

# The potential of flexible thermal grids to decarbonize the heating sector



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Practical insides from the flagship project ThermaFLEX

IEA Experts' Group on R&D Priority Setting and Evaluation (EGRD)

#### DDr. Stefano Coss

AEE – Institute for Sustainable Technologies (AEE INTEC) 8200 Gleisdorf, Feldgasse 19, Austria



Experts' Group on R&D Priority-Setting and Evaluation



### Outline

- I. Developments and challenges related to the increased use of RES
- II. Why flexibility?
- III. Possible contributions of the heating sector
- IV. Practical insides of flexibility measures in Austria: The flagship project - ThermaFLEX
- V. Large-scale demonstrators of ThermaFLEX



## Developments in renewable energy – EU projections



Investments into RES in the EU - conservative assumptions!

- Dependend on the assumptions: more or less invetsments.
- However: Huge increase in RE generation unevitable!
- Will lead to high shares of RE (power, heat, cold), especially at "end nodes" of the grids.



Source: Bointner, R.; Pezzutto, S.; Grilli, G.; Sparber, W. Financing Innovations for the Renewable Energy Transition in Europe. Energies 2016, 9, 990

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## Challenges involved with high shares of RE – The Duck Curve



- Higher shares of PV change peak and base load production
- Hence, with current consumer loads, residual loads increase massivly!
- More "flexible" generation needed to compensate (increase or decrease) power generation (Flexibility services)

Duck Curve (residual loads) for a network in California, current values and projections 2020

- This situation leads to a need for more conventional capacity (fossil, especially gas-fired), in order to compensate fluctating and highly volatile RE generation
- True for the power, but also for the heating and colling sector (solar thermal generation etc., waste heat recovery etc.)



Source: http://large.stanford.edu/courses/2015/ph240/burnett2/docs/flexible.pdf

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| 13.05.2019

## Flexibility: An example from the power sector on household level



#### **!!!** Flexibility services better when power and heating sector is integrated **!!!**

Fleischhacker, A., Lettner, G., et al., 2018. UrbanEnergyCells - Anforderungen zur Umsetzung von Energiezellen in zukünftigen Energiesystemdesigns [WWW Document]. URL https://nachhaltigwirtschaften.at/de/sdz/projekte/urban-energy-cells.php.



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## Contribution of the heating sector for flexibility services

Heating sector, especially thermal grids, can provide 3 types of flexibility:

- 1. Spatial flexibility through the grid itself
- 2. Temporal flexibility through the grid as storage+external storages
- 3. Acceptance of various energy vectors power, waste heat, solar thermal, P2X
- Flexibility of thermal networks is inherety integrated but can also be extended through different measures, such as thermal storage, smart control, heat pumps etc.



Elements of flexibility of a given energy system



"Typical" possibilities to increase flexibility



https://www.nordicenergy.org/flagship/flex4res/



## The flagship project ThermaFLEX – factsheet

### Consortium – 27 Partners (Research – Industry – Tech)

<u>AEE INTEC, FH Joanneum, Bioenergy 2020+, StadtLABOR, TU-Graz, Stadtwerke</u> Gleisdorf, S.O.L.I.D., Wien Energie, TU-Wien, Feistritzwerke, Joanneum Research, AIT, Salzburg AG, Rotreat Abwasserreinigung, SIR, Alois Haselbach GmbH, Energie Steiermark, Horn Consult, ENAS, Pink GmbH, GREENoneTEC Solarindustrie, STM Schweißtechnik Green Tech Cluster, FRIGOPOL, Abwasserverband Gleisdorfer Becken, Schneid GmbH, Nahwärme Tillmitsch

- Funding regime :
  - Energy Model Region, Flagship and Demonstrators
- Project Budget:
  - 4,6 M€+5 M€ additional funding for demonstrators
  - => Largest (budget-wise) project of the call
- Key aspects of the project:
  - Duration: November 2018 October 2022
  - 8 Work Packages
  - Multiple departments involved (TES + IP)
  - Subproject of Green Energy Lab





## Scope of ThermaFLEX

**Objective:** 

 Define, plan, implement, evaluate and roll-out measures for increased flexibility in thermal systems using large scale industrial demonstrators to decarbonize the heating sector

#### Why?

- Decarbonization of heating sector towards 100 % renewables necessary
- Thermal networks provide >25 % of Austrian households
- Fluctuating, volatile renewables + waste heat need a flexible and smart energy system for integration!
- Thermal networks can be flexible and smart, due to their ability to balance on temporal and spatial scale and accept different energy vectors



## Concept and project outline

#### How? Combining technology, smart operation and innovation!



- 1. Technologies
- 2. System concepts
- 3. New Business Models
- => Smart Thermal Networks



Biomasse

· Etc.

