Public Energy Alternatives

Bioenergy Promotion

Baltic Sea Region Programme 2007-2013

Part-financed by the European Union (European Regional Development Fund and European Neighbourhood and Partnership Instrument)

Distributed CHP systems for autonomous energy regions

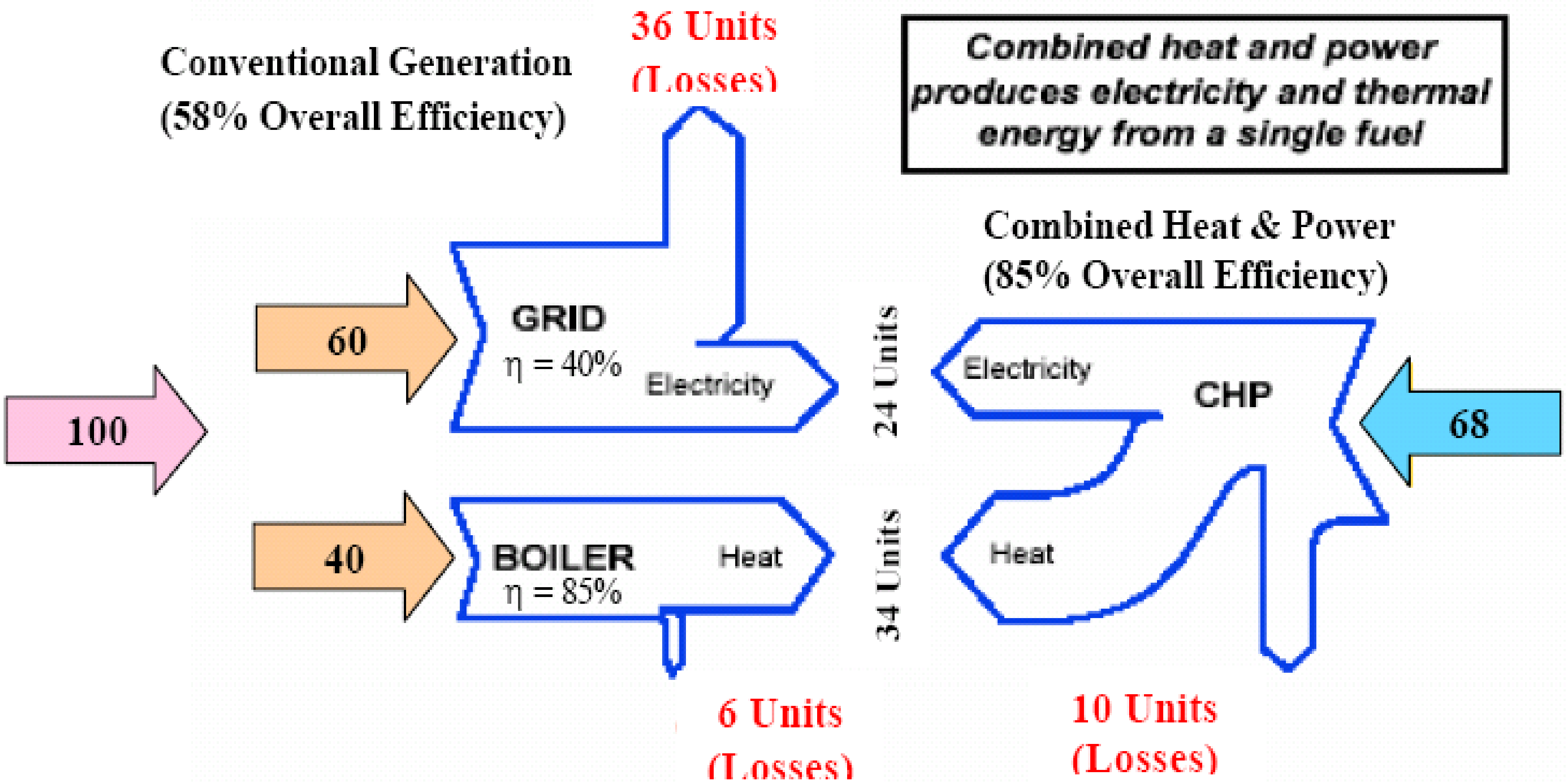
The Szewalski Institute of Fluid-Flow Machinery
Polish Academy of Sciences, Gdańsk
Baltic EcoEnergy Cluster

Adam CENIAN, Jan KICIŃSKI

Baltic Biogas Forum
Gdańsk, 17 September 2012

Bałtycki Klaster Ekoenergetyczny

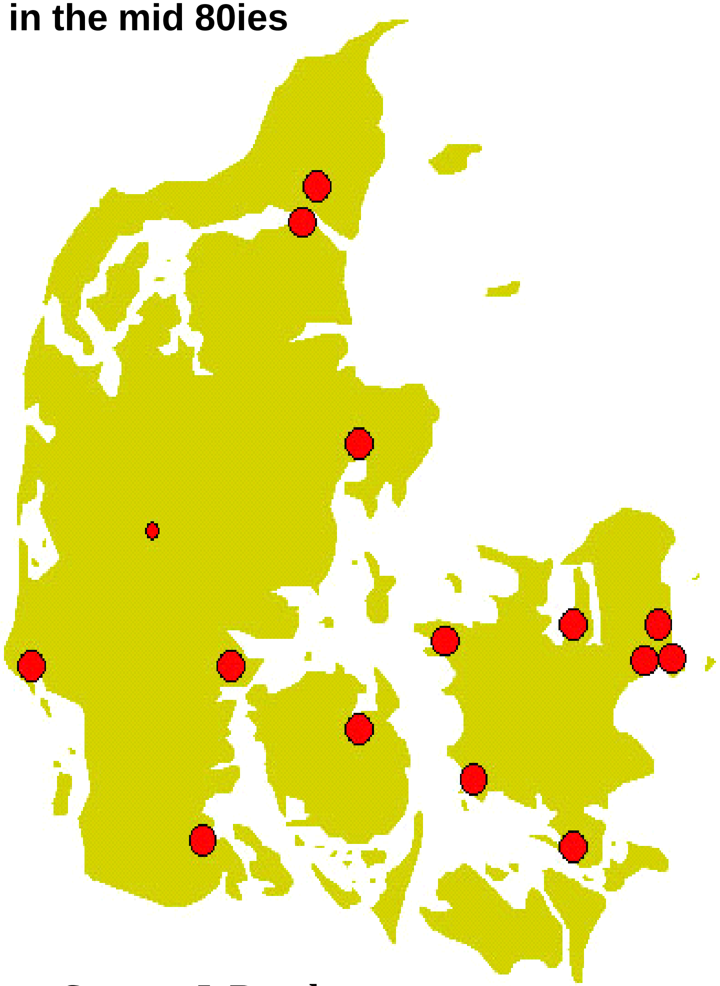
Cogeneration



Energy efficiency advantage of a cogeneration system (UNESCAP, 2000)

