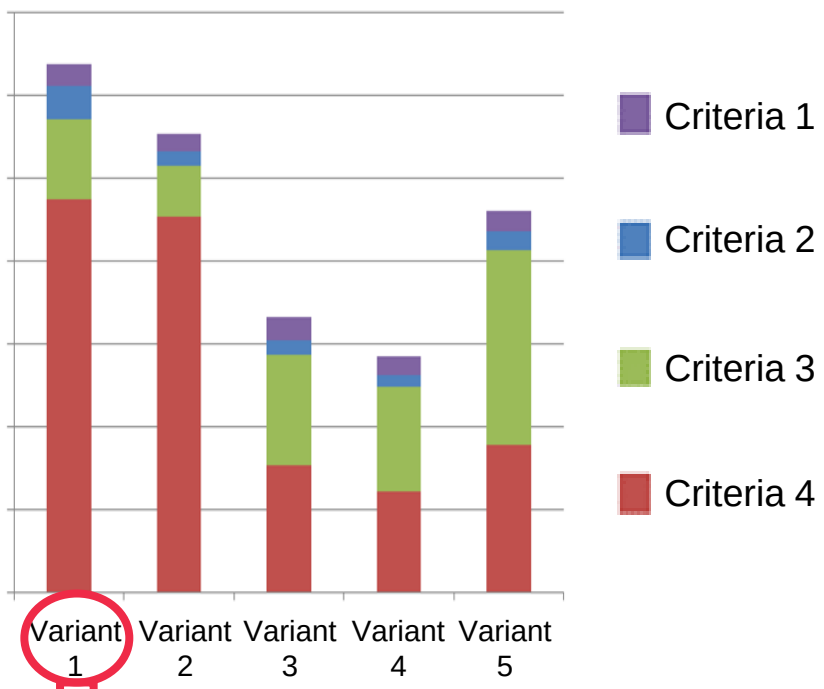
Heat pumps

Waste incineration

…

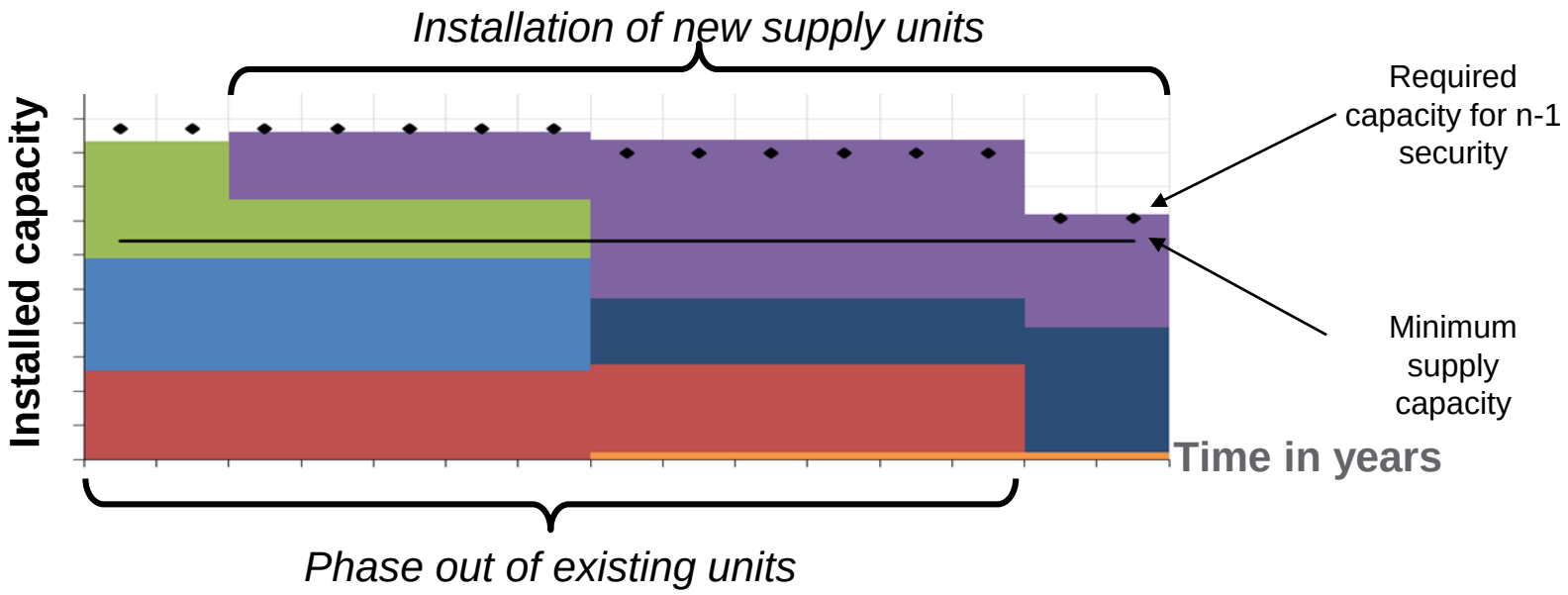
SCALED AND WEIGHTED DECISION SUPPORT MATRIX