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### **Demonstrator – Flexibility Matrix**



		Flexib	ility Mo	easures	;				
rators		Multiple renewables	Storage	Sector Coupling	User integration	Smart Control	Integrated planning	Low Temperature	
itegration in Demonst	100% renewable district heating Leibnitz	<b>~</b>	$\checkmark$		~	~	~	-	
	Big Solar Salzburg	×	$\checkmark$	×		× .	× .	×	
	Salzburg AHP	<b>_</b>		× -		<ul> <li>Image: A second s</li></ul>			
	Virtual Heating Plant Gleisdorf	<b>~</b>	$\checkmark$	$\checkmark$	$\checkmark$	$\sim$	$\sim$	× .	
	Vienna high-temperature heat pump Spittelau			-		$\checkmark$			
	Vienna Waste heat recovery from sewage water	<b>1</b>	1	<b>V</b>		$\checkmark$	×	× .	
	Energy Island Weiz	<b>A</b>	× .	<b>1</b>	<b>~</b>	$\sim$	$\sim$	<b>_</b>	



## 100% renewable district heating Leibnitz





- Demonstration of a smart renewable energy and waste-heat based municipal DH system
  - Merge of 3 currently independent DH systems with >8 supply units
  - Multi-stage industrial waste heat extraction
  - Bi-directional heat exchange
  - Cascade heat supply
  - Thermal storage
  - App and IoT interface development for both customers and system operators
- Connections: 104 (2017) / 196 (> 2019)
- Heat sold: 7117 MWh/a (2017) / 24968 MWh/a (>2019)
- Innovation: Two players, 1 network => sandbox for thermal energy market.



### Demonstrator Salzburg – Big Solar





Energy system and elements in demo Big Solar Salzburg



Large-scale seasonal storage

Source: Vernetzungsworkshop Projekte 3. Ausschreibung "Stadt der Zukunft" & "Smart City Demo"; PlanEnergi

Flexibility and RE measures:

- Large-scale solar thermal generation
- Absorption heat pump
- Large-scale seasonal storage
- Waste heat utilization at low temperatures
- Innovative part: combination of largescale storage with absorption heat pump and waste heat utilization!
- Absorption heat pumps decreases temperature of return flow => lowtemp waste heat recovery possible



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### Demonstrator Gleisdorf - Virtual Heating Plant



- Implementation of a Virtual Heating Plant concept
  - Large-scale and small-storage water and sorption storage
  - Sector coupling
    - Integration WWTP
    - Heat pump solutions
  - Low-temperature heat supply
  - Advancing monitoring and control
  - Central and decentral renewable heat supply
  - Integrated planning process with user integration
- Innovation: Distributed renewable generation is managed through virtual plant approach.



### Demonstrator Vienna – Flue gas recovery Spittelau



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- Implementation of high-temperature heat pump for heat recovery from flue gas heat
  - 110°C output at normal operation
  - thermal capacity: 16 MW<sub>th</sub>
  - COP heat pump system > 3.4
- Integration in unit commitment DH heat supply
- Provided heat supply appr. 95 GWh / a
  - heat demand of around 16,000 households
- 11 further W2E plants in Austria
  - Potential of 118 MW<sub>th</sub>





### Recap

- Fluctuating RE generation will lead higher residual loads
- Both demand side measures and flexibility services are important measures to tackle the challenges
- Heating sector, both on household as well as on network level can significantly contribute
- Major players in Austria are implementing flexibility measures to prepare for a decarbonized future
- ThermaFLEX roll-out plans will be available for future projects on EU level





## Thank you!