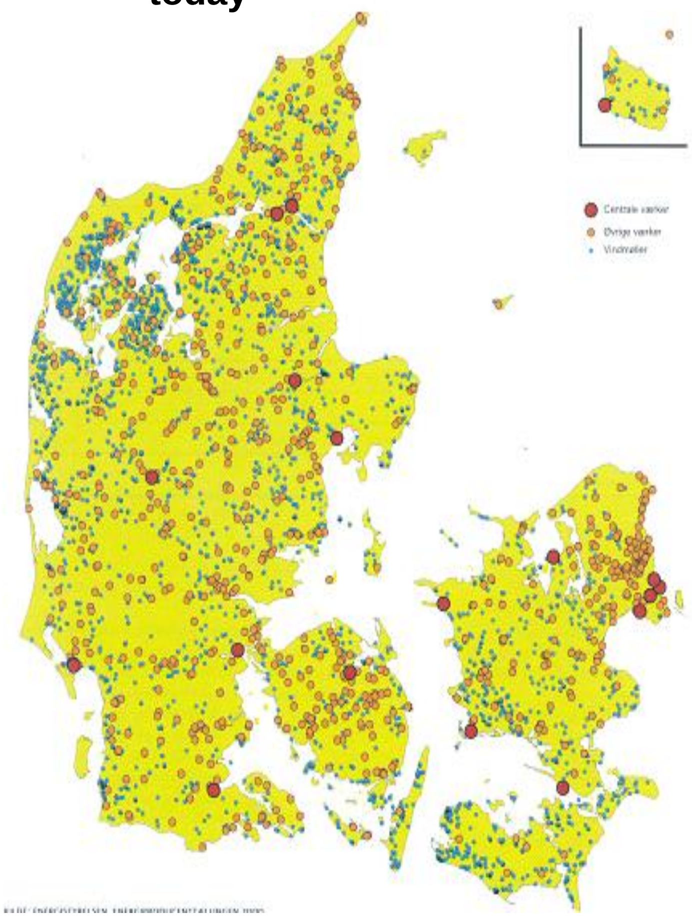
Cogeneration

centralized electricity production in the mid 80ies



Danmark revolution

decentralized (distributed) energetics today



Source: J. Buzek

PEA Public Energy Alternatives

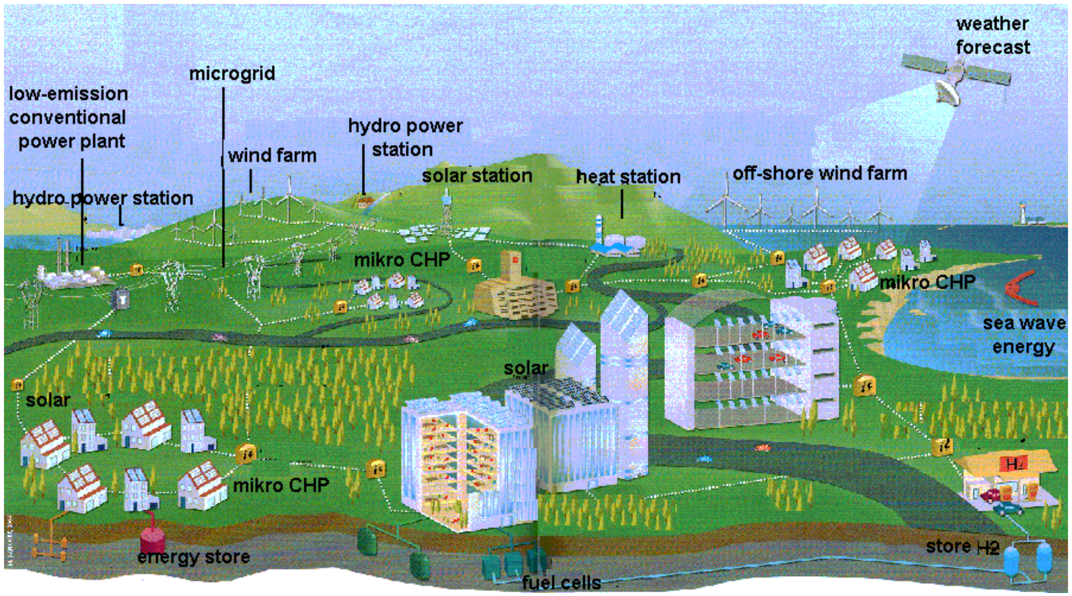
Bioenergy Promotion

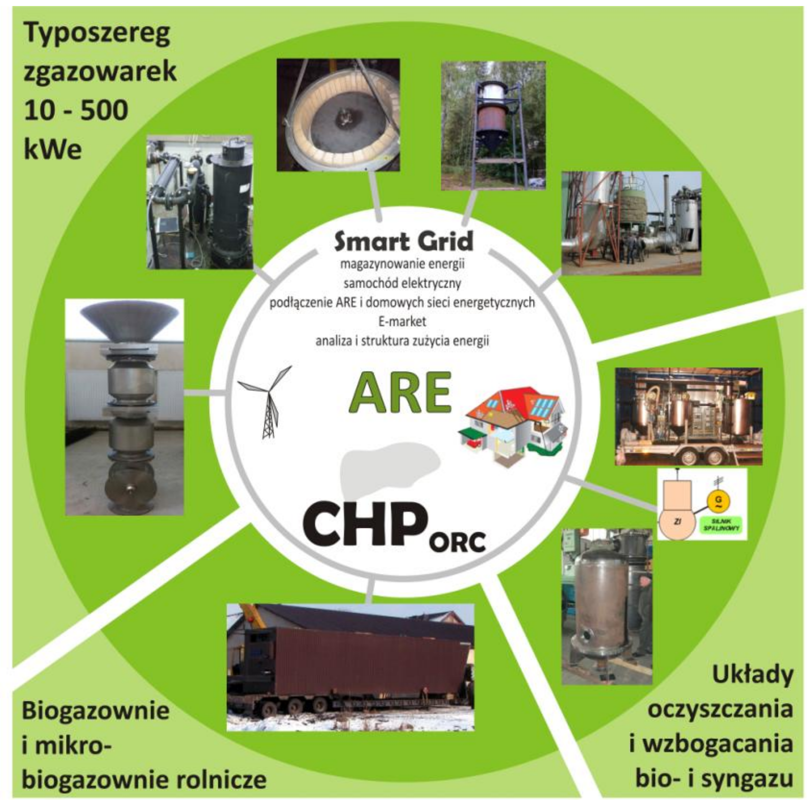
Baltic Sea Region Programme 2007–2013

ARE

Autonomic Energy Regions

Autonomiczne Regiony Energetyczne





ARE plan and develope local energy market
+ energy mix (biomass, wind, solar, water,…
+ smart grid
+ technologies developed in strategic project National Center R&D