		Variant 1	Variant 2	Variant 3	Variant 4	Variant 5
wirtschaftliche Kriterien	**Gewichtung**	**Punkte (auf 0,5 gerundet)**				
niedrige Wärmegestehungskosten mit KWKG						
niedrig						
niedrig	Economic					
niedrig						
gering	criteria					
gering						
	100%	-	-	-	-	-
ökologische Kriterien	**Gewichtung**	**Punkte (auf 0,5 gerundet)**				
hoher Anteil erneuerbarer Energien mit KWKG						
hoher						
niedrig	Ecologic					
niedrig						
niedrig	criteria					
niedrig						
	100%	-	-	-	-	-
technische Kriterien	**Gewichtung**	**Punkte**				
hohe						
kleine						
gering	Technical					
Schad						
hohe	criteria					
Erzeug						
	100%	-	-	-	-	-
sonstige Kriterien	**Gewichtung**	**Punkte**				
schnell						
zeitnah						
gering	Other					
von Im						
hohe	criteria					
	100%	-	-	-	-	-
Gesamtbewertung	**Gewichtung**					
Wirtschaftliche Kriterien						
Ökologische Kriterien						
Technische Kriterien						
Sonstige Kriterien						
Gesamtpunktzahl	100%	0,0	0,0	0,0	0,0	0,0
Rang		1	1	1	1	1



Selection of the most favourable variant!

TRANSITION STRATEGY FOR THE SELECTED VARIANT



+ development of an action plan

- Permissions/ approval
- Detailed planning and tendering
- Further measures (e.g. return temperature reduction)
- …

MEDIA APPEARANCE

MEGA-ERFOLG FÜR CHEMNITZER UMWELTSCHÜTZER! WAR'S DAS MIT DER MÜLLVERBRENNUNG?

26.04.2017 06:00 | 2.016

Von Doreen Grasselt

Chemnitz - **Mega-Erfolg für die** Chemnitzer Umweltschützer**! Der Umweltausschuss hat die geplante Müllverbrennungsanlage am Dienstag von der Tagesordnung genommen. Nun wird neu verhandelt.**

Rathaus und Stadträte haben sich darauf geeinigt, die Chemnitzer mehr einzubeziehen. „Es gab zu wenig Öffentlichkeitsarbeit seitens der Verwaltung", schimpft CDU-Fraktions-Chef Tino Fritzsche (55). „Außerdem hat bisher keiner Alternativen zur Verbrennung aufgezeigt."

Deshalb hat der Ausschuss das Thema postwendend an den Stadtrat überwiesen. „Wir werden Müllverbrennung grundsätzlich ablehnen", sagt Grünen-Fraktions-Chef Thomas Lehmann (48). „Denn in Zeiten der Müllvermeidung machen wir mit so einer Anlage unsere Kinder zu Müllsammlern."

