October 5th, 2017 Dubrovnik, Croatia

CE-HEAT: Comprehensive model of waste heat utilization in CE regions

Saša Erlih, E-zavod, Ptuj, Slovenia

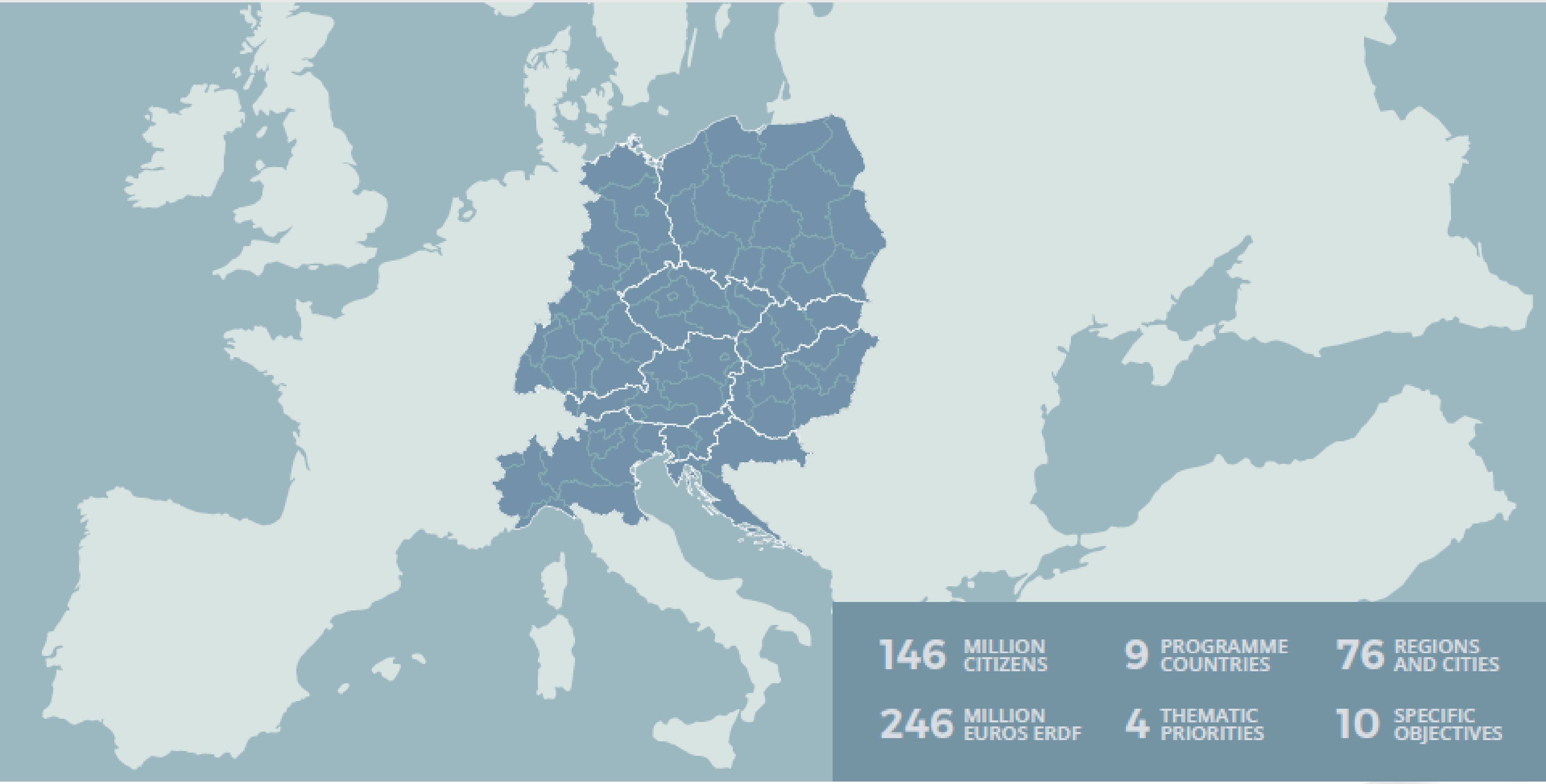
CONTEXT OF THE PROGRAMME

Interreg CENTRAL EUROPE

CE-HEAT

European Union European Regional Development Fund

12th sdewes Conference Dubrovnik 2017



PROJECTS

35 projects approved in first call

PRIORITY AXIS 1
Cooperating on innovation to make CENTRAL EUROPE more competitive

Technology/Innovation Transfer
- FabLabNet
- NUCLEI
- 3DCentral

Innovation financing
- PPI2Innovate
- CROWD-FUND PORT

Innovation ecosystems
- URBAN INNO
- Trans3Net

Innovation management
- I-CON

Social innovation
- Focus IN CD

Entrepreneurship
- CERIecon

PRIORITY AXIS 2
Cooperating on low carbon strategies in CENTRAL EUROPE

Public buildings
- TOGETHER,
- ENERGY@SCHOOL

Public infrastructure
- Dynamic Light

Energy planning
- CitiEnGov
- CE-HEAT
- GeoPLASMA-CE

Urban mobility
- MobiPlan
- SOLEZ
- SULPiTER

PRIORITY AXIS 3
Cooperating on natural and cultural resources for sustainable growth in CENTRAL EUROPE

Natural heritage and biodiversity
- UGB
- Sustree

Water management
- AMIIGA
- PROLINE-CE

Waste and resource efficiency
- STREFOWA

Soil and brownfields
- ReSites
- LUMAT

Air and noise
- InAirQ

Cultural and creative industries
- Forget Heritage

Heritage sites and historic buildings
- RESTAURA
- COME-IN!

Intangible cultural heritage
- ECRR
- YouInHerit
- InduCult2.0

PRIORITY AXIS 4
Cooperating on transport to better connect CENTRAL EUROPE

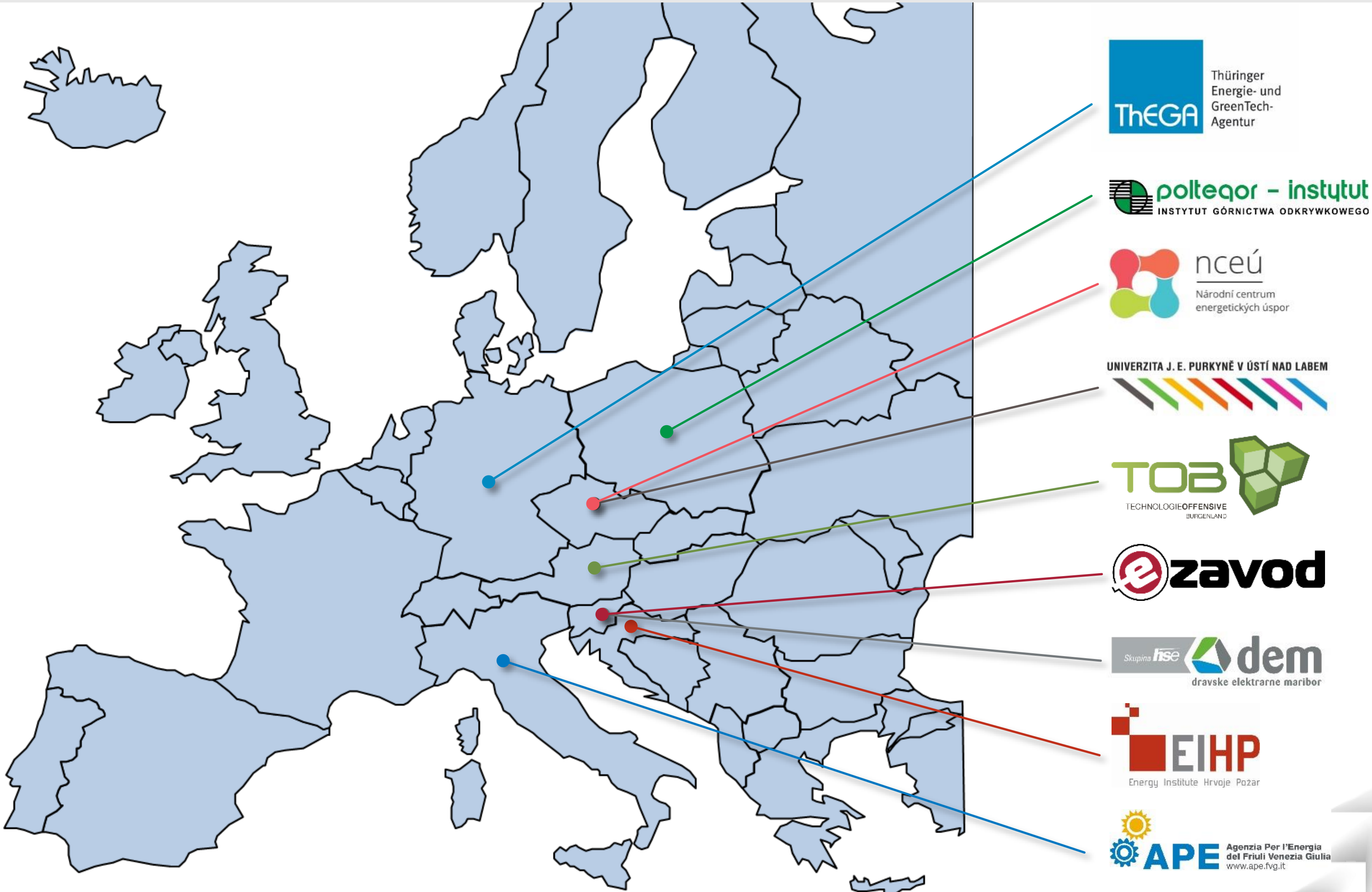
Passenger transport
- RUMOBIL

Freight transport
- ChemMultimodal

Background

- The **challenge** was identified as one of the pressing issues at the global and local scale - with **little success in the past**.
- In order **to improve governance in waste heat utilization**, better and **comprehensive planning,** but also **monitoring tools** are needed.
- Additionally to these, strategic solutions has to be integrated into policies on regional/local level.

PROJECT PARTNERS

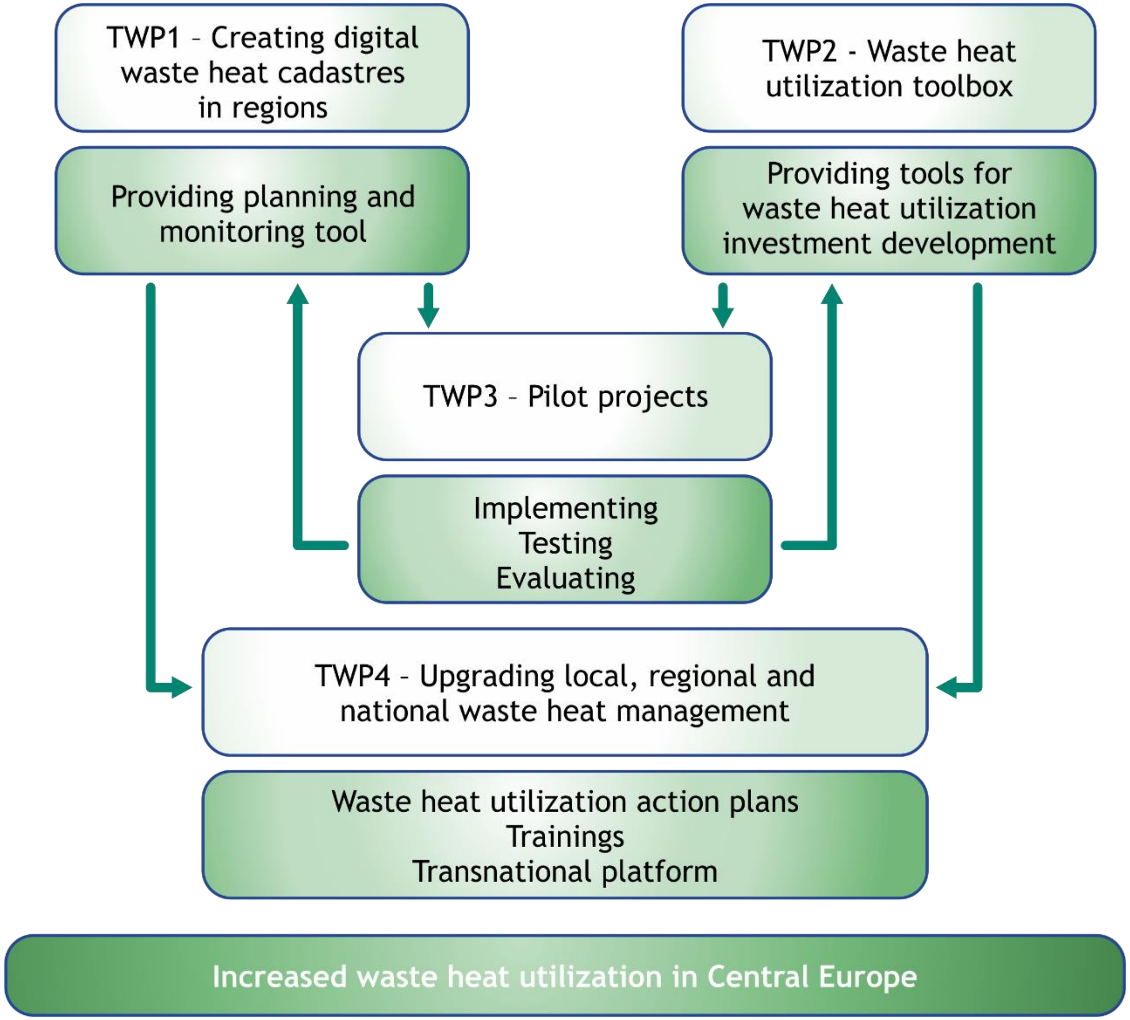


PROJECT OBJECTIVES

Main objective

Improving governance of energy efficiency in Central Europe by **increased exploitation of waste heat** – endogenous Renewable energy source.

APPROACH


TWP1 – Creating digital waste heat cadastres in regions
Providing planning and monitoring tool
TWP2 - Waste heat utilization toolbox
Providing tools for waste heat utilization investment development
TWP3 – Pilot projects
Implementing
Testing
Evaluating
TWP4 – Upgrading local, regional and national waste heat management
Waste heat utilization action plans
Trainings
Transnational platform
Increased waste heat utilization in Central Europe

MAIN OUTPUTS

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7 DIGITAL GIS CADASTRES

developed and integrated into existing cadastres

1 WH UTILIZATION TOOLBOX &PLATFORM

for planning and management of WH utilization investments (guidelines and manuals for planning and management)

7 PILOT PROJECTS

3 strategic low-carbon planning, 4 thematic projects

7 REGIONAL WH UTILIZATION ACTION PLANS

developed and integrated into low-carbon strategies

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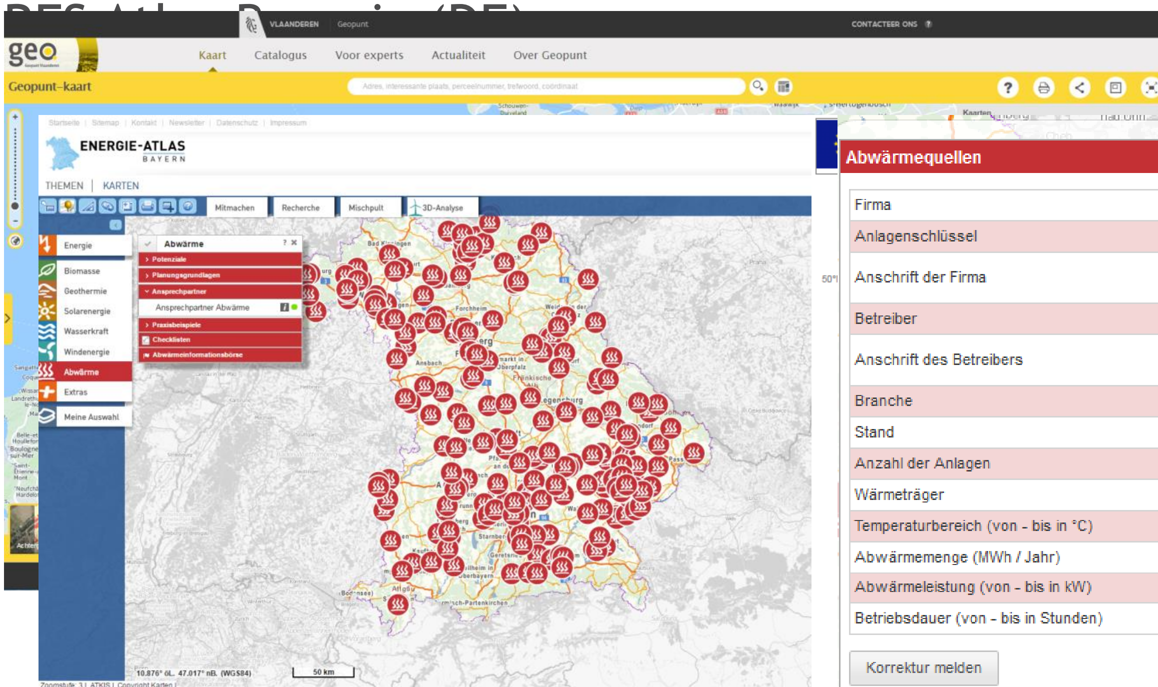
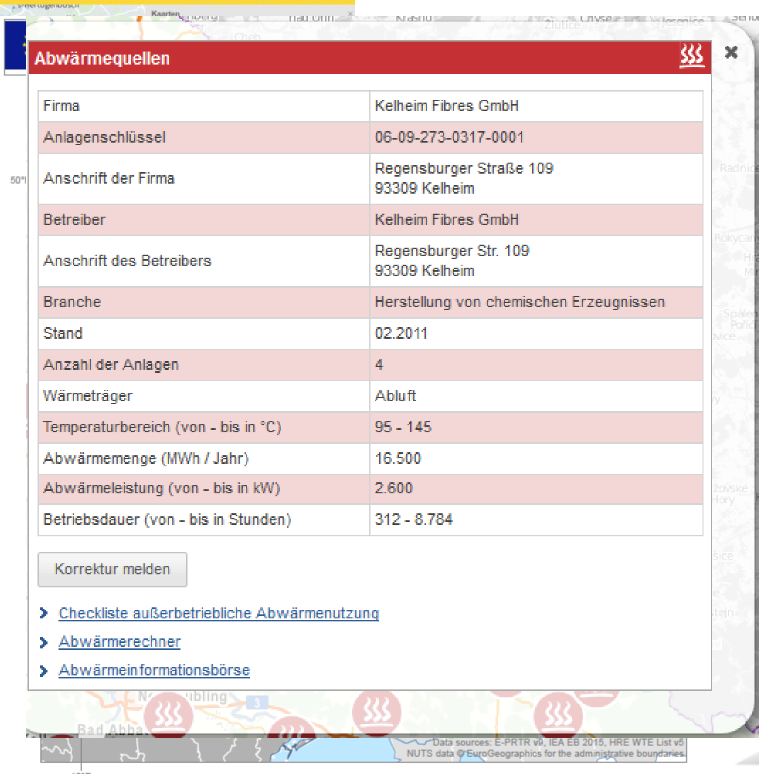
European Union

- Heat Atlas Flanders (BE)





Abwärmequellen

Firma	Kelheim Fibres GmbH
Anlagenschlüssel	06-09-273-0317-0001
Anschrift der Firma	Regensburger Straße 109 93309 Kelheim
Betreiber	Kelheim Fibres GmbH
Anschrift des Betreibers	Regensburger Str. 109 93309 Kelheim
Branche	Herstellung von chemischen Erzeugnissen
Stand	02.2011
Anzahl der Anlagen	4
Wärmeträger	Abluft
Temperaturbereich (von - bis in °C)	95 - 145
Abwärmemenge (MWh / Jahr)	16.500
Abwärmeleistung (von - bis in kW)	2.600
Betriebsdauer (von - bis in Stunden)	312 - 8.784

Korrektur melden

- Checkliste außerbetriebliche Abwärmenutzung
- Abwärmerechner
- Abwärmeinformationsbörse

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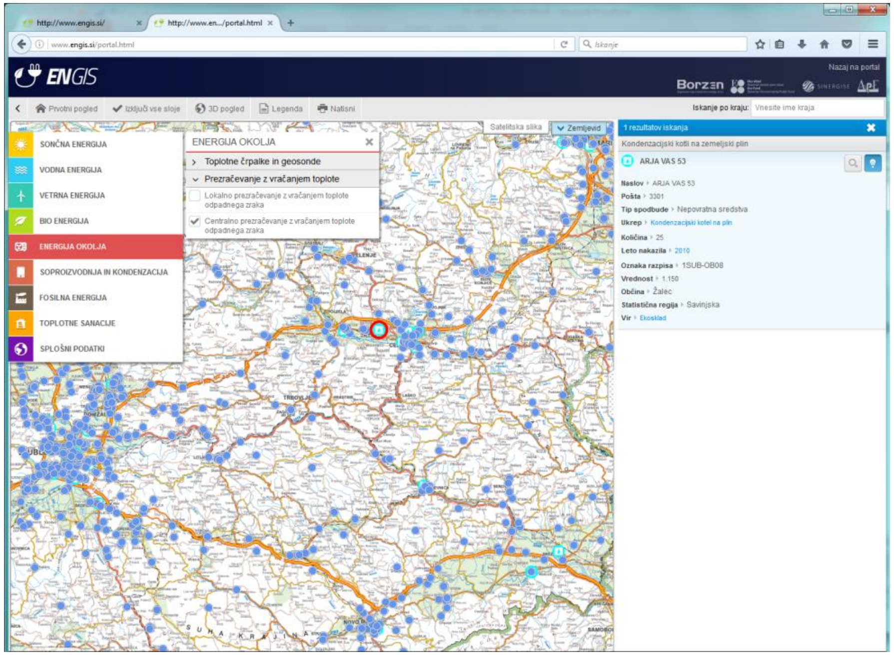
Slovenia

- EnGIS – web-portal visualization of renewable energy sources in Slovenia (presentation of RES / overview of RES potentials)
- New platform in development (BORZEN)



Integration of stakeholders into project activities

- Establishment and involvement of Regional steering groups
- Putting the Waste heat into discussion

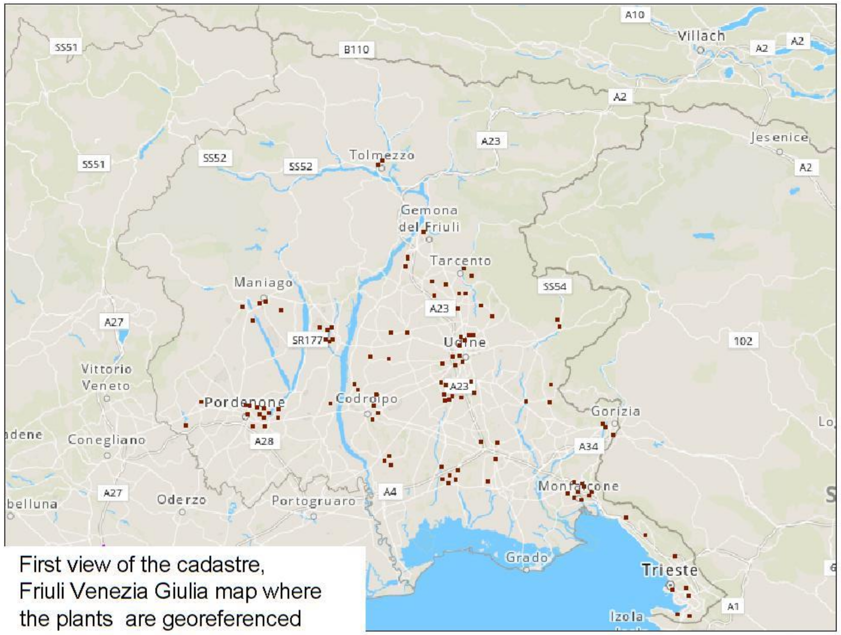
Facilitate investments

- Creation of platform for investors
- Stressing importance of WH utilization on CE level and beyond

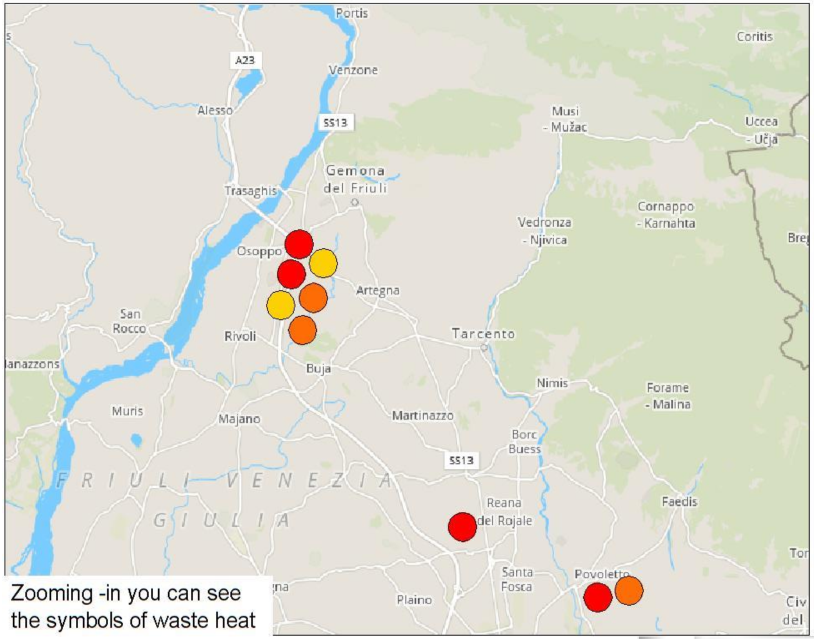
RESULTS

Identification of WH sources and creation of GIS cadastres

- Developed WH cadastre for Thuringia (Germany)
- Establishment of preliminary cadastre for Friuli Venezia Giulia
- Others to follow



First view of the cadastre, Friuli Venezia Giulia map where the plants are georeferenced



Zooming -in you can see the symbols of waste heat

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Sdewes 2017
Dubrovnik, October 2017

Waste heat recovery using ORC for bottoming IC engine

Aleš Hribernik, University of Maribor

Content

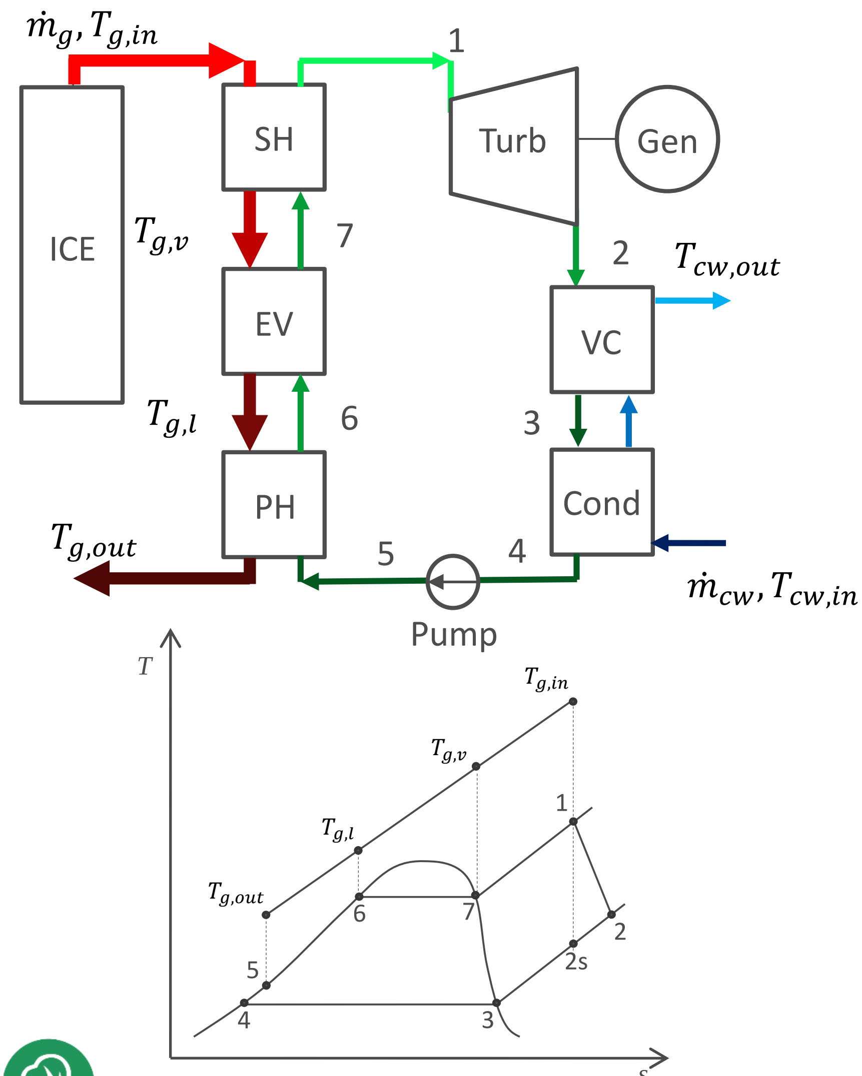
- Introduction
- ORC model
- Economic model
- Results and discussion
- Conclusions

WASTE HEAT RECOVERY TECHNOLOGIES

Waste heat recovery technologies

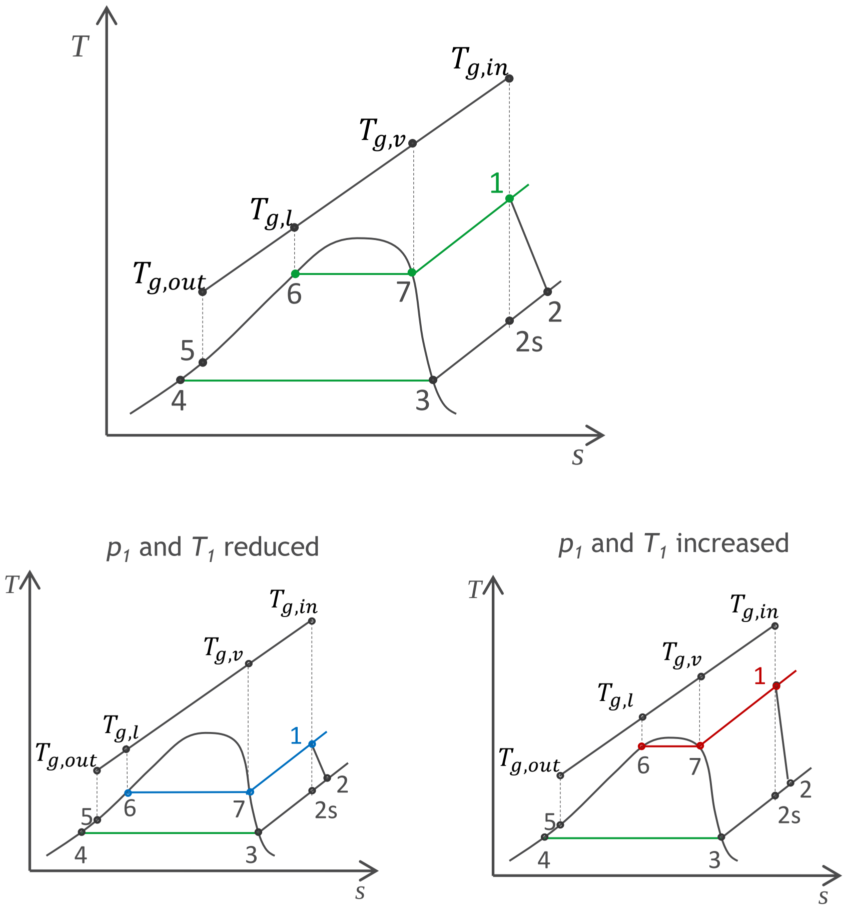
- Active
  - Waste heat to heat (WHTH)
    - Mechanical vapour compressor (MVC)
    - Sorption heat pump
  - Waste heat to cold (WHTC)
    - Sorption chiller
  - Waste heat to power (WHTP)
    - Steam Rankine Cycle
    - Organic Rankine Cycle
    - Kalina Cycle
- Passive
  - Heat exchangers
  - Thermal Energy Storage (TES)

BOTTOMING ORC SYSTEM



Exhaust gases leaving the IC engine flow through the super-heater, evaporator and preheater, and reject their heat to the working fluid before being released to the atmosphere. High pressure working fluid vapour expands in the turbine and then enters the condenser, where the exhausted vapour first rejects heat to the vapour cooler and finally condenses to the liquid phase. The condensate is then pumped to the working pressure and fed to the system of heat exchangers to produce fresh high pressure superheated vapour.

THERMODYNAMIC ORC MODEL



A simple model written in Excel was developed to determine the main system operational parameters. ORC operational points 1 through 7 are calculated, when the fresh vapour thermodynamic state (p_1 and T_1) and condensation temperature T_3 are set as input data. Using the REFPROP database as an Excel Add-in, it was possible to find all other thermodynamic states, turbine and pump specific work and thermodynamic efficiency of the system.

THERMODYNAMIC EFFICIENCY AND OPTIMAL T_1

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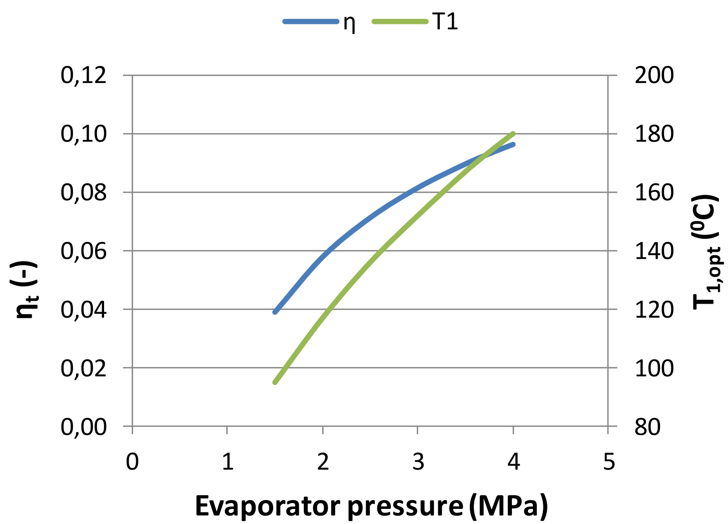
R134a was used as ORC working fluid with critical temperature and pressure at 101.06 ^{0}C and 4.059 MPa, respectively. Condensation temperature was set constant at 35 ^{0}C while evaporator pressure and fresh vapour temperature T_1 were changing. When the evaporator pressure was set constant, a simple trial and error procedure was used to find the optimal fresh vapour temperature T_1 at which the thermal efficiency is the highest.



ECONOMIC MODEL

Electricity Production Cost (*EPC*) can be estimated as:

$$EPC = \frac{C \cdot R + M}{E}$$

where: *C* – capital cost of the ORC system,

$R = \frac{i(1+i)^{time}}{(1+i)^{time} - 1}$ – capital recovery factor,

E – ORC system annual electricity output,

M – operating and maintaining annual cost.

ECONOMIC MODEL

Capital cost is the sum of the capital cost of each system component, including the cost of assembling:

$$C = C_T + C_P + C_{PH} + C_E + C_{SH} + C_{VC} + C_C$$

Any component capital cost was adopted from the literature.

Turbine capital cost: $C_T = f_T(P_T)$

Pump capital cost: $C_P = f_P(P_P, \Delta p_P)$

Heat Exchanger cost: $C_{HE} = f_{HE}(A_{HE})$

HEAT TRANSFER AREA OF HEAT EXCHANGER

The plate type heat exchangers were applied due to their compactness and high heat transfer coefficients. The heat transfer area is calculated as:

$$A_{HE} = \frac{\dot{Q}}{U \Delta T_m}$$

where:

$\dot{Q}$ – heat flow rate,

U – overall heat transfer coefficient,

ΔT_m – logarithmic mean temperature difference.

HEAT TRANSFER AREA OF HEAT EXCHANGER

Overall heat transfer coefficient is calculated from:

$$\frac{1}{U} = \frac{1}{\alpha_h} + \frac{l}{k} + \frac{1}{\alpha_c} + R_f$$

where: α_h - heat transfer coefficient at the hot side,

α_c - heat transfer coefficient at the cold,

l – plate thickness,

k – plate conductivity,

R_f – fouling resistance for both surfaces of the plate.

RESULTS

Both ORC and the economic model were applied in a parametric study to investigate the parameters that influence thermodynamic and economic effectiveness of the bottoming ORC system.

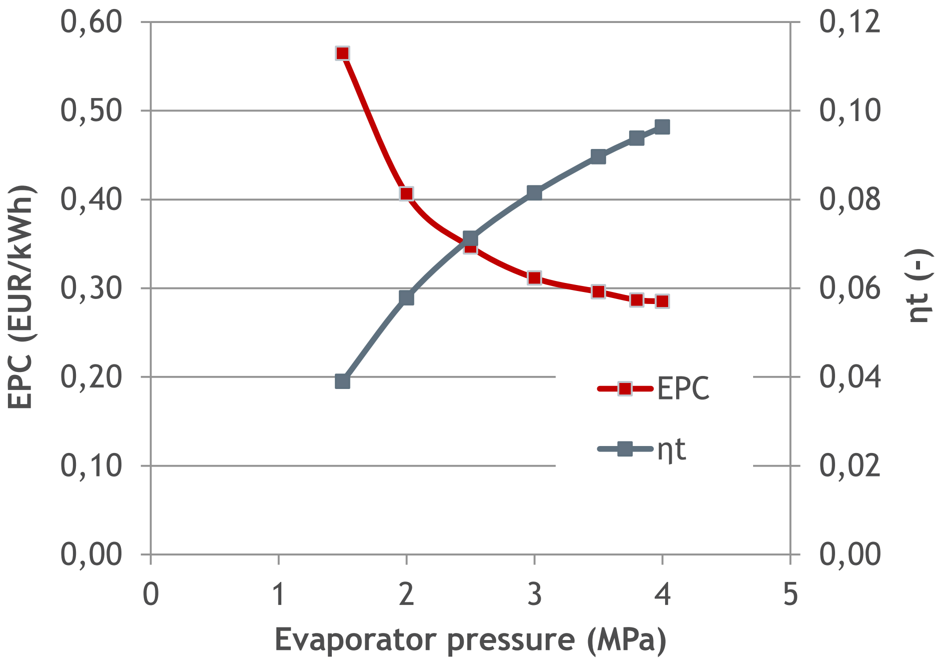
A commercial diesel generator set is considered as a topping system. The engine is an inline 6 cylinder 4 stroke supercharged diesel engine.

Parameter	Value	Parameter	Value
Electrical power output (kW)	235.8	Engine speed (rpm)	1501
Torque (Nm)	1500	Fuel consumption (kg/h)	47.79
Exhaust temperature (^{0}C)	519	Exhaust mass flow (kg/h)	990.79

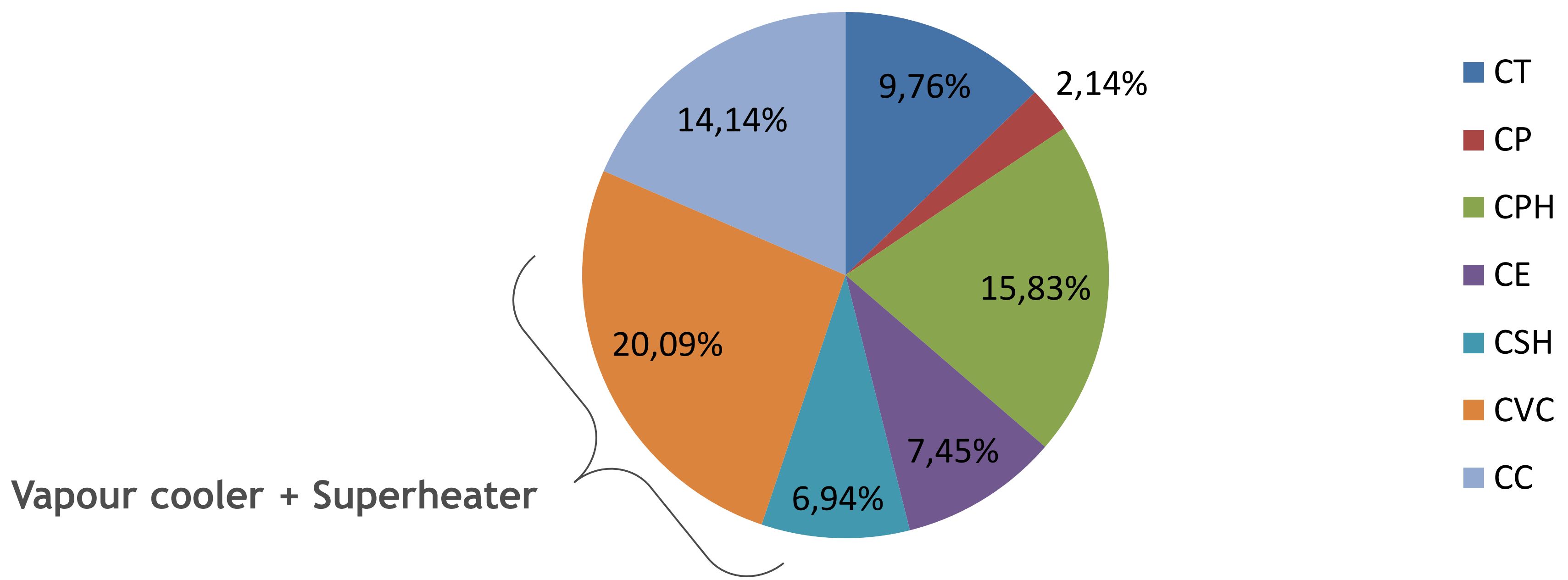
RESULTS

Electricity production cost

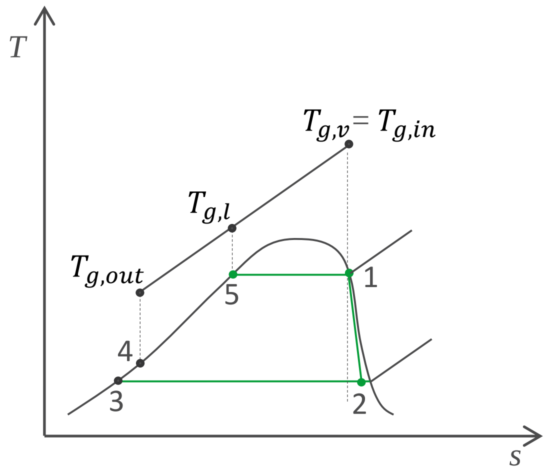
- EPC reduces with p_{ev};
- EPC to high.



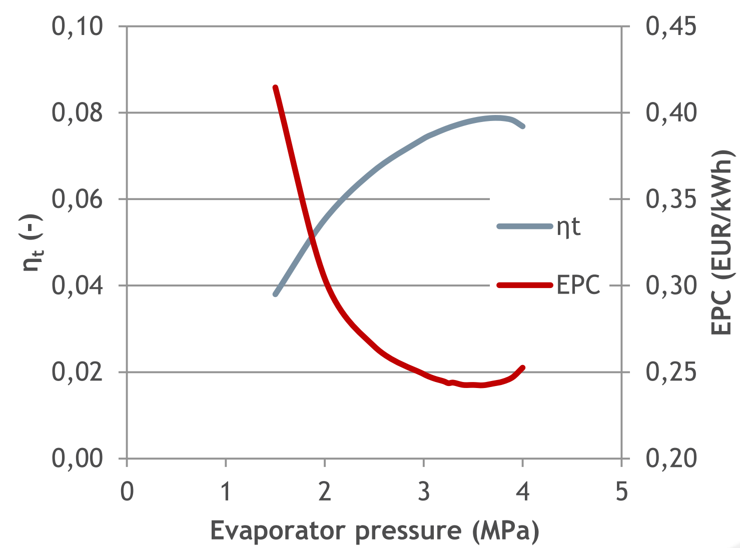
ORC investment cost structure at p_{ev} = 3 MPa



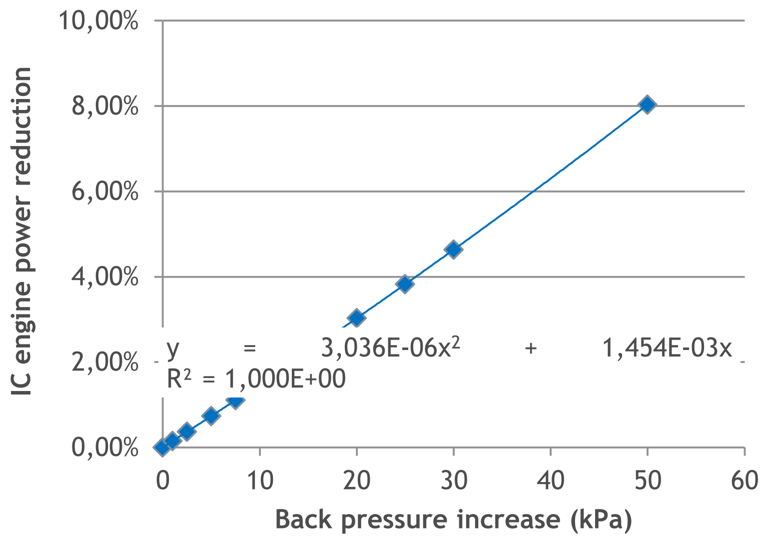
ORC operating with saturated vapour

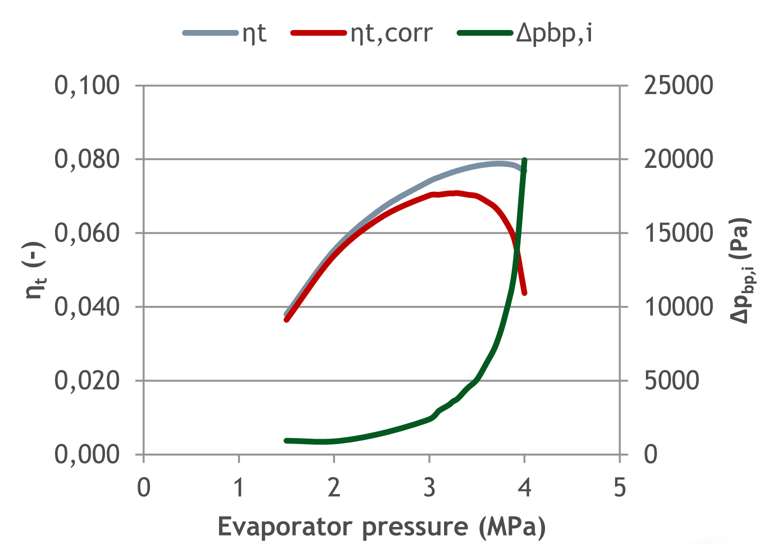


- EPC and η_t have extreme valules;
- Maximal thermal efficiency reduces;
- Minimal EPC reduces by 0.05 EUR/kWh.



ORC influence on topping IC engine





- Back pressure increases with p_{ev};
- Maximal corrected thermal efficiency reduces;
- $\eta_{t,corr}$ extreme moves to lower p_{ev}.

RESULTS

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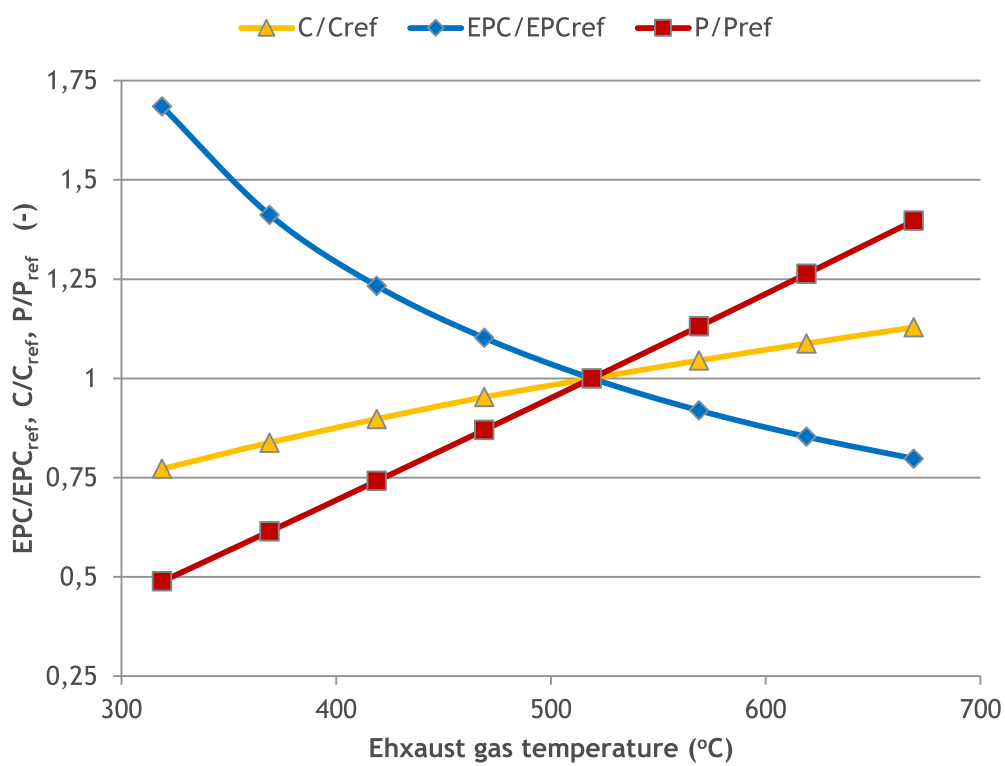
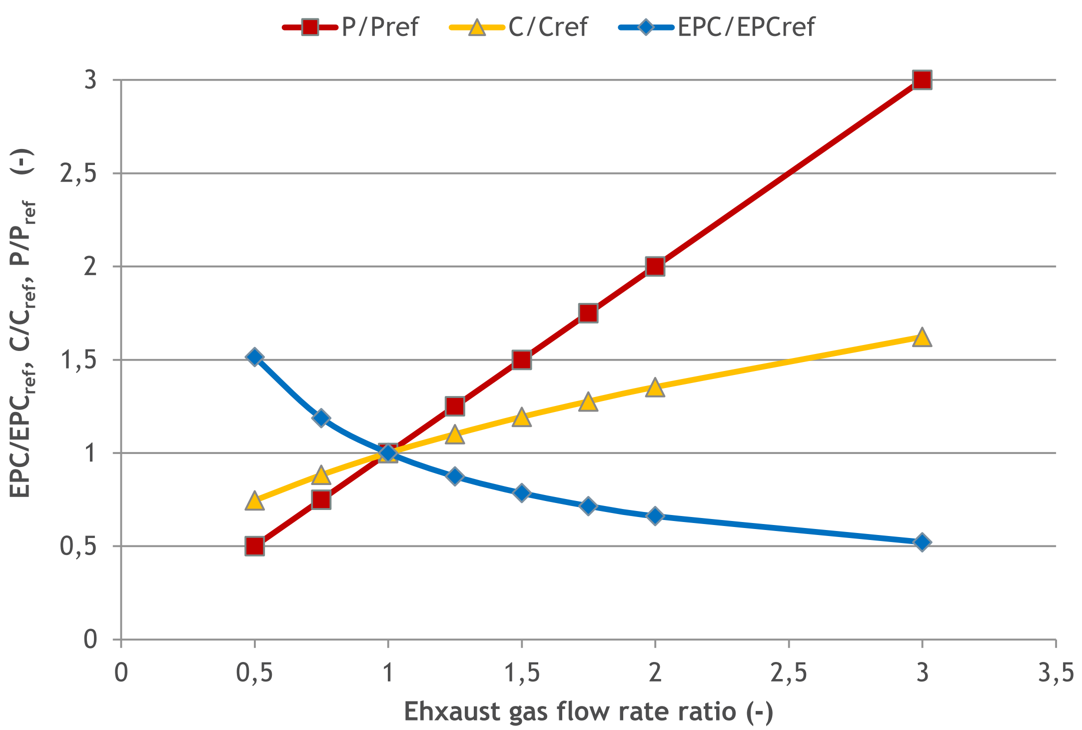
Exhaust gas temperature influence on *EPC*, power and cost of ORC system



RESULTS

Exhaust gas flow rate influence on *EPC*, power and cost of ORC system



CONCLUSIONS

- Electricity Production Cost does not correlate proportionally with the thermal efficiency. A thermodynamically more efficient ORC working with superheated vapour does not attain higher economic efficiency than a simple ORC working with saturated vapour; moreover, the estimated Electricity Production Cost was more than 15% higher.
- Pressure drop at the exhaust gas side of heat exchanger can reduce the topping IC engine output power substantially, therefore, special attention has to be paid to hold pressure drop low even at the cost of increased investment cost of the heat exchanger.
- High exhaust gas temperature and mass flow rate improve the economic viability of an ORC system the most. Both increase ORC power faster than system cost. Therefore, the Electricity Production Cost reduces with exhaust gas temperature and mass flow rate.

THANK YOU FOR YOUR ATTENTION!

Dubrovnik/ 05 October 2017

Czech Institutional Setting of Waste Heat Utilization and Construction of a Local Central Heating System in the Context of People’s Preferences

CE HEAT/ National energy savings center/ Ondrej Vojacek

WASTE HEAT UTILIZATION IN CR: INSTITUTIONAL SETTINGS

- Broader context:
  - 38,1 % of the czech households is supplied with the district heating systems (1,5 mil households)
  - 1800 central heating sources over 5 MW
  - 31 % of all fuels used in energy sector in CR goes into heat generation (out of which is 68 % domestic fuels – mainly coal and wood)
  - 57 % => the share of heat supply over 300 MWth input
  - 75 % => share of heat produced in co-generation
  - 400 entities in EU ETS

WASTE HEAT UTILIZATION IN CR: INSTITUTIONAL SETTINGS

- Energy Efficiency Directive (2012/27/EU)
- Supporting schemes in the Czech Republic:
  Enterprise and Innovations for Competitiveness
    - PA 3.2.:Increase of energy efficiency of the commercial sector *(main criteria are CO_2 emissions reduction and final energy consumption reduction)*
    - PA 3.4.: Use of low-carbon technologies in the fields of energy treatment and secondary raw materials usage
    - PA 3.5.: Increase of the efficiency of the district heating systems"
- Operational program Environment
    - Improving the quality of air in towns and cities
    - Waste and material flows, environmental burdens and risks
    - Energy savings

WASTE HEAT UTILIZATION IN CR: INSTITUTIONAL SETTINGS

- Other important general barriers:

- Third side acces to the networks =>stability of waste heat supplies

- Huge amount of regulations in energy sector
  - 2 energy acts
  - 30 public notices
  - Several hundred technical norms
  - Not well working Energy regulatory office (LR discussion)
  - etc.

- Building law act (very long approval procedures with not given deadlines)

CASE STUDY OF SKRIPOV VILLAGE

CURRENT SITUATION

- Skřípov village/city: 350 inhabitants

- Office furniture manufacturer

(Big amount of wood waste from production)

- Currently: 2 boilers (aprox. 2MW)

- Existing small district heating (within the town of Skripov) aprox. 100 metres from the company distance (18 households + municipal buildings)

- Current price of the heat EURO 13/GJ (tax included)

COMPANY DRIVERS TO CHANGE

- New emmision limits: needed instalation retrofit
- Additional wood waste since 2019

(moving 2nd part of the factory from Opava to Skripov

- Burning biomass at zero cost vs. storage costs (EUR 76 000/year)
- Possibility of covering own electricity consumption
- Extension of the current district heating
- Planned: solar power plant on the roof of the new building

In order to find out the demand for joining the Skripov district heating the research in the Skripov city was done

THE RESEARCH AMONG HOUSEHOLDS

Interreg CENTRAL EUROPE CE-HEAT
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- Methodology: the questionnaire distributed together with the local newspaper

- Return rate only 38% (133 households responded)

- Current heating:
  - Coal (35%)
  - Wood (41%)

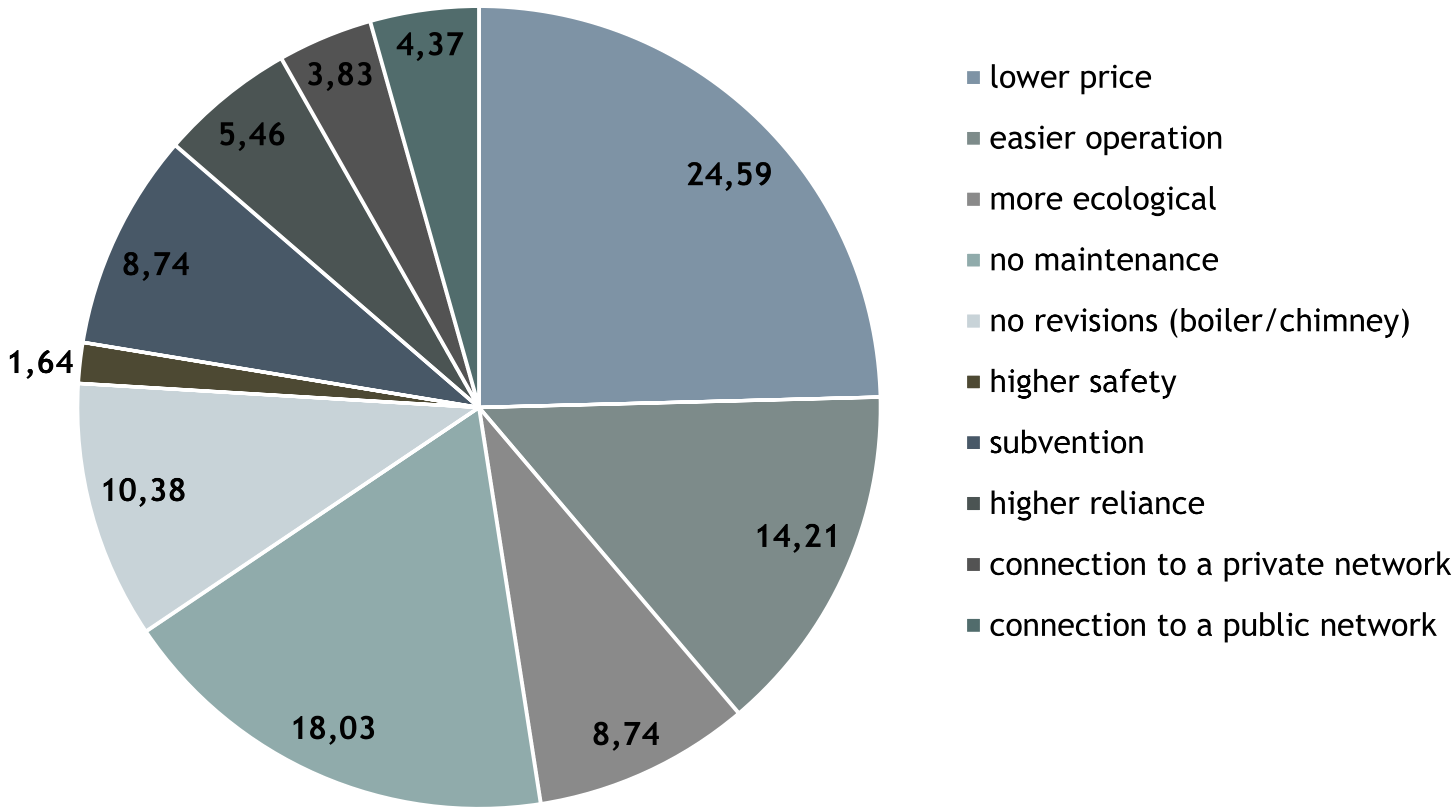
Spending on heating:
- EUR 380 – 680 /year (28%)
- EUR 680 – 1060 /year (37%)
- EUR 1060 – 1450 /year (21%)

WILLINGNESS TO CHANGE HEATING

- Over 50% (answer „Yes“)
- Potential of 83% (answer „maybe“)

- Main reasons initiating the change:
  - Lower price
  - Easier operation
  - No maintenance

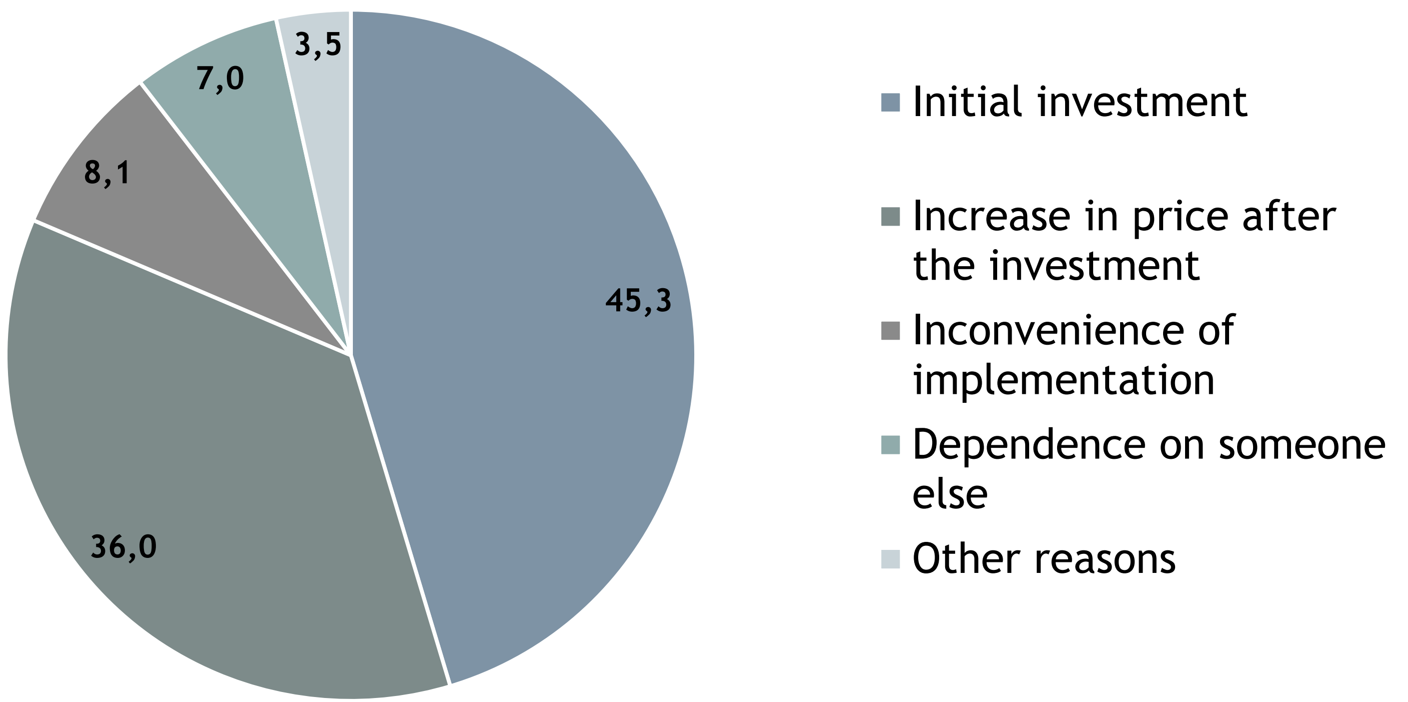
WILLINGNESS TO CHANGE HEATING



REASONS WHY NOT TO CHANGE HEATING

- Initial investment
- Heat price increase after the investment is done

= legitimate reasons



HOUSEHOLD´S TRADE OFF

- Switching to the central heting system has both: benefits and risks
- The central heating systém is:
  - ☐ Easier to operate
  - ☐ Requires little maintenance and effort
  - ☐ Requires investment
  - ☐ Is more expensive

Households need to consider these factors before making the decision

It is difficult to design system without the knowledge of the conrete heat demand

CONCLUSIONS

- Long tradition of the central heating in the Czech Republic
- Currently several programs fo energy efficiency running => not any of them focused directly to the waste heat utilization
- Generally energy investments in the Czech Republic complicated: many pointless administrative burdens
- Potential of heating in the village not utilized
  - Burning the wooden chips is economically viable
- Households are hesitant
  - The new technology is costly
  - User-friendliness may not outweight the monetary costs

Ondrej Vojace/Jan Brabec/Lenka Zemkova
National centre for Energy Savings / Jan Evangelista Purkyně University in Ústí nad Labem
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12th SDEWES Conference, CE Heat Special session
5th October 2017, Dubrovnik

Recycling Management in Biogas Plant

CE 622 CE-HEAT, Forschung Burgenland GmbH, Johann Binder

BIOGAS PLANT - CE HEAT

Situation in Austria	Example 1 Biogas Plant WOLF	Example 2 Biogas Plant STREM	Challenges Recommendation

Recycling Management in Biogas Plant

Situation in Austria

- 300 Biogas plants
- 80 MW Capacity
- feed in tariff for electric power
- obligation to use parts of “waste heat”

Recycling Management in Biogas Plant

Upcoming problems for biogas plants in Austria

- Biogas plants are operating with (expensive) agricultural products (e.g. maize, sun flower)
- Market price for el. power is decreasing the last 10 years
- follow up funding seems to be insufficient, because only short term support is guaranted
- searching for alternatives is just at the beginning

BIOGAS PLANT - CE HEAT

Situation in Austria	Example 1 Biogas Plant WOLF	Example 2 Biogas Plant STREM	Challenges Recommendation

Recycling Management in Biogas Plant

Example 1: Biogas Plant WOLF (Burgenland, Austria)

Different input material including "waste"

- *Dung from hen and cattle: 6 tons/day*
- *Waste from soy oil production: 3 tons/day*
- *Maize or panic grass: 6 tons/day*
- *Grass from green fields: 6 tons/day*
- *Waste from corn: 3 tons/day*

Recycling Management in Biogas Plant

Example 1: Biogas Plant WOLF (Burgenland, Austria)

realising circle economy by using synergies

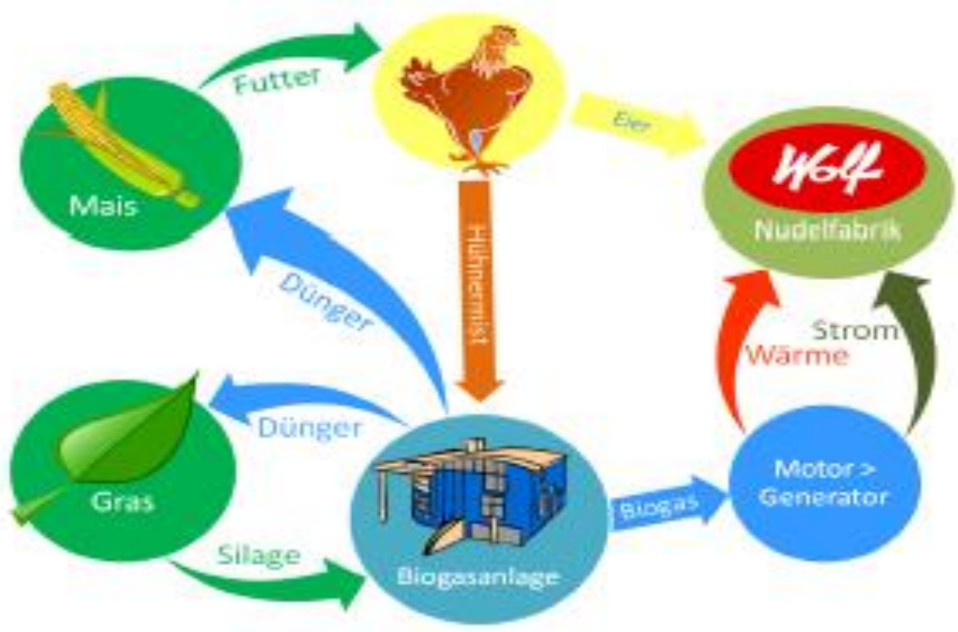

Bild: Wolfnudeln GmbH

Recycling Management in Biogas Plant

Example 1: Biogas Plant WOLF (Burgenland, Austria)

Main goals

- *reaching a full recycling process*
- *using only regional available products including waste*
- *sustainable operation of the plant*
- *at least economic balance of the plant*

BIOGAS PLANT - CE HEAT

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Situation in Austria	Example 1 Biogas Plant WOLF	Example 2 Biogas Plant STREM	Challenges Recommendation

Recycling Managment in Biogas Plant

Example 2: Biogas Plant Strem (Burgenland, Austria)

Recycling Management in Biogas Plant

Example 2: Biogas Plant Strem (Burgenland, Austria)

Input material in the beginning (2005)

- *Maize silage: 25 tons/day*
- *Grass silage: 6 tons/day*

Goal: to replace maize with "waste input" like grass

Recycling Management in Biogas Plant

Example 2: Biogas Plant Strem Cogeneration

Recycling Management in Biogas Plant

Example 2: Biogas Plant Strem (Burgenland, Austria)

Circle economy is aspired

- *500 kW electric power with feed in tariff*
- *550 kW thermal power (waste heat) for the local district heating system*
- *residues from biogas plant are used as dung for the local fields which produce Maize*

Recycling Management in Biogas Plant

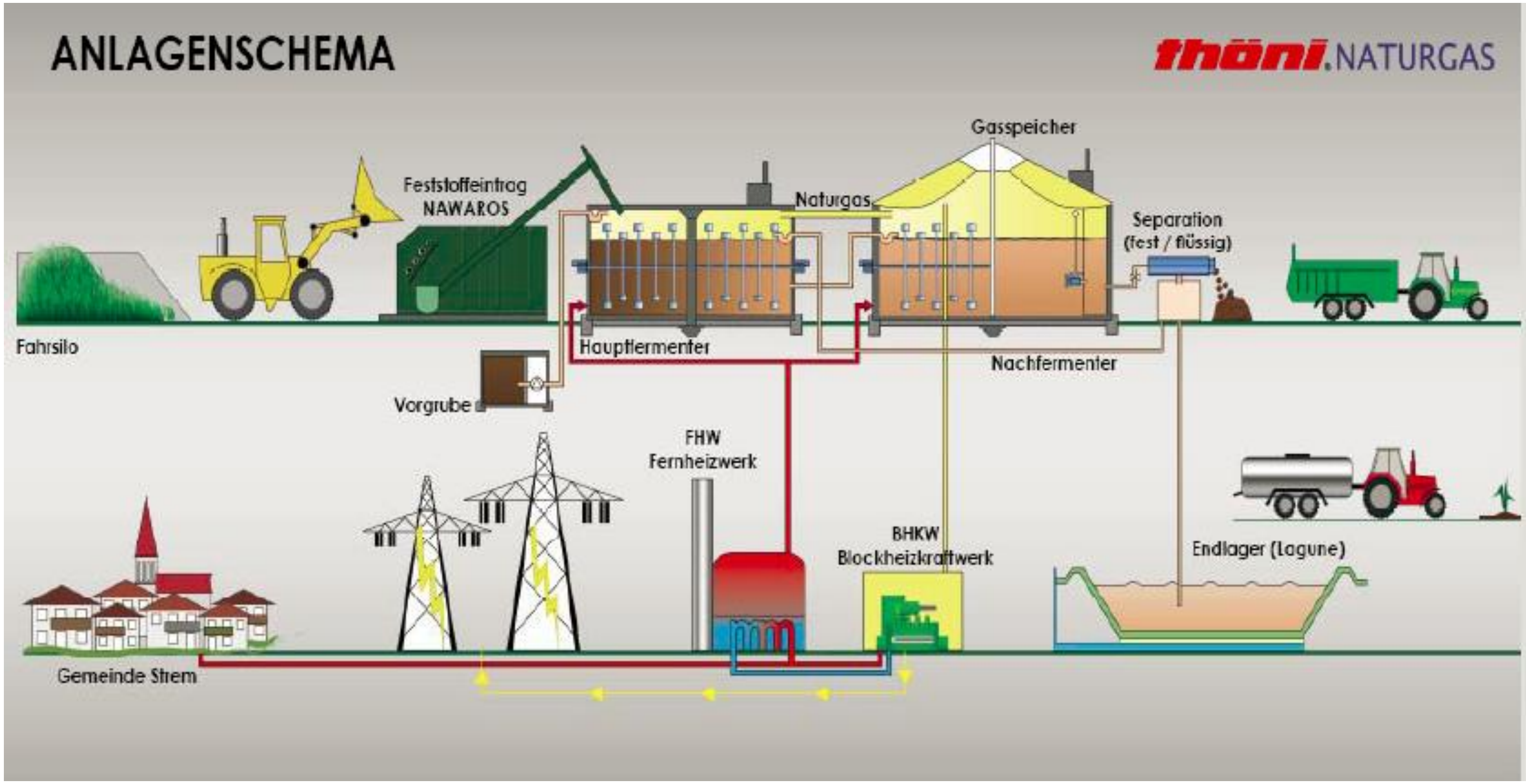
Example 2: Biogas Plant Strem (Burgenland, Austria)

Conception of the plant

- *thermophil fermentation (2 fermentation units)*
- *separation of digestates (remains from fermentation)*
- *storing of input materials in flexible silo*
- *storing of liquid residues in lagune*

Recycling Management in Biogas Plant

Example 2: Biogas Plant Strem (Burgenland, Austria)



Recycling Management in Biogas Plant

Example 2: Biogas Plant Strem (Burgenland, Austria)

acting as research and demonstration plant

- *using local agricultural resources*
- *using local "waste" resources*
- *using residues from local wastewater treatment plants*

Recycling Management in Biogas Plant

Example 2: Biogas Plant Strem (Burgenland, Austria)

Topics for research and development

- *optimization of start up process*
- *handling of “dry” fermentation process*
- *optimization of process engineering and reactor loading*
- *development of expert system for the process*

BIOGAS PLANT - CE HEAT

Situation in Austria

Example 1
Biogas Plant WOLF

Example 2
Biogas Plant STREM

Challenges
Recommendation

Recycling Management in Biogas Plant

Challenges, Recommendations

- *“traditional” production will end;*
  new strategies have to be developed
- *agricultural materials become too expensive;*
  new input materials have to be used
- *el. power production is not sufficient*
  further products have to be market
  (heat, gas, CO^2, residues)
- *stand alone solutions are risky*
  co-operation with synergies should be searched

12th SDEWES Conference, CE Heat Special session
5th October 2017, Dubrovnik

Recycling Management in Biogas Plant

CE 622 CE-HEAT, Forschung Burgenland GmbH, Johann Binder

October 4th – 8th, 2017 Dubrovnik, Croatia

UTILIZATION OF WASTE HEAT FROM HYDRO-POWER PLANTS

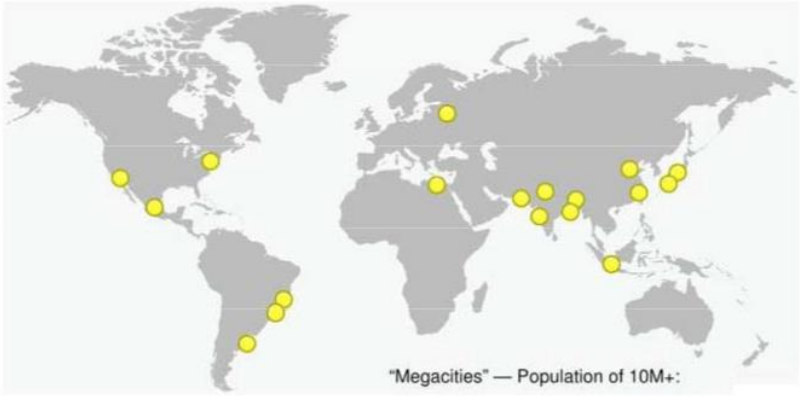
Saša Erlih, E-zavod, Ptuj, Slovenia

Boštjan Gregorc, Dravske elektrarne Maribor, Slovenia

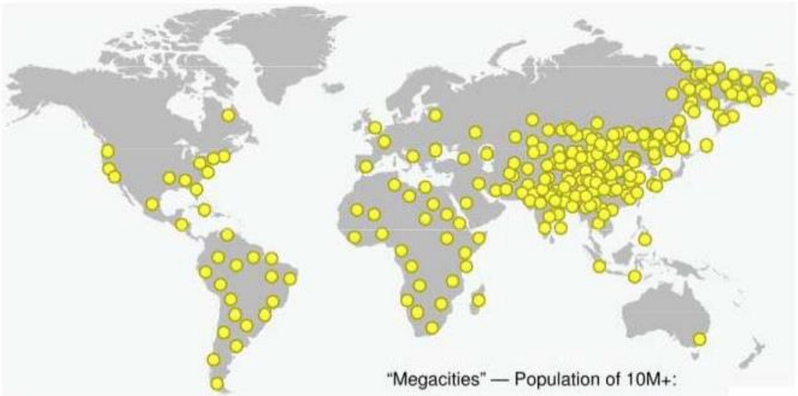
GLOBAL TRENDS

- Global growth of human population to 10 billion up to year 2050 (50% of the population will be located in metropolitan areas)
- Issues of Climate changes and economic migrations
- **Increase of energy demand**

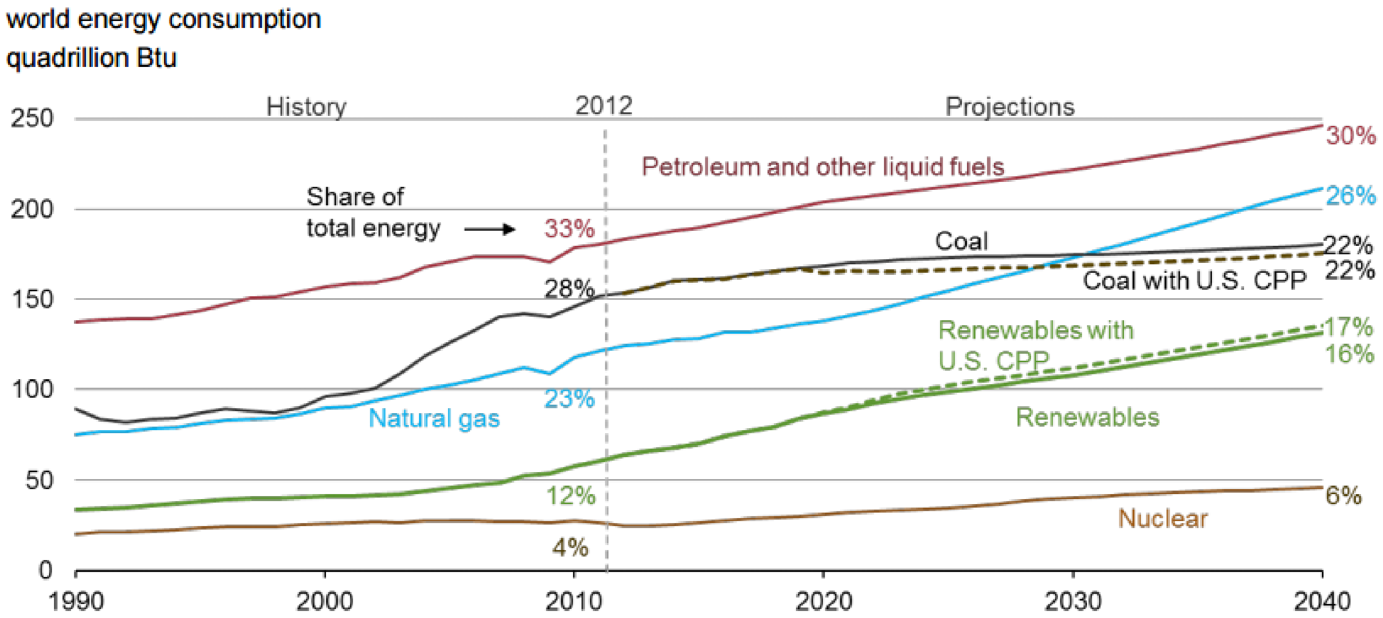
18 Megacities in the World Today



Over 400 Megacities in the World by 2050



WORLD ENERGY CONSUMPTION - TRENDS



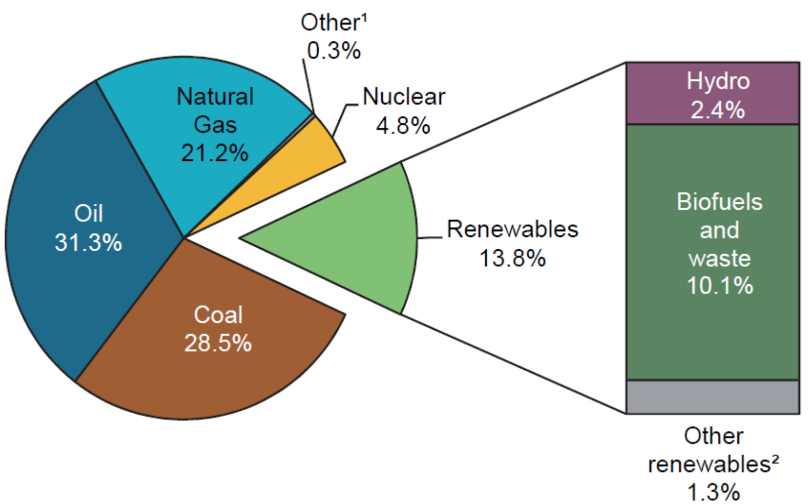
Source: EIA, International Energy Outlook 2016 and EIA, Analysis of the Impacts of the Clean Power Plan (May 2015)

- Increased consumption of natural gas and petroleum products
- Stagnation of coal use
- **Growth of energy produced from renewable sources**

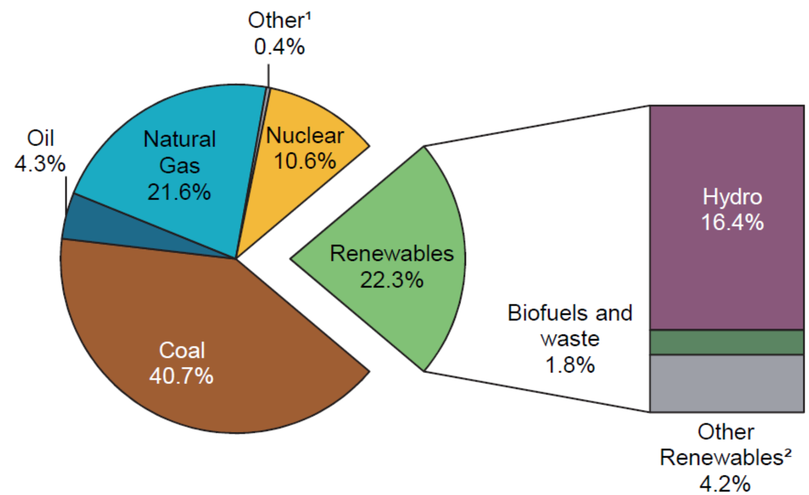
FUEL SHARES IN ENERGY PRODUCTION

Interreg CENTRAL EUROPE
CE-HEAT
European Union European Regional Development Fund
12th sdewes Conference Dubrovnik 2017

2014 fuel shares in world total primary energy supply

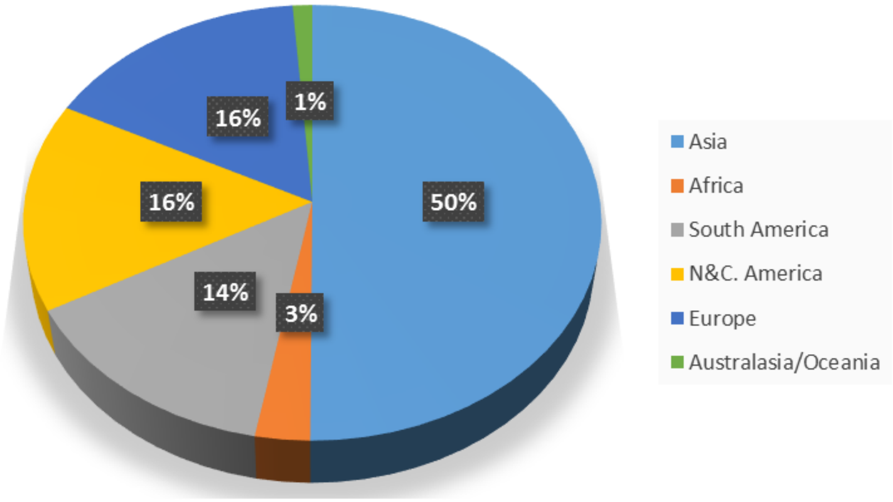


Fuel shares in world electricity production in 2014

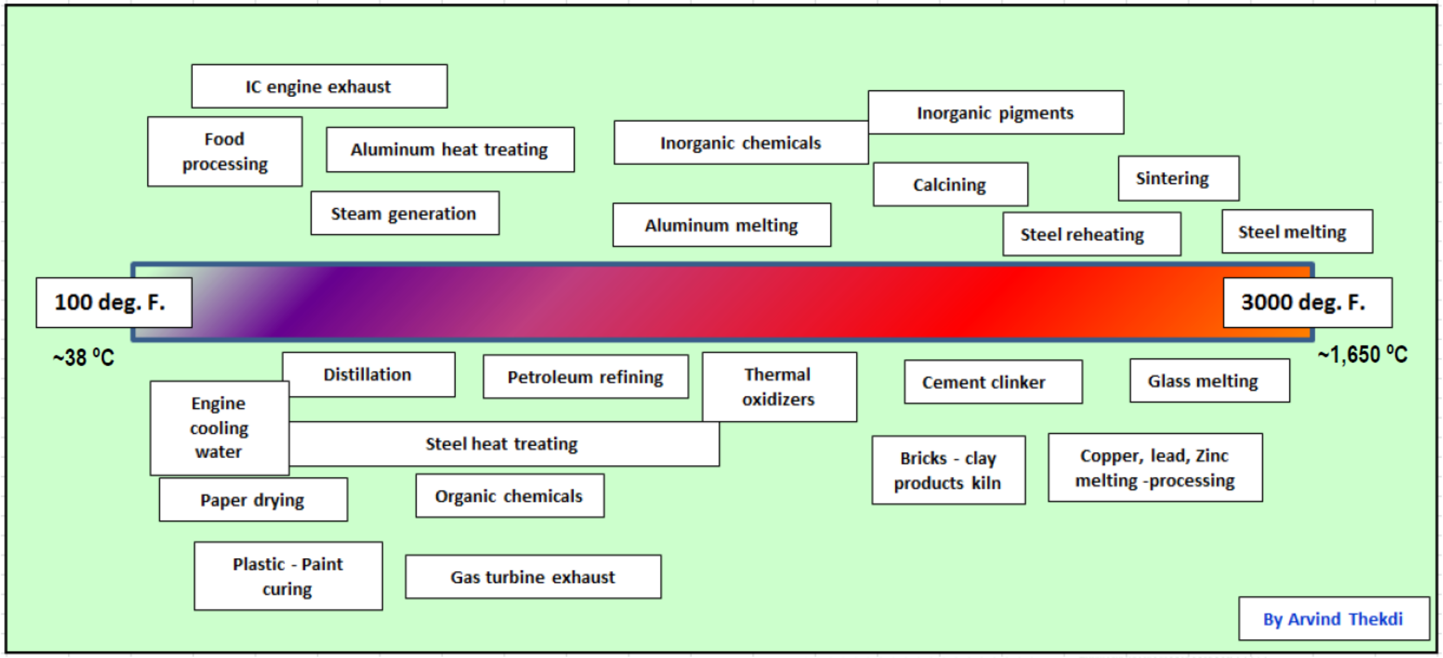


HYDRO CAPACITY IN OPERATION - WORLD

- Hydro capacity in operation ≈ 1123 GW (in 2016)
- The largest share of electricity generation from hydroelectric power plants is generated in the Asian region
- **The potential for waste heat?**

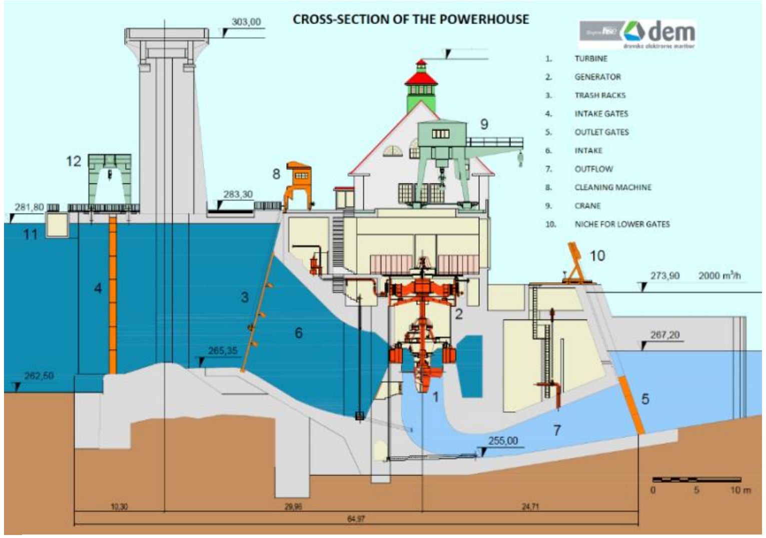


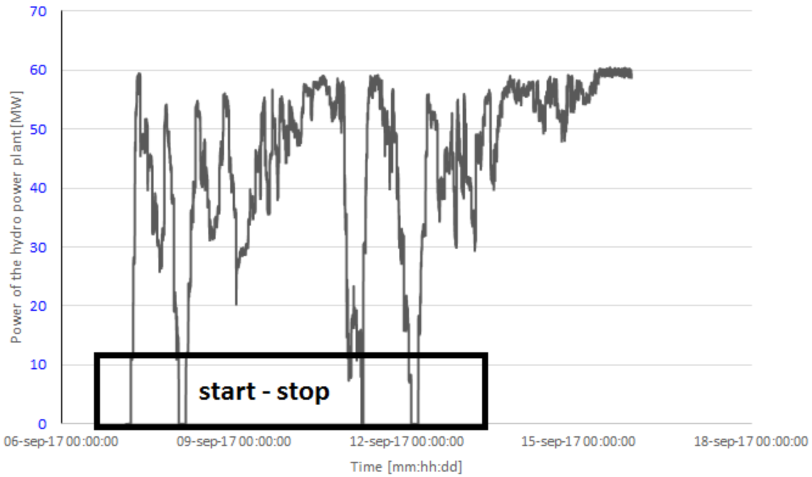
WASTE HEAT IN INDUSTRIAL AND ENERGY PROCESSES



- Temperature regime of waste heat source - °C
- Transfer medium - gas, liquid …
- Waste Heat source power - MW
- Annual potential of waste heat source - MWh

- Exploitation of waste heat of cooling systems of generators and bearings
- Low temperature heat source (20 - 40 °C)
- Dynamic operation of hydroelectric power plants (covering peak energy)
- Location of hydroelectric power plants - distance to potential heat consumers



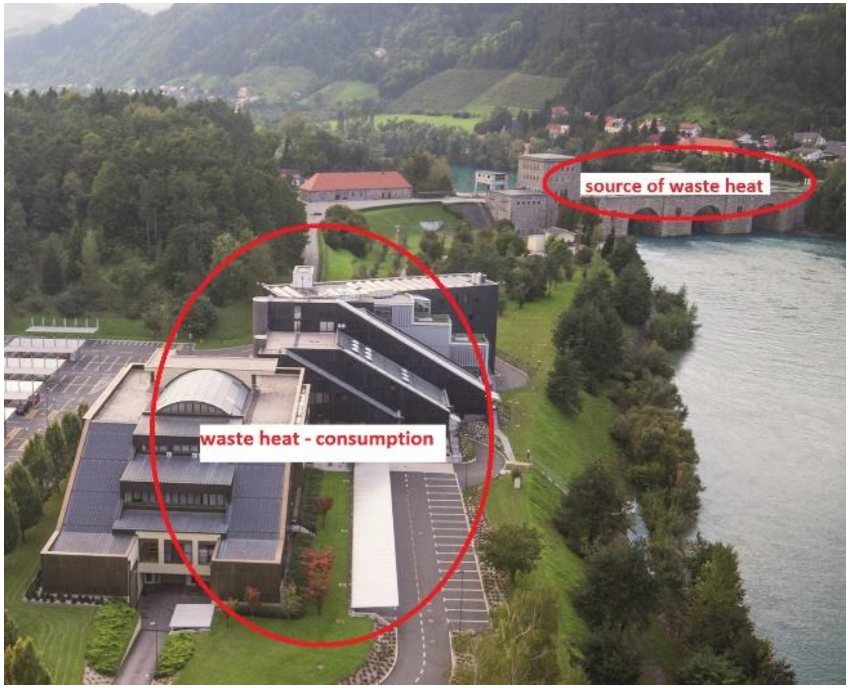


REVIEW OF WASTE HEAT UTILIZATION ON HPP MARIBORSKI OTOK

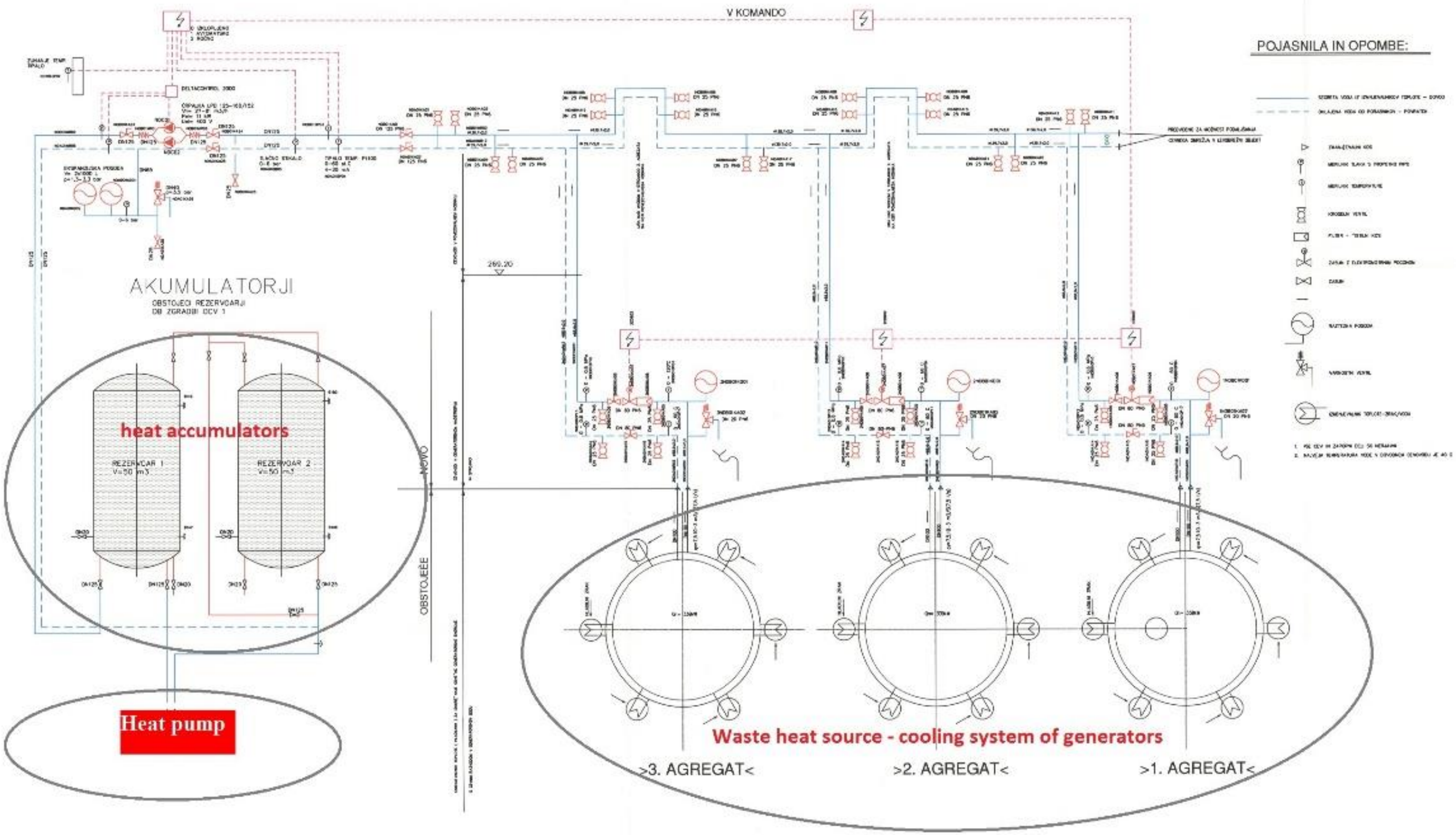
Technical data HPP

- Annual generation – 270 GWh
- Net capacity - 60 MW
- Installed flow - 550 m3/s

- **Potential of a waste heat source at a HPP Mariborski otok approx. 500 kW**
- **Waste heat is utilized for the heating of DEM premises (the center of management of all DEM plants)**
- **Optimization with heat storage system and heat pumps**

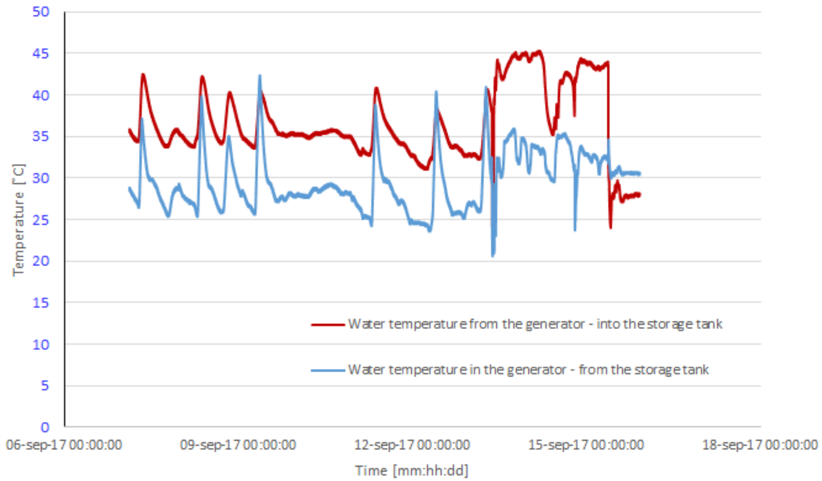


TECHNOLOGICAL SCHEME OF WASTE HEAT RECOVERY SYSTEM



WASTE HEAT RECOVERY SYSTEM - HPP

- The use of a dual cooling systems (generators) at the HPP (open / closed)
- Use of storage tanks (reservoirs) 2 x 50 m^3
- Working temperature of the heat sink 25 - 35 °C
- Utilization of heat pumps to raise the temperature level of water



CONCLUSION

- By developing novel technologies for exploiting low-temperature heat sources, the use of waste heat is becoming more and more attractive for investors
- Utilization of waste heat improves the energy efficiency of existing systems
- The utilization of waste heat at the hydroelectric power plant increases the total energy efficiency by approx. 1.5%
- Estimation of the specific costs of the investment of the waste heat recovery system at the hydroelectric power plant is approx. 500 € / kW

Thank you for your attention

SDEWES2017 (Sustainable Development of Energy, Water and Environment Systems)
Dubrovnik, Croatia / 5.9.2017

Exploiting waste heat in Croatia, potential and challenges

CE-HEAT, Energy Institute Hrvoje Požar, Ilja Drmač

WASTE HEAT IN CROATIA

Introduction
Project CE-HEAT

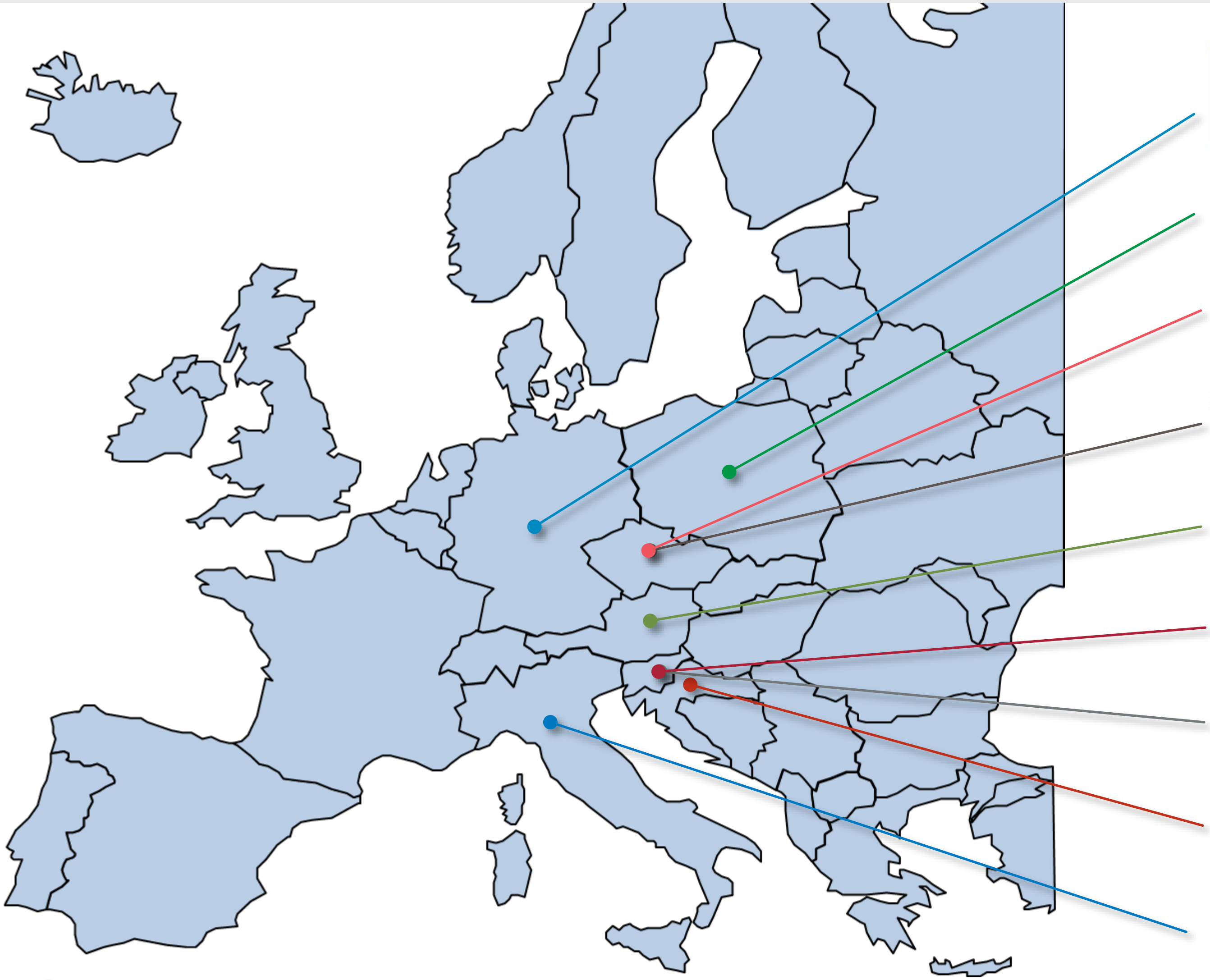
Introduction
EI Hrvoje Požar

Focus-preferential electricity producers (biomass, biogas, cogeneration)

Waste heat utilization

Conclusion

PROJECT PARTNERS



ThEGA Thüringer Energie- und GreenTech-Agentur

poltegor – instytut INSTYTUT GÓRNICTWA ODKRYWKOWEGO

nceú Národní centrum energetických úspor

UNIVERZITA J. E. PURKYNĚ V ÚSTÍ NAD LABEM

TOB TECHNOLOGIEOFFENSIVE BURGENLAND

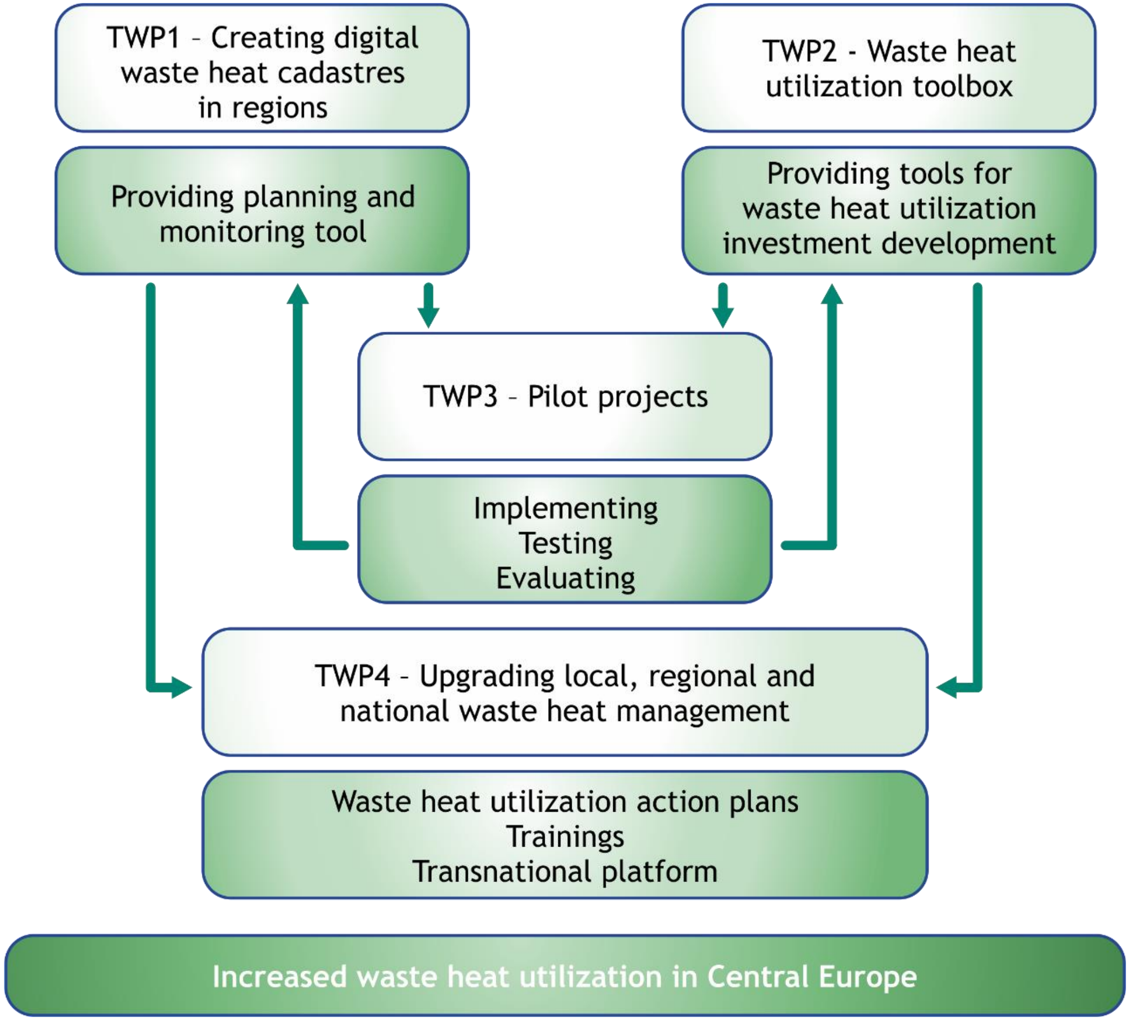
ezavod

Skupina hse dem dravske elektrarne maribor

EIHP Energy Institute Hrvoje Pozar

APE Agenzia Per l'Energia del Friuli Venezia Giulia www.ape.fvg.it

CE HEAT



TWP1 – Creating digital waste heat cadastres in regions
Providing planning and monitoring tool
TWP2 - Waste heat utilization toolbox
Providing tools for waste heat utilization investment development
TWP3 – Pilot projects
Implementing
Testing
Evaluating
TWP4 – Upgrading local, regional and national waste heat management
Waste heat utilization action plans
Trainings
Transnational platform
Increased waste heat utilization in Central Europe

CE HEAT

Where?
How much?
What can we do with it?
Is it feasible?
Is it economically justified?
WASTED (LOST) ENERGY

ENERGY INSTITUTE HRVOJE POŽAR

Energy Institute Hrvoje Požar
Address: Savska cesta 163,
10001 Zagreb, Hrvatska;
PP 141

Phone:	*01/6040-588*
	01/6326-100
Fax:	*01/6040-599*
E-mail:	*eihp@eihp.hr*

http://www.eihp.hr/

EIHP IN THE REGION

EIHP AROUND THE REGION

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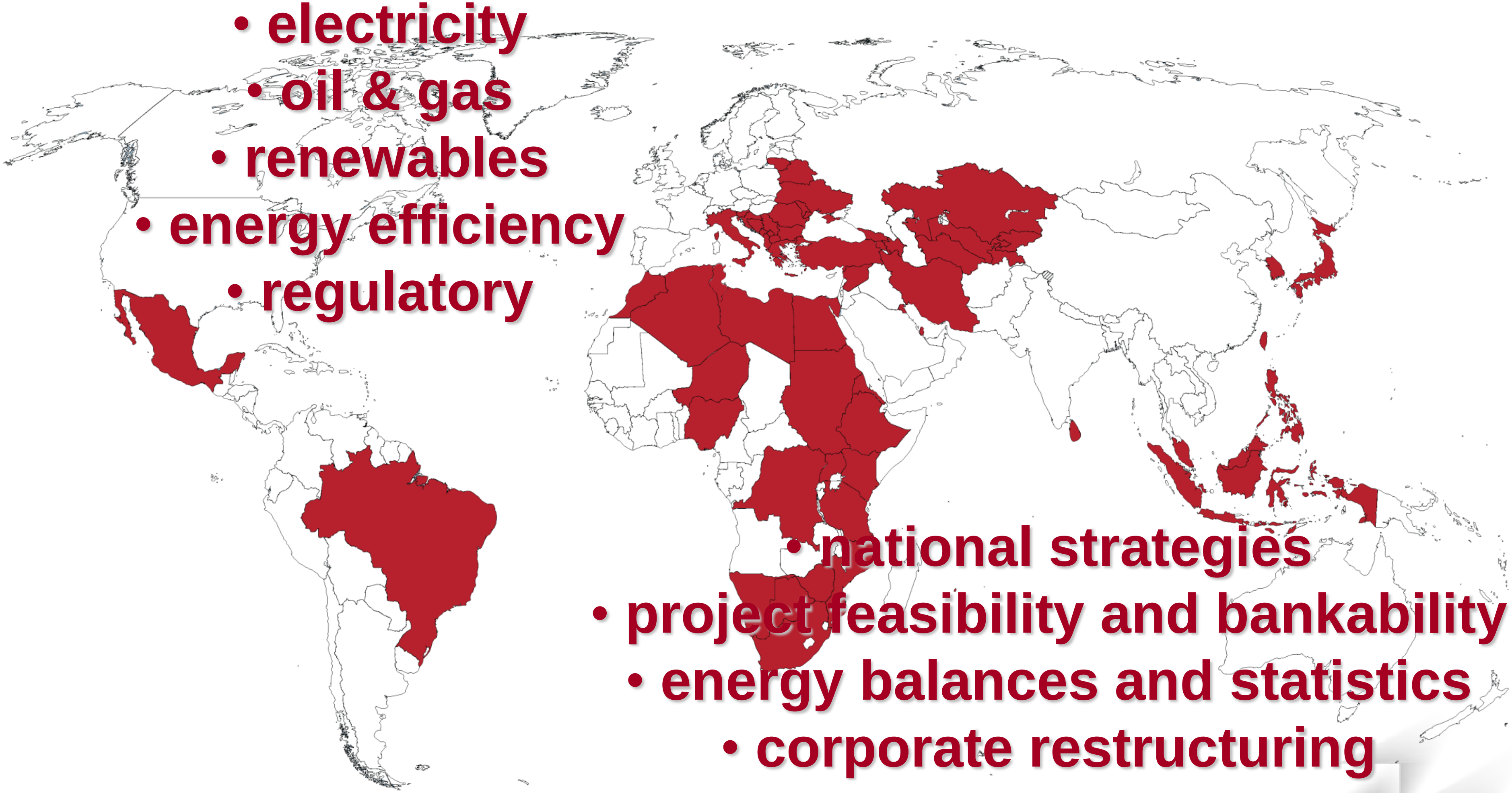
EIHP AROUND THE WORLD



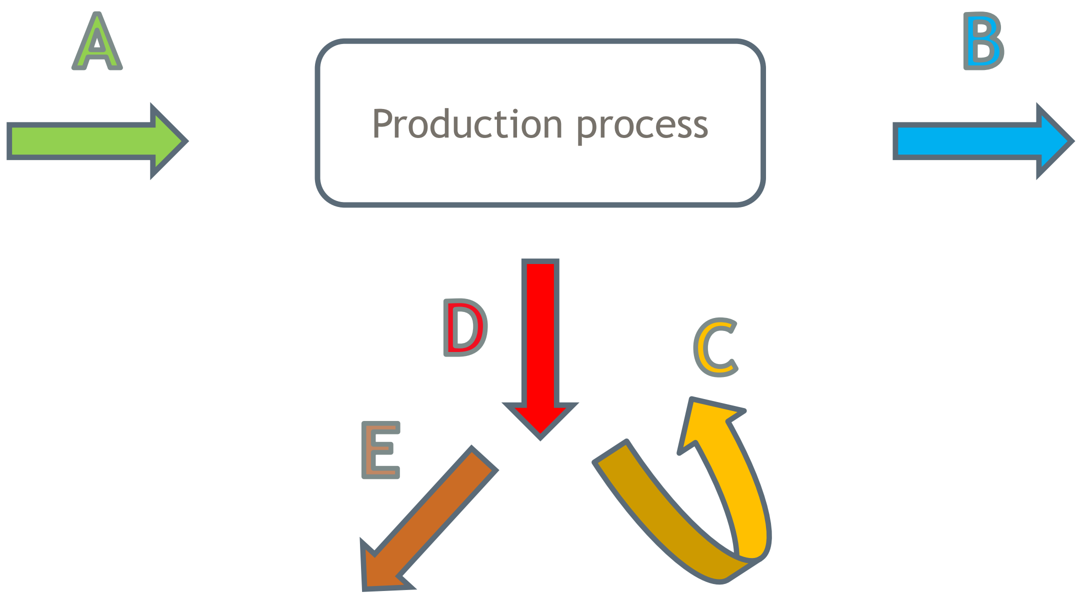
- electricity
- oil & gas
- renewables
- energy efficiency
- regulatory

- national strategies
- project feasibility and bankability
- energy balances and statistics
- corporate restructuring
- mergers and acquisitions

PARTNERS

eDF
SOFRECO
TRACTEBEL Engineering GDF SUEZ
IPA Energy + Water Economics
AETS Application Européenne de Technologies et de Services
pwc
MERCADOS ENERGÉTICOS CONSULTORES
SNC·LAVALIN
NORSK ENERGI
Fraunhofer ISI
KEMA DNV
NORPLAN
Danish Management Group
LAHMEYER INTERNATIONAL
MWH BUILDING A BETTER WORLD
KPMG
eXergia
Deloitte.
FICHTNER
MVV decon
CESI ismes EGH IPH
PÖYRY
intec GOPA International Energy Consultants
COWI FØRENDE RÅDGIVNINGSVIRKSOMHED MED EN 360°-TILGANG
LDK CONSULTANTS Pioneer in integrated consulting services
RWE The energy to lead
ERNST & YOUNG Quality In Everything We Do
Mott MacDonald
RAMBOLL

PREFERENTIAL ELECTRICITY PRODUCERS (BIOMASS, BIOGAS, COGENERATION)



A	Primary fuel energy	[MWh]
B	Electricity production	[MWh]
C	Produced useful heat	[MWh]
D	Produced heat	[MWh]
E	Waste heat	[MWh]

PREFERENTIAL ELECTRICITY PRODUCERS (BIOMASS, BIOGAS, COGENERATION)

*Type of plant / primary energy source	Number of plants	Power [MW]	Electricity production [MWh]
Biomass power plants	12	25,955	177.911
Biogas power plants	26	30,435	210.162
Cogeneration plants	6	113,293	234.053
Total	44	169,683	622.126

Type of plant / primary energy source	Report of annual efficiency of the production plant
Biomass power plants	4/12
Biogas power plants	7/26
Cogeneration plants	1/6

A	Primary fuel energy	[MWh]
B	Electricity production	[MWh]
C	Produced useful heat	[MWh]

*Annual report on the work of the Croatian Energy Regulatory Agency for 2016

**Annual efficiency of the production plant

PREFERENTIAL ELECTRICITY PRODUCERS (BIOMASS, BIOGAS, COGENERATION)

Average values			
	Biomass	Biogas power	Cogeneration[1]
Ratio between produced heat energy and electricity	4,68	1,58	2,45
Ratio between utilizied heat energy and produced	0,37	0,35	0,11
Degree of energy utilization	55%	60%	11%

Type of plant / primary energy source	*Power [MW]	**Power [MW]	Power ratio * and ** [%]	*Electricity production [MWh]	**Electricity production [MWh]	Production ratio * and ** [%]
Biomass power plants	25,955	13,50	52%	177.911	112.665,72	63%
Biogas power plants	30,435	29,44	97%	210.162	233.376,19	111%

Available data:
Nominal electric power-40/44;
Nominal heat power-30/44;
Primary fuel energy, Electricity production, Produced useful heat – 13/44

[1]Ratio between utilized heat energy and produced = 0,5; Degree of energy utilization=50%.

*Annual report on the work of the Croatian Energy Regulatory Agency for 2016
**Calculated from available data (we had access to information for 10/12 biomass plants).

PREFERENTIAL ELECTRICITY PRODUCERS (BIOMASS, BIOGAS, COGENERATION)

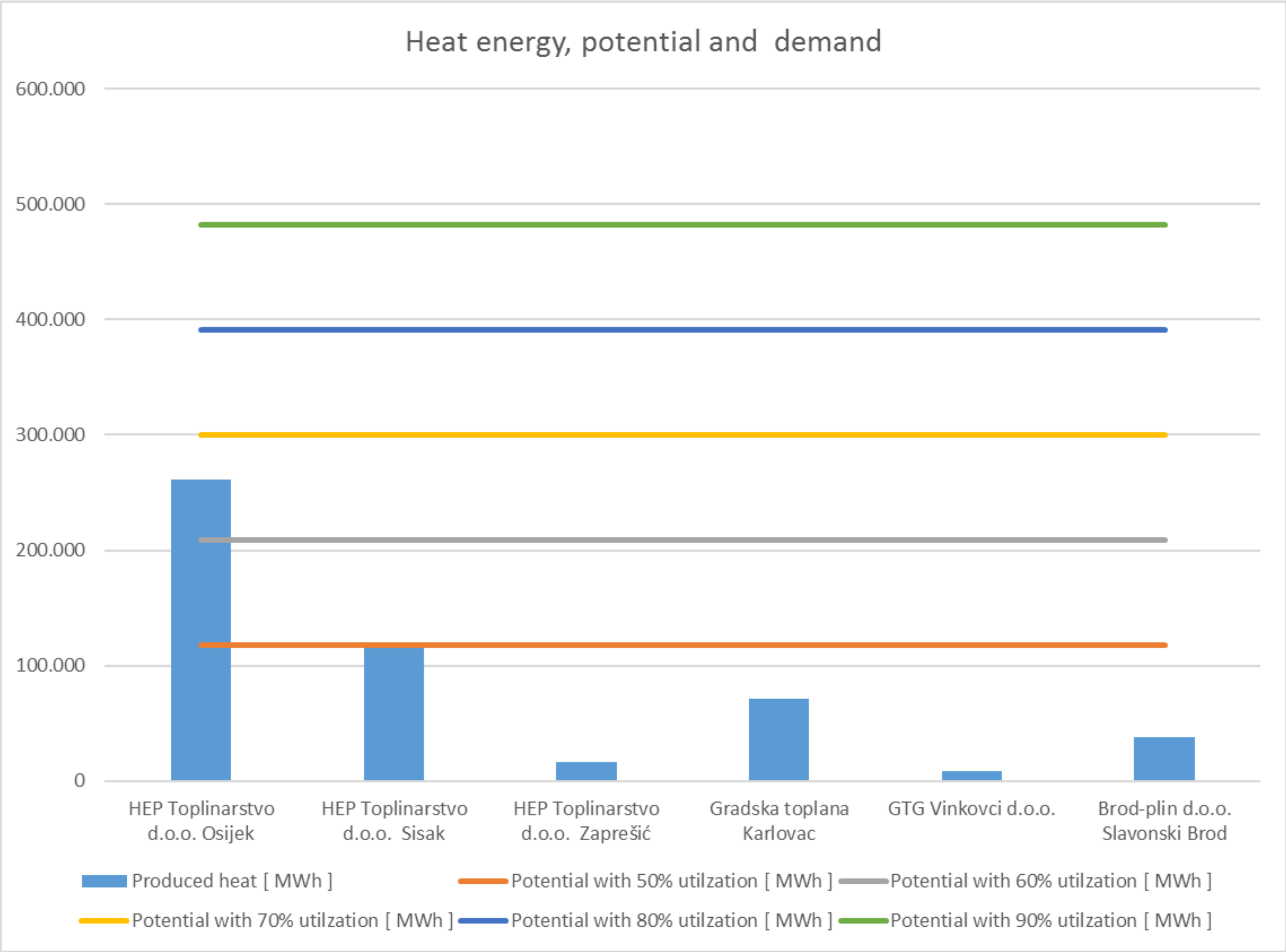
Production of heat energy - calculation

Type of plant / primary energy source	Produced heat [MWh]	Produced useful heat [MWh]	Heat losses [MWh]	Produced useful heat with 50% utilization [MWh]	Potential [MWh]
Biomass power plants	832.320	310.502	521.817	416.160	105.658
Biogas power plants	78.402	27.176	51.226	39.201	12.025
Total	910.722	337.679	573.044	455.361	**117.683**

Heat energy, potential for utilization

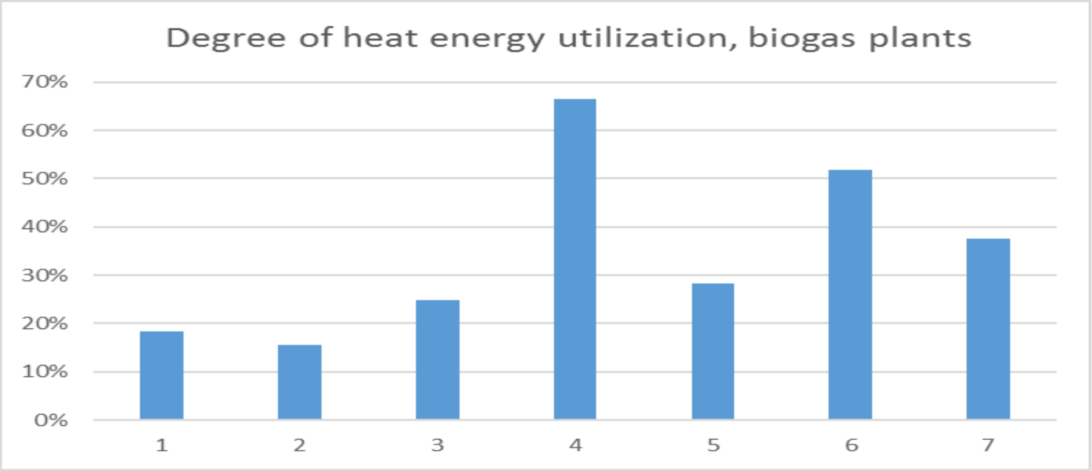
Type of plant / primary energy source	Potential with 60% utilzation [MWh]	Potential with 70% utilzation [MWh]	Potential with 80% utilzation [MWh]	Potential with 90% utilization [MWh]
Biomass power plants	188.890	272.122	355.354	438.585
Biogas power plants	19.865	27.705	35.546	43.386
Total	208.755	299.827	390.899	481.971

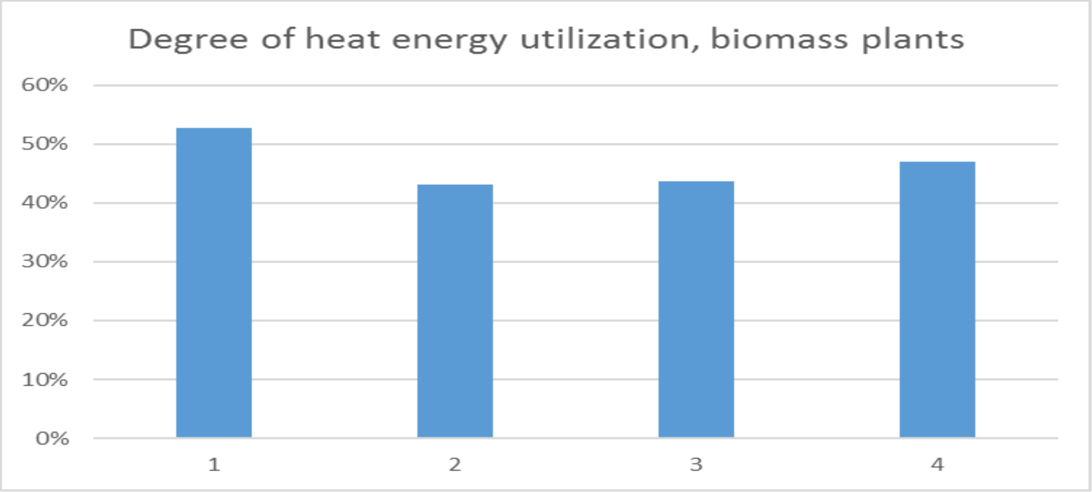
PREFERENTIAL ELECTRICITY PRODUCERS (BIOMASS, BIOGAS PLANTS)



PREFERENTIAL ELECTRICITY PRODUCERS (BIOMASS, BIOGAS, COGENERATION)

WASTE HEAT UTILIZATION

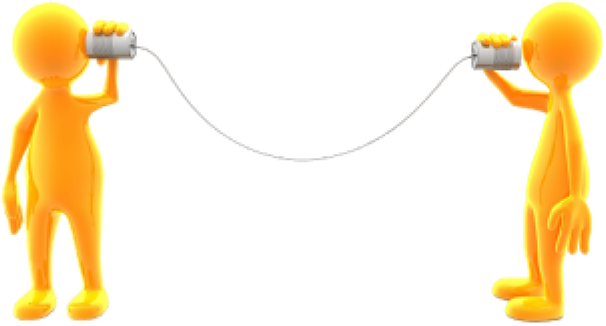




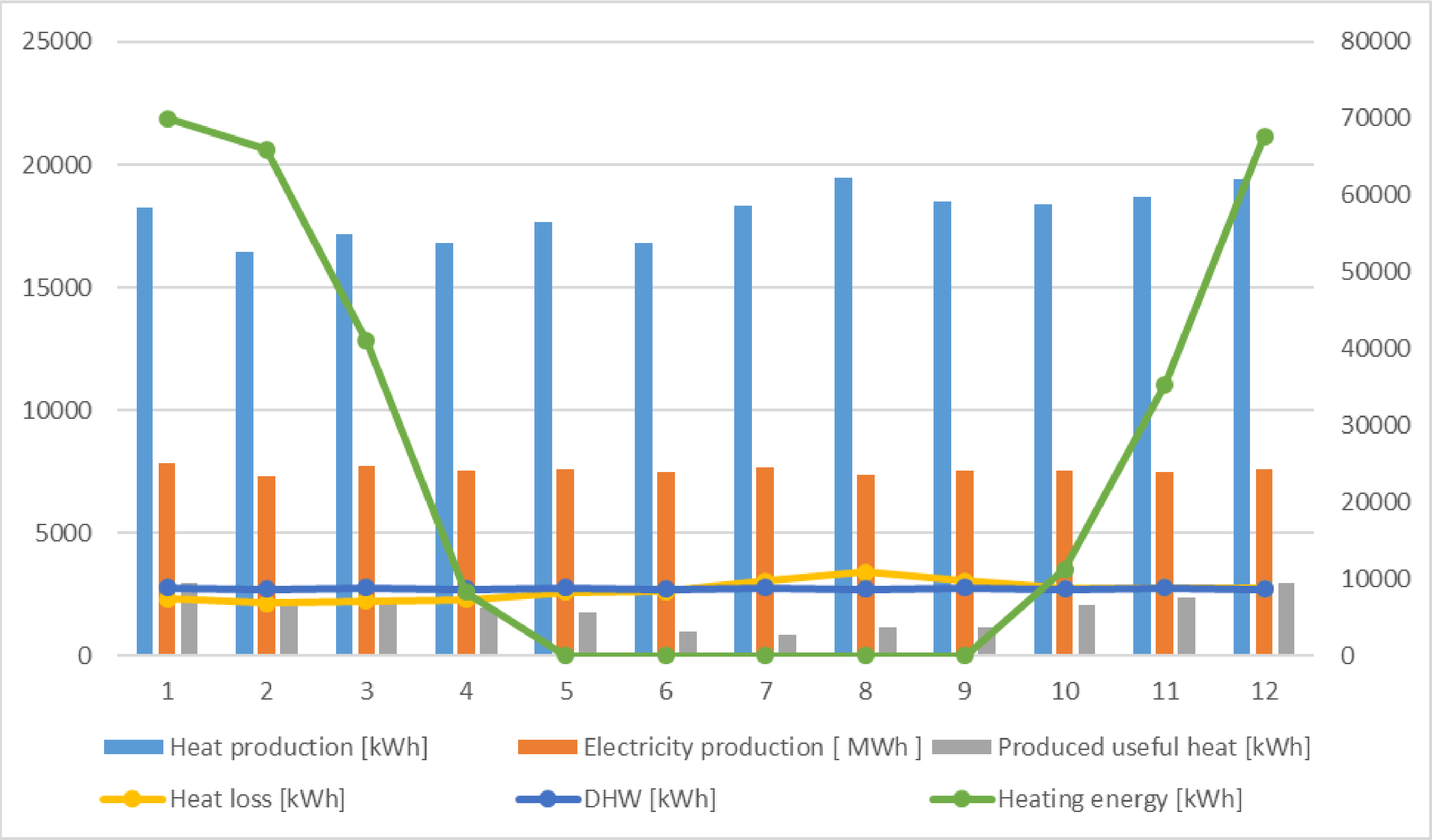
WASTE HEAT UTILIZATION

Increase efficiency of the plant:

- Pre(heating) of fermenter
- Sterilization of equipment
- Greenhouse heating
- Dryers
- Pre(heating) of domestic hot water...



BIOGAS PLANT



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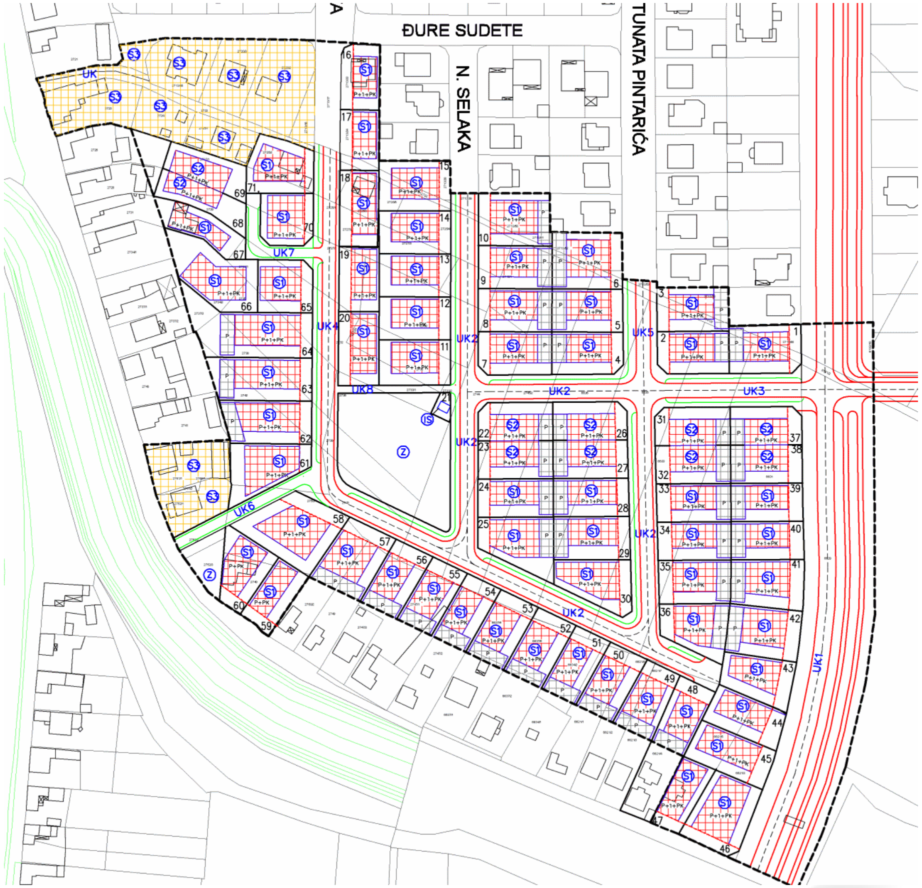
European Union European Regional Development Fund

12th sdewes Conference Dubrovnik 2017

Incorporate development of energy facilities with physical planning.



CONCLUSION

Steps for moving forward in waste heat utilization:

Identification of the waste heat
Feasibility study
Legal and financing issues

Development and promotion of waste heat utilization handbook
Promotion of sustainable physical planning
Technology transfer

Ilja Drmač
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12th SDEWES Conference
Dubrovnik, 05.10.2017

Utilization of Waste Heat in Thuringia - Current State and Outlook

Thüringer Energie- und GreenTech-Agentur GmbH - Anton Wetzel

AGENDA

Introduction

Potential &

Best Practice Examples

Waste heat cadaster & Pilot projectes

Funding

Opportunities

Conclusion

INTRODUCTION

Thuringian Energy and GreenTechAgency

Thüringer Energie- und GreenTech-Agentur

- Founded in 2010, currently 18 employees
- Mainly financed by the Free State of Thuringia
- Tasks:
  - neutral, independent, pre-competitive consulting
  - cross-linking of public authorities, companies, R&D and educational institutes as well as with local citizens
  - Initiating, moderating and coordinating of projects
- Project examples: wind energy service point, energy management for municipalities, e-mobility etc.

Opportunities for Waste Heat Utilization

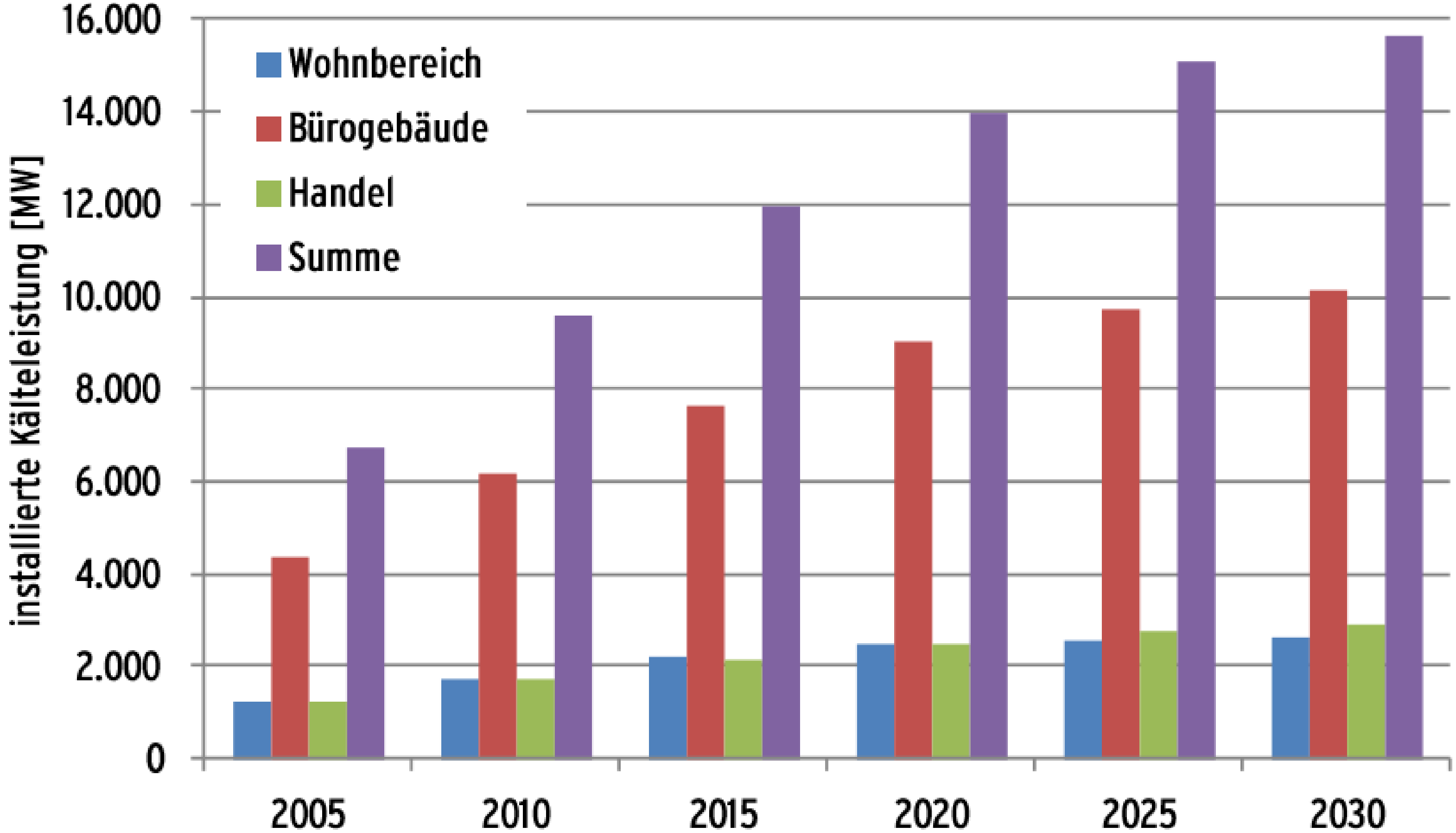
1. Internal Heat Utilization:
   - Decreasing the occurence of waste heat
   - Reintegration of waste heat into the production process or in the heat supply in buildings
   - Internal transformation for other useful energy forms (electric energy, air conditioning)

2. Heat that cannot be utilized internally can be used by third parties(i.e. neighboring establishments, for residential or commercial heating)

WASTE HEAT POTENTIAL IN THURINGIA

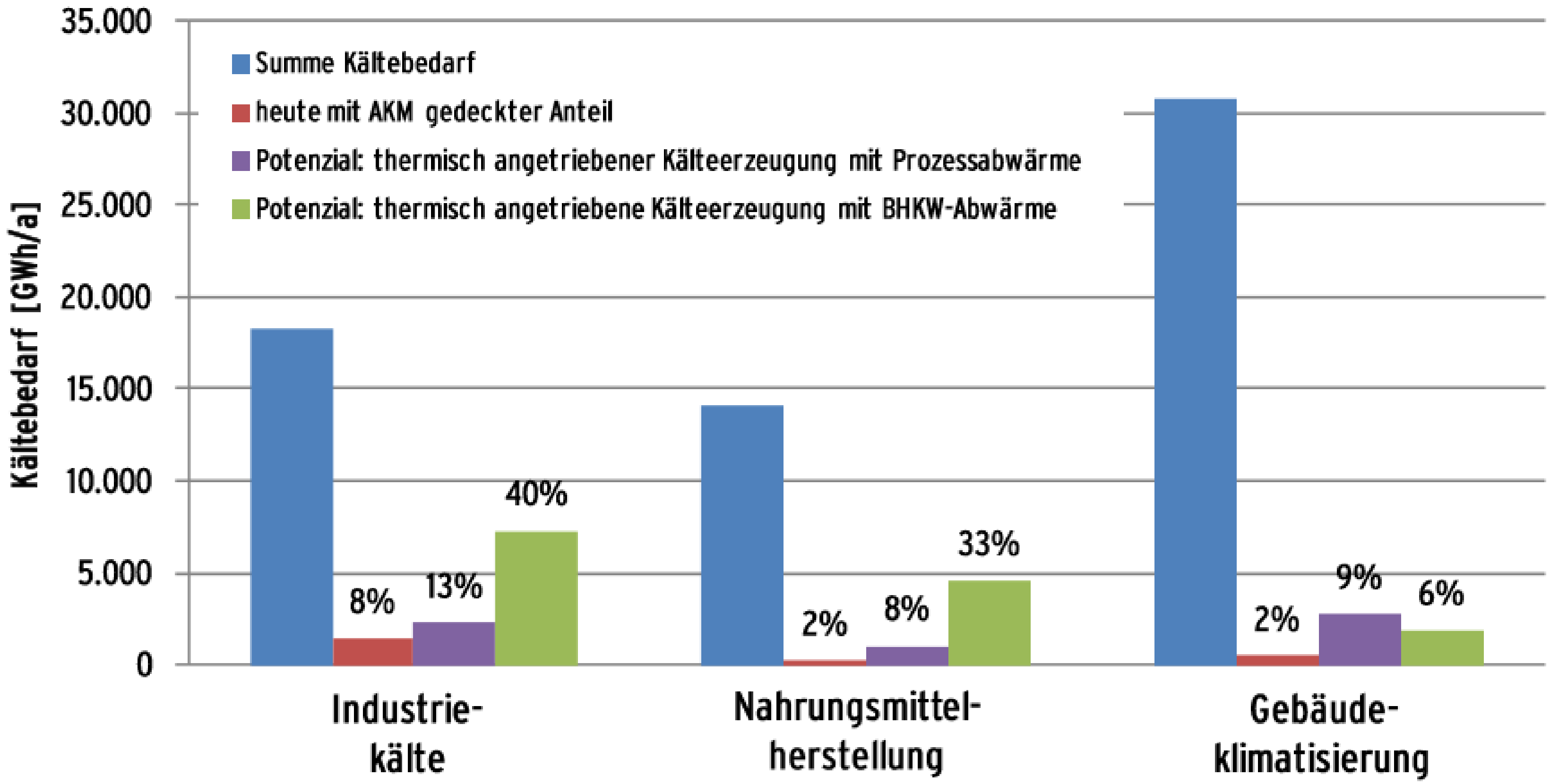
Branch of Industry	Energy consumption in TJ in 2014	WH-share % (60-140°C)	Source	WH potential 60-140°C in TJ	WH potential <60°C in TJ	Total WH potential in TJ
Mining and quarrying	154					
Manufacture of food products, bevarages, tobacco	3960	15% (total)	Hita et al., 2011			594,0
Manufacture of textiles, wearing apparel, leather ect.	444					
Manufacture of wood and of products of wood and cork	2563	3%	estimation ThEGA	76,9	38,4	115,3
Manufacture of paper and paper products	9726	20% (total)	Schnitzer, 2012			1945,2
Printing and reproduction of recorded media	530					
Manufacture of chemicals and chemical products	3781	8%	ifeu, 2010	302,5	151,2	453,7
Manufacture of basic pharmaceutical products	190					
Manufacture of rubber and plastic products	3739	3%	ifeu, 2010	112,2	56,1	168,3
Manufacture of other non-metallic mineral products	14434	40% (total)	estimation ThEGA			5773,6
Manufacture of basic metals	4904	30%	ifeu, 2010	1471,2	735,6	2206,8
Manufacture of fabricated metal products	3820	3%	ifeu, 2010	114,6	57,3	171,9
Manufacture of computer, electronic and optical products	1119					
Manufacture of electrical equipment	721					
Manufacture of machinery and equipment	1439	3%	ifeu, 2010	43,2	21,6	64,8
Manufacture of motor vehicles and transport equipment	3275	3%	ifeu, 2010	98,3	49,1	147,4
Manufacture of furniture	271					
Other manufacturing	294					
Repair and installation of machinery and equipment	237					
Biogas plants			TLL, ThEGA 2017			1501,20
Server			estimation ThEGA			1323,56
Total	55601					14465,70

Progression of installed cooling



Source: Umweltbundesamt 2014

Waste heat potential to meet demand for cooling in Germanys operations



Source: Umweltbundesamt 2014

Schuler Pressen GmbH, Factory in Erfurt

- Heat recovery in a forge via heat exchange (700 kW)
- Utilization of exhaust gas temperature (up to 600° C)
- Yearly savings: ca. 1.000 MWh Heat
- Pay back period: 1,58 years

BEST PRACTICE

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12th sdewes Conference Dubrovnik 2017

Fraunhofer-Institute for Digital Media Technology in Ilmenau

- New building constructed utilizing waste heat from servers
- Server cooling through heat exchange and air recirculation cooling
  (14°C/18°C)
- Summer: Cooling (Building & Server) with further heat transfer and 36 bore hole heat exchangers; meeting the peak load through additional cooling units
- Winter: Temperatur increased from 18 to 28°C (concrete core activation) or 45°C (Heating) via heat pumps (peak heat load)

BEST PRACTICE

Interreg CENTRAL EUROPE CE-HEAT European Union European Regional Development Fund 12th sdewes Conference Dubrovnik 2017

Venner Energie eG (citicen energy cooperative)

- Waste heat from a wafer manufacturer: ca. 8 GWh
- Installation of finned tube heat exchangers (50 to 200 kW) on 15 baking lines
- 154 connected housing units
- 6,5 Mio. kWh/ year heat demand
- ca. 90 % met through waste heat
- 10 km of pipeline
- 1.000m³-heat storage + gas boiler for peak load
- 4 Mio. € Investition
- 1.100 t CO_2-Savings

Bildnachweis:
Waffelfabrik Meyer zu Venne GmbH und Co. KG

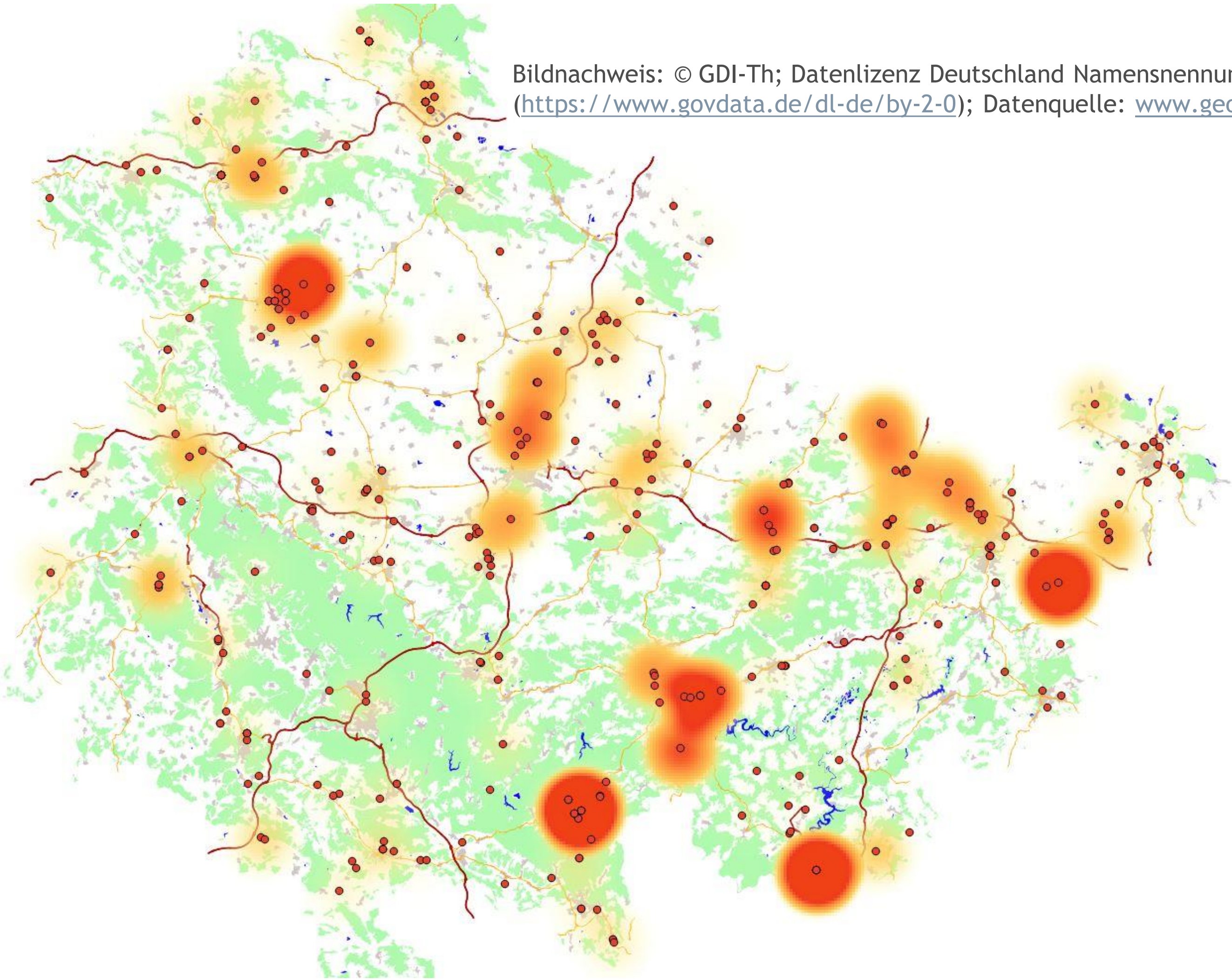
Goals

- Create awareness for „Waste Heat Resources "
- Depict industrial and agricultural waste heat potential
- Increase the transparency for producers and consumers of waste heat
- Gain input for heat concepts from communities and energy providers
- Initiate capital investment

Waste heat sources in Thuringia from BImSchV

- 366 Data records for 2012
- In total 753 GWh waste heat
- 77 Biogas plants
- 134 Data records > 1 GWh
- TOP 5
    - Zellstoff- und Papierfabrik Rosenthal GmbH: 62 GWh
    - Glaswerk Ernstthal GmbH: 59 GWh
    - Erdgasverdichterstation Rückersdorf: 57 GWh
    - Stahlwerk Thüringen GmbH: 32 GWh
    - ulopor Thüringer Schiefer GmbH: 23 GWh

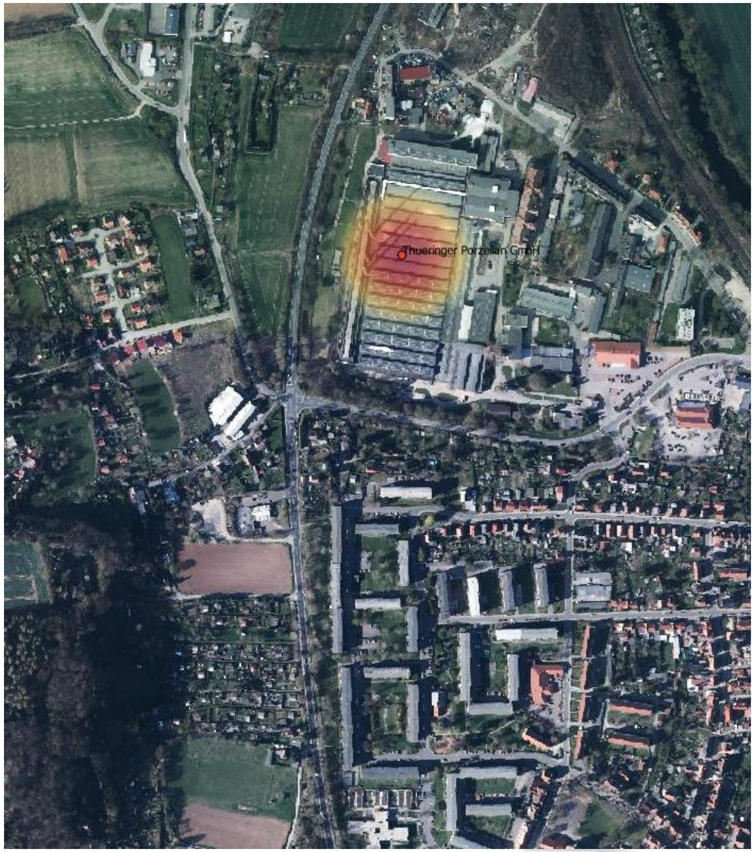
WASTE HEAT CADASTER



Bildnachweis: © GDI-Th; Datenlizenz Deutschland Namensnennung2.0 (https://www.govdata.de/dl-de/by-2-0); Datenquelle: www.geoportal-th.de; ThEGA GmbH

WASTE HEAT CADASTER

Examples of proposed projects:



Bildnachweis: Google Maps; ThEGA GmbH

HFP Bandstahl GmbH & Co. KG

Thüringer Porzellan GmbH

Call for Project Idea Submissions

- Financing of at least two feasibility studies a 15.000 €
- Requirement: Registration of waste heat source in Cadaster
- Selection criteria: CO_2-savings and reproducibility, but flexibilty with respect to the object of investigation
- Submission deadline: 31.10.2017
- Expert support from ThEGA

- Current status: 5 interested companies

FUNDING OPPORTUNITIES

- GREEN invest (maximum amount up to 80%)
    - Energy Efficiency (consultation & Investment)
    - Demonstration projects (Studies & Investment)
- KfW-Energy Efficiency Program – Waste Heat (loans + repayment subsidies or subsidies: 30-40%; 10 % Bonus for KMU)
- BAfA Support program for main technologies (subsidies: 20-30%)
- NKI - Support program for cooling and air condition systems (subsidies for thermal cooling plants, heat storage, heat pumps for waste heat utilization)
- MAP Premium (60 €/m + 1.800 € per building connection) + KWKG (district heating + heat storage)
- In preparation: Support program for rural heating networks

CONCLUSION

- A diverse potential for waste heat in Thuringia exists
- Identification of sources of waste heat in the cadaster:

  www.thega.de/abwaerme

- continuously enhancement and update of the cadastre
- Identification of 5 promising waste heat sources for pilot projects
- Waste heat utlization can be very economically (support programs in Germany)
- External use of waste heat: new business models for energy supply companies, ESCOs and citicen energy cooperatives

THANK YOU FOR YOUR ATTENTION

Anton Wetzel
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(ThEGA) anton.wetzel@thega.de

CE-HEAT
www.interreg-central.eu/ce-heat

www.thega.de/abwaerme