Narodowe Centrum Badań i Rozwoju

PEA Public Energy Alternatives

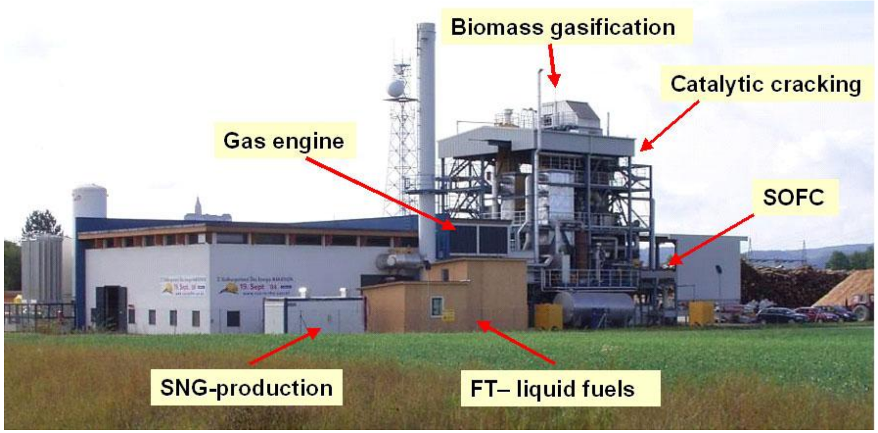
Bioenergy Promotion

Baltic Sea Region Programme 2007–2013

ARE Autonomic Energy Regions

Autonomiczne Regiony Energetyczne

Guessing gasification plant



ARE local energy centers known in world:
- Güssing in Austria
- Stockholm and Malmoe in Sweden
- Feldheim i Freiberg in Germany
- Toronto in Canada
- Tangshan w Chinach.

Main goal is to keep profits from energy production in the region;
to increase local energy and agro- market (diversify, activate,)

ARE – few counties or powiat, mainly of agricultural character;
+ responsible for local waste utilization and environment protection
+ local smart grid

Narodowe Centrum Badań i Rozwoju

PEA Public Energy Alternatives

Bioenergy Promotion

Baltic Sea Region Programme 2007–2013

ARE

Autonomic Energy Regions

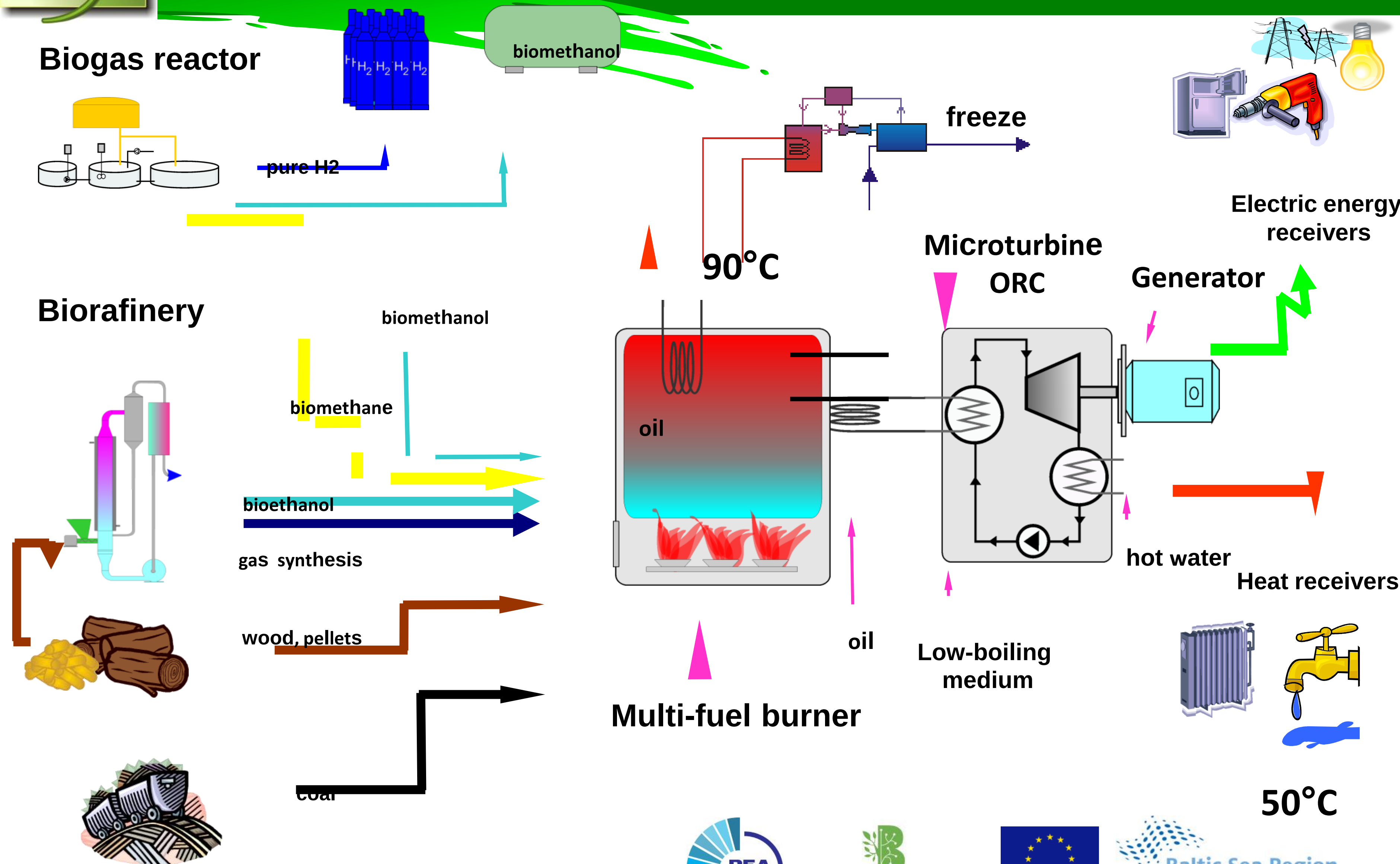
Autonomiczne Regiony Energetyczne

ARE
Role of public – private partnership;
Consumer – prosumer evolution (energy consumer and producer);

New technologies, Smart grid, new professions (energy audit, waste utilization technology, installation RES, …)

ARE as knowledge centers:
+ advisory services, brocarage for other gminas
+ seminars provider on RES for counties, regions, …
+ energy audits, strategies
+ business consultation,
+ technology propagator: smart housing, energy farms, smart grid, CHP systems

ORC POLIGENERATION SYSTEMS



PEA Public Energy Alternatives
Bioenergy Promotion
Baltic Sea Region Programme 2007–2013

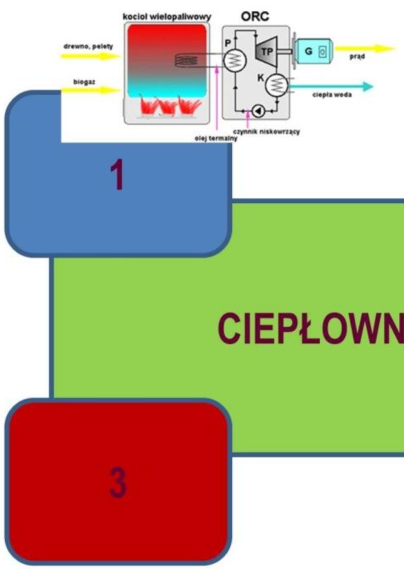
„ŻYCHLIN" ORC installation

Koncepcja modernizacji lokalnych ciepłowni małych mocy (do 50 MWt mocy zainstalowanej) do układów CHP - skojarzonego wytwarzania ciepła i energii elektrycznej

PROPONOWANE ROZWIĄZANIA TECHNICZNE

Blok ORC
0,14 MWe
0,83 MWt

Blok parowy
2,70 MWe
5,20 MWt



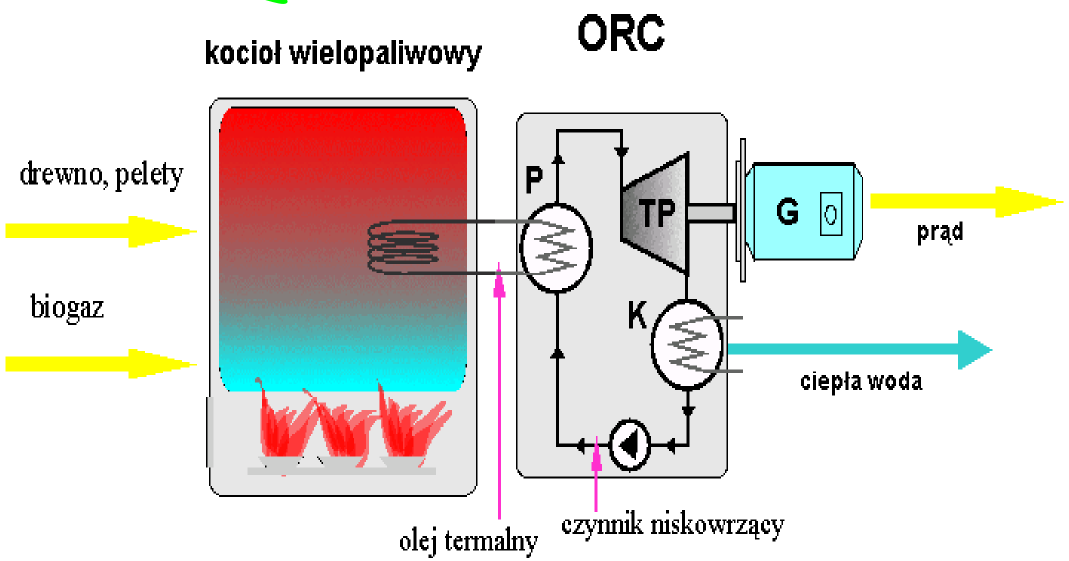
Kotły węglowe
0,00 MWe
17,00 MWt

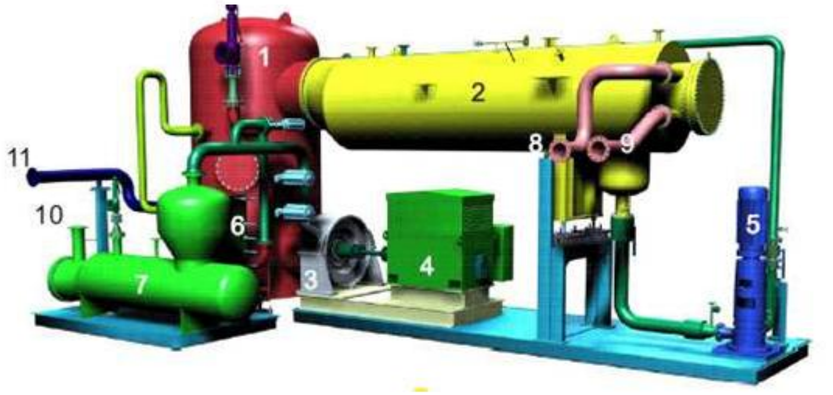
Silniki gazowe
3,10 MWe
3,40 MWt

Public Energy Alternatives
Bioenergy Promotion
Baltic Sea Region
Programme 2007-2013

„ŻYCHLIN" ORC installation

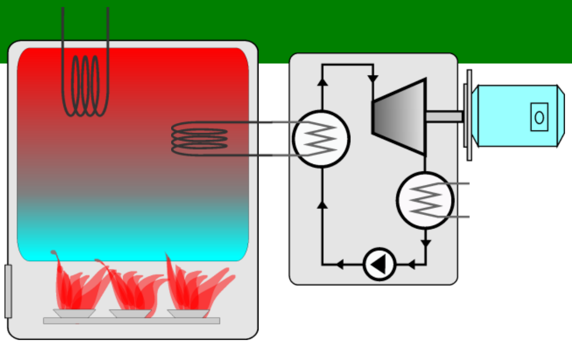
Pilotażowy układ kogeneracyjny w Żychlinie (kocioł wielopaliwowy, układ ORC) powiązany funkcjonalnie z koncepcją modernizacji lokalnych ciepłowni do układów skojarzonego wytwarzania ciepła i energii elektrycznej.





Public Energy Alternatives
Bioenergy Promotion
Baltic Sea Region
Programme 2007-2013

Why ORC (Organic Rankine Cycle) ?



- ⇨ Possibility to use low-temperature heat sources,
- ⇨ Possibility to use biogas and biomass,
- ⇨ Possibility to utilise recovery heat,
- ⇨ Modular construction,
- ⇨ Possibility of trigeneration, operation with diesel engine, gas turbine, fuel cells

Innovation of ORC – scientific input

- ⇨ Vapour Rankine cycle with a turbine working on low-boiling fluid in a specific power range,
- ⇨ Innovative design of multi-fuel burner operating with ORC,
- ⇨ Innovative design of high-rotating turbogenerator, technology of high-rotating bearings,
- ⇨ Innovative design of micro heat exchangers,

Efekty ARE

Efekty ekologiczne
- redukcja emisji pyłów o 15 Mg rocznie,
- redukcja SO_2 aż o ponad 100 Mg,
- redukcja 11 000 Mg CO2 rocznie
- zmniejszenie opłaty środowiskowej (w sumie o ok. 20 000 PLN rocznie).

Efekty ekonomiczne. Wstępne analizy
Układ kogeneracyjny (ORC).
- suma **nakładów inwestycyjnych** wynosi **7 mln PLN**.
- **zysk netto NPVFCFF** w okresie 15 lat, tj. do końca 2026 r - ok. **1.7 mln PLN**.
- **współczynnik IRR** wynosi 11.2%
- **okres spłaty** inwestycji to ok. 13 lat.
- **zysk netto** dla właściciela z uwzględnieniem wartości rezydualnej (zysków osiąganych po okresie 15 lat funkcjonowania instalacji)

NPVFCFE > 15 mln PLN.

Efekty ARE

Efekty ekonomiczne. Wstępne analizy
ARE w Żychlinie
- zysk netto całej instalacji *(uwzględniając całk. eksploatację)* ponad **145 mln PLN.**

Po uwzględnieniu rynku podobnych siłowni w Polsce (ok. 300) zyski ARE, wynikające jedynie z modernizacji i rozbudowy instalacji, można szacować na sumę ok. 45 mld PLN.

Dodatkowo, wdrożenie tej technologii pobudziłoby rynek produkcji instalacji kogeneracyjnych sumą ok. 15 mld PLN.

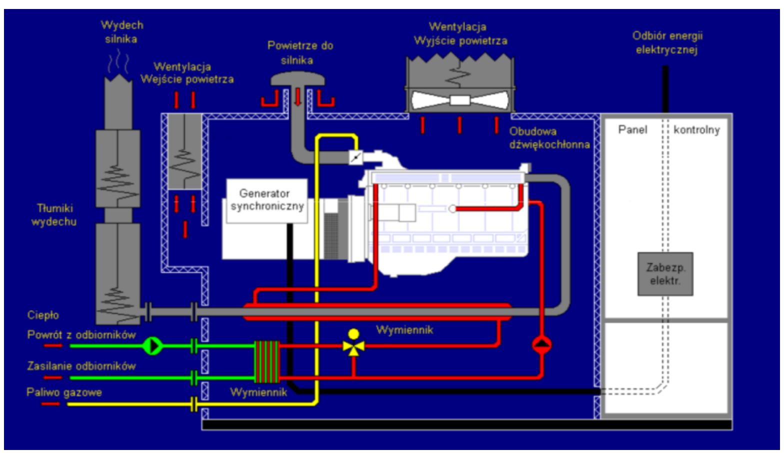
Dodatkowe pozytywne efekty o wymiarze społecznym m.in.:
- poprawa bezpieczeństwa energetycznego w gminie Żychlin,
- zwiększenie zatrudnienia w elektrociepłowni – 15 – 20 os. wysoko kwalifikowanych,
- powstanie nowych miejsc pracy w sektorze związanym z logistyką biomasy,
-aktywizację lokalnej społeczności wiejskiej wokół upraw roślin energetycznych; nawet kilka tys. ha gruntów rolnych

Biogas Microinstallations, PŚI, PG

+ 120 000 farms > 20 ha
+ CHP system: 7-10 kWe, 10 kWt

Narodowe Centrum Badań i Rozwoju
PEA Public Energy Alternatives
Bioenergy Promotion
Baltic Sea Region Programme 2007-2013

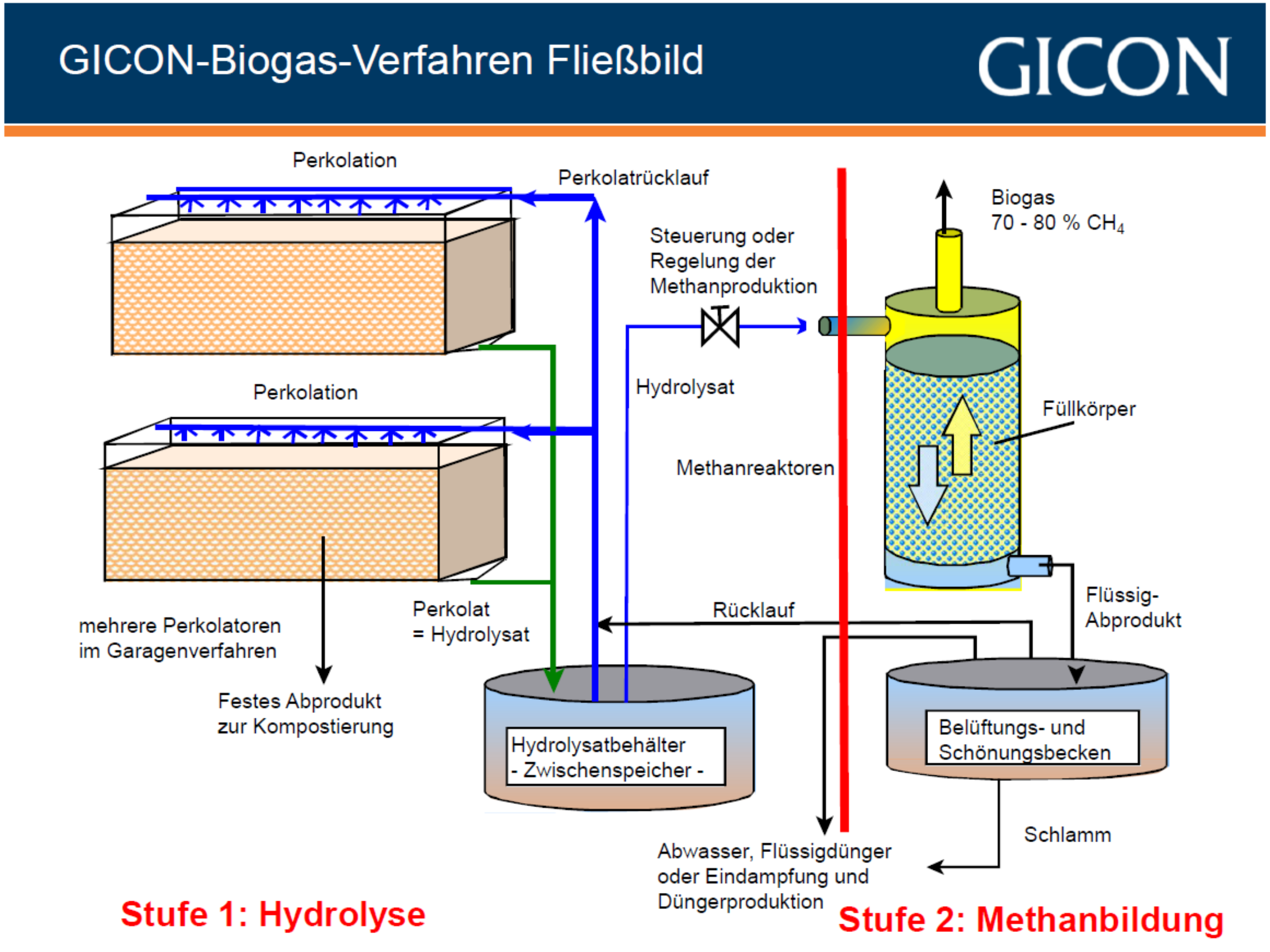
CHP system, UWM



CHP 10 kWe/11kWc biomethan (China, import IMPLaser Ltd),
+ biogas system development + transportation + certyfication

PEA Public Energy Alternatives · Bioenergy Promotion · Baltic Sea Region Programme 2007–2013

Two-stage **dry fermentation** of GICON - Cottbus



PEA Public Energy Alternatives | Bioenergy Promotion | Baltic Sea Region Programme 2007-2013

Gasification systems

Narodowe Centrum Badań i Rozwoju

CHP: 10 – 20 kWe

+ steam gasification
+ modular

100 kWc/ 40 kWe

+ oxygen gasification
+ hardly menaged wastes

180 kWc/ 75 kWe

+ sewage sludge
+ introductory biomass drying

Advantages of gasification: higher combustion temperatures, higher CHP efficiency (especially small scale), tolerates bad quality (non-uniform, wet, …) biomass, …

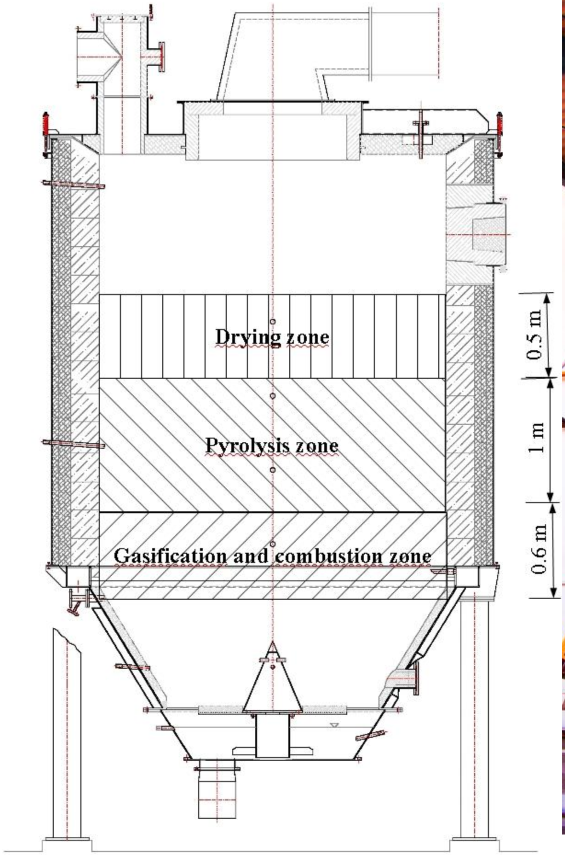
PEA Public Energy Alternatives
Bioenergy Promotion
Baltic Sea Region Programme 2007-2013

Gasification - fader utilization (MTF Warszawa, UW)

Narodowe Centrum Badań i Rozwoju

fader and turkey waste

fader and chicken waste



PEA Public Energy Alternatives

Bioenergy Promotion

Baltic Sea Region Programme 2007-2013

Thermal mikrogas installation 75 kWe, PCz

- e.g. for sewage sludge

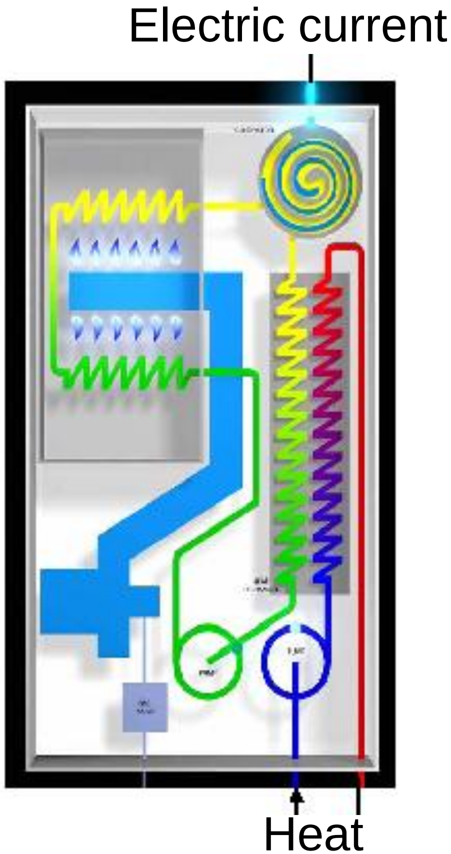
PEA Public Energy Alternatives
Bioenergy Promotion
Baltic Sea Region Programme 2007-2013
Narodowe Centrum Badań i Rozwoju

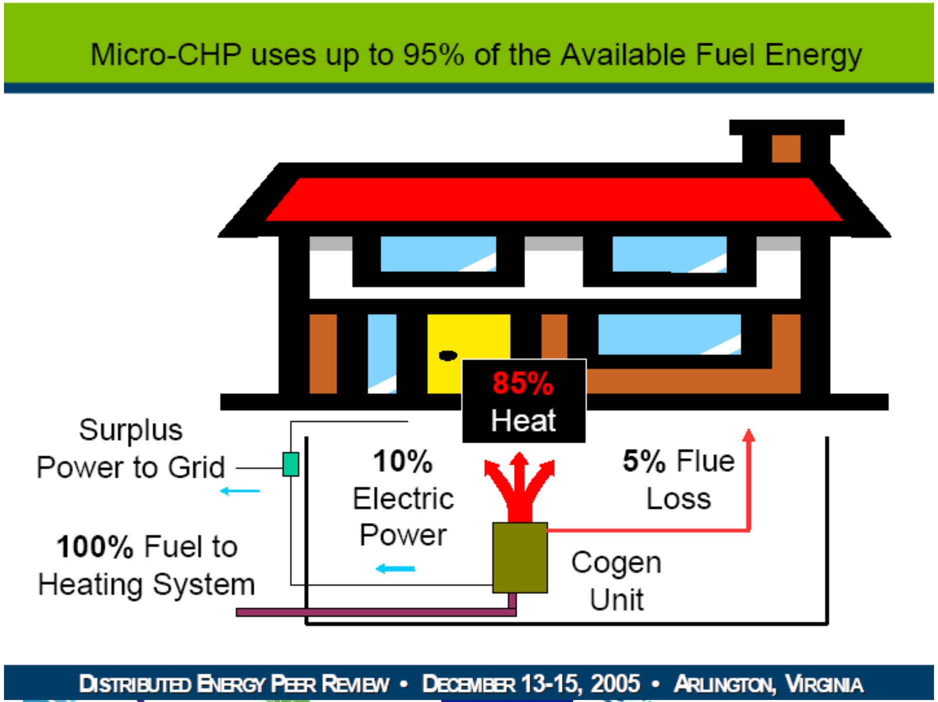
HOME MICRO POWER PLANTS

CHP – ORC systems [from a few to a few hundred KW]

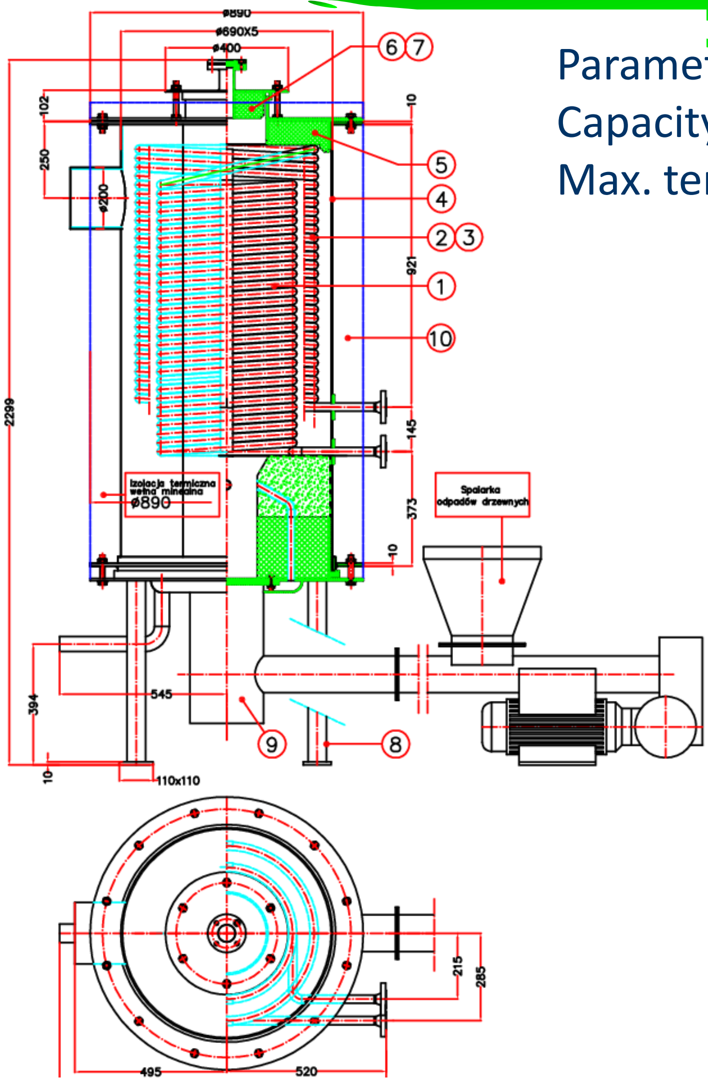
Cogeneration micro power plants in cooperation with ecological boilers.

Organic Rankine cycles - ORC. Feeding: biomass, biogas, biofuel





Oil boiler with a cooling loop

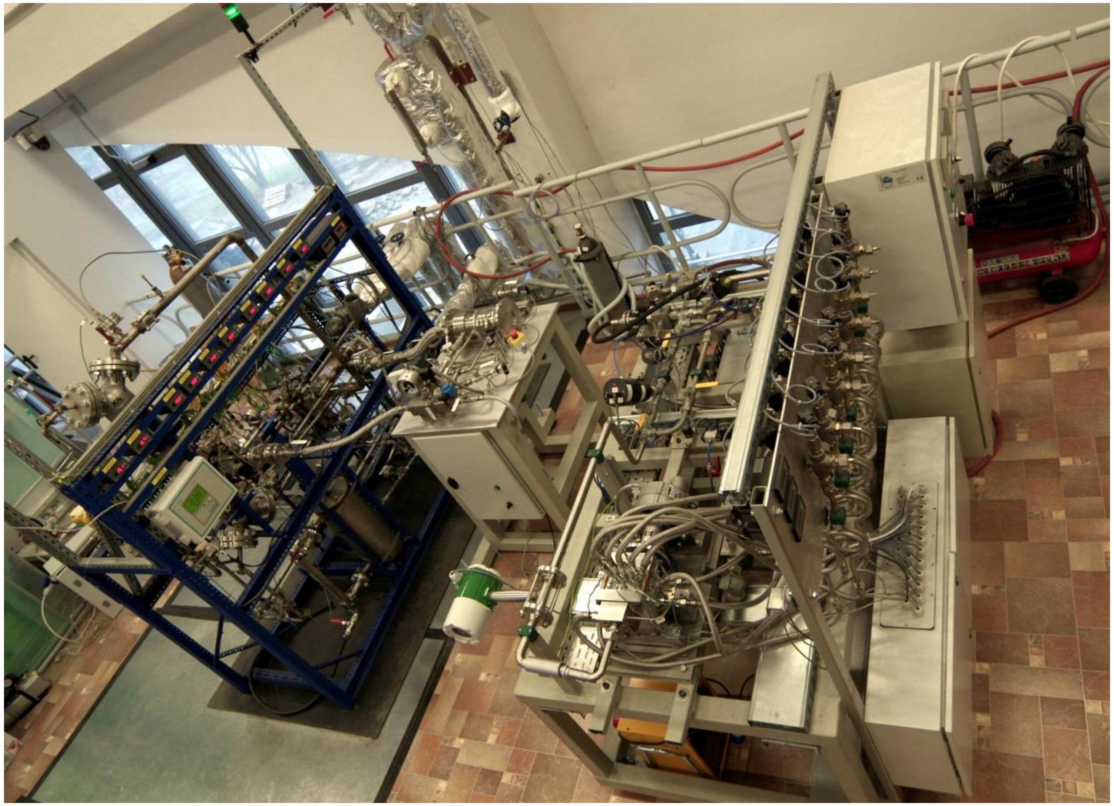


Parameters:
Capacity 30kW, Maximum pressure 16bar
Max. temperature 250 C, Coil volume 40l, Mass 500kg

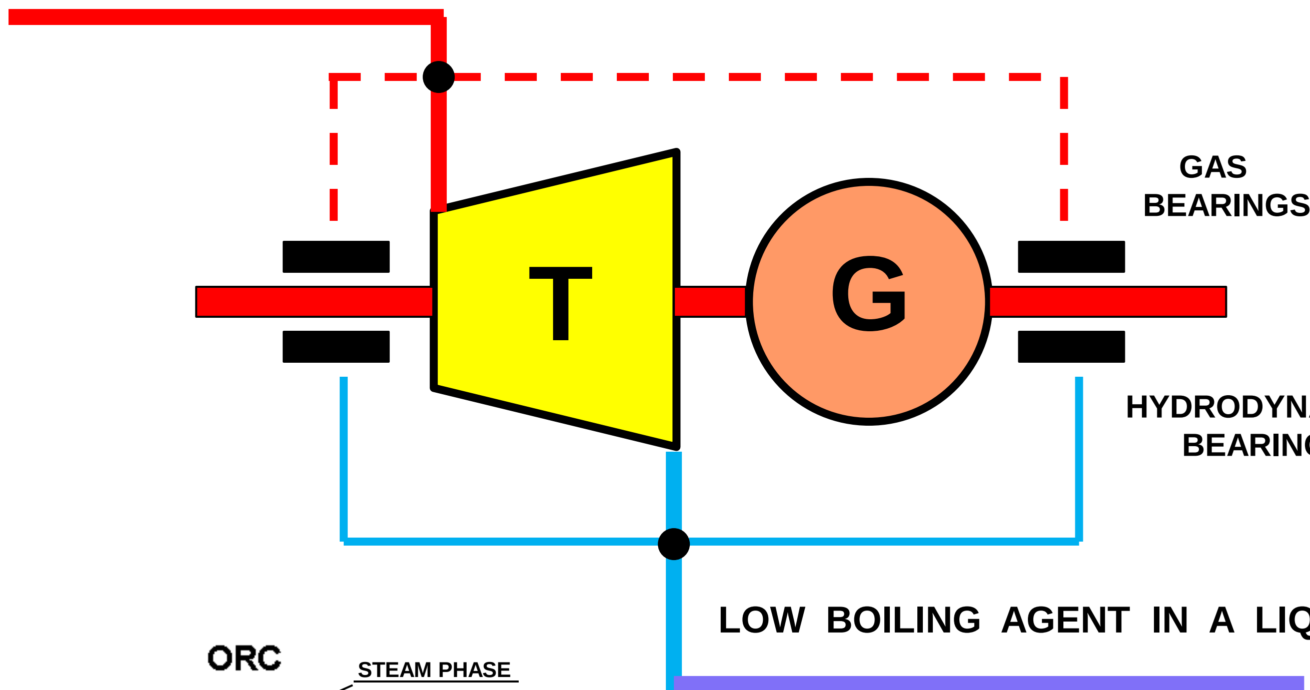
PEA Public Energy Alternatives
Bioenergy Promotion
Baltic Sea Region Programme 2007–2013

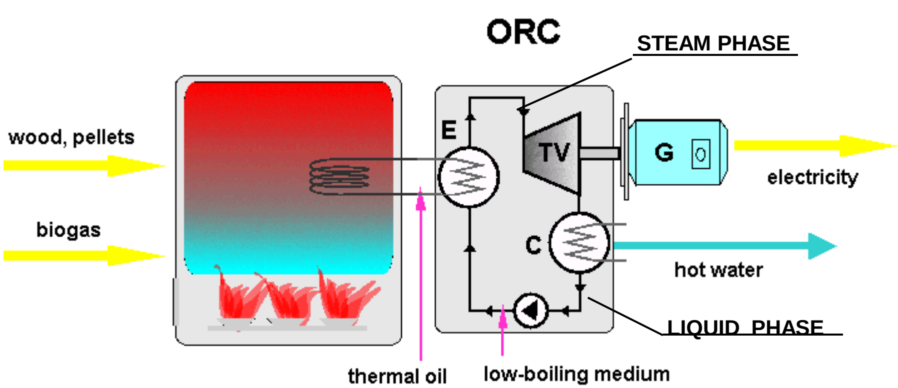
Domowa mikrosiłownia kogeneracyjna ORC

Laboratorium IMP PAN - Stan aktualny: Zbudowano nowe stanowiska do badania podzespołów mikrosiłowni



MAIN IDEA: APPLICATION OF LOW BOILING AGENT BOTH IN THE THERMODYNAMIC CYCLE OF MICROTURBINE AS WELL AS FOR LUBRICATIONS PURPOSES IN BEARINGS SYSTEM