Der Umweltausschuss un
Müllverbrennungsanlage

Der Zeisigwald müsste auf der 1,5 Hektar großen Fläche zwischen Chemnitz und Niederwiesa laut Plan abgeholzt werden, das Naherholungsgebiet wäre in Gefahr (TAG2 entscheiden.

https://www.tag24.de/nachrichten/chemnitz-muellverbrennung-umweltschutz-naherholungs-gebiet-zeisigwald-stadtrat-rathaus-242594

Chemnitzer Energieversorger will aus Braunkohle aussteigen

ONLINE FOCUS

Freitag, 04.08.2017

Der sächsische Strom- und Wärmeerzeuger Eins Energie aus Chemnitz will von 2028 an keine Braunkohle mehr verfeuern. Das Unternehmen werde in den kommenden zwölf Jahren aus der Braunkohle aussteigen, sagte der Vorsitzende der Geschäftsführung, Roland Warner. Er begründete das damit, dass die Anlage 2028 abgeschrieben sein wird. „Ich gehe davon aus, dass es keine Verlängerung geben wird", sagte Warner. Für die Wärme- und Stromerzeugung verbrennt der Energieversorger nach eigenen Angaben pro Jahr eine Million Tonnen Braunkohle. Diese Zahl sei seit Jahren konstant, sagte ein Unternehmenssprecher am Freitag. Schon seit geraumer Zeit würden Experten an einem neuen Versorgungskonzept arbeiten. Unabhängig von dem Ergebnis werde man seine Versorgungspflicht erfüllen, betonte der Sprecher.

http://www.focus.de/regional/chemnitz/energie-chemnitzer-energieversorger-will-aus-braunkohle-aussteigen_id_7437328.html

SUMMARY AND CONCLUSIONS

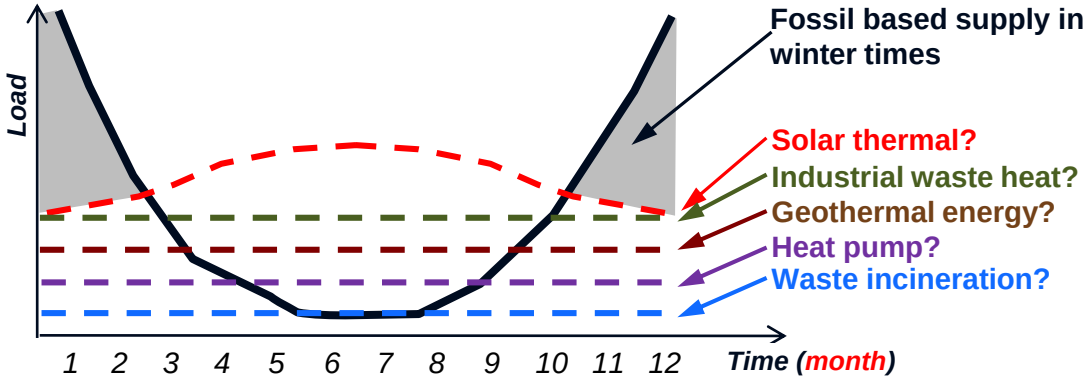
- The **developed decision support methodology** is
  - highly transparent and follows a clear sequential approach
  - allowing the network operator
    - to follow the process easily and as a consequence
    - to make distinct decisions, leading to a clear investment strategy

- **Main results**:
  - Development of a detailed concept for the heat supply in Chemnitz considering
    - supply security,
    - sustainability and
    - economic viability.
  - Decision against the extension of the existing coal CHP!

    (more results cannot presented since the project is sensitive)

BARRIERS FOR RENEWABLES

- Subsidies for gas CHP
- High electricity prices (barrier for HP)
- Uncertain or small potential for industrial waste heat and geothermal energy
- Local resistance against waste incineration
- Competition among each other in summer times



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THANK YOU FOR YOUR ATTENTION!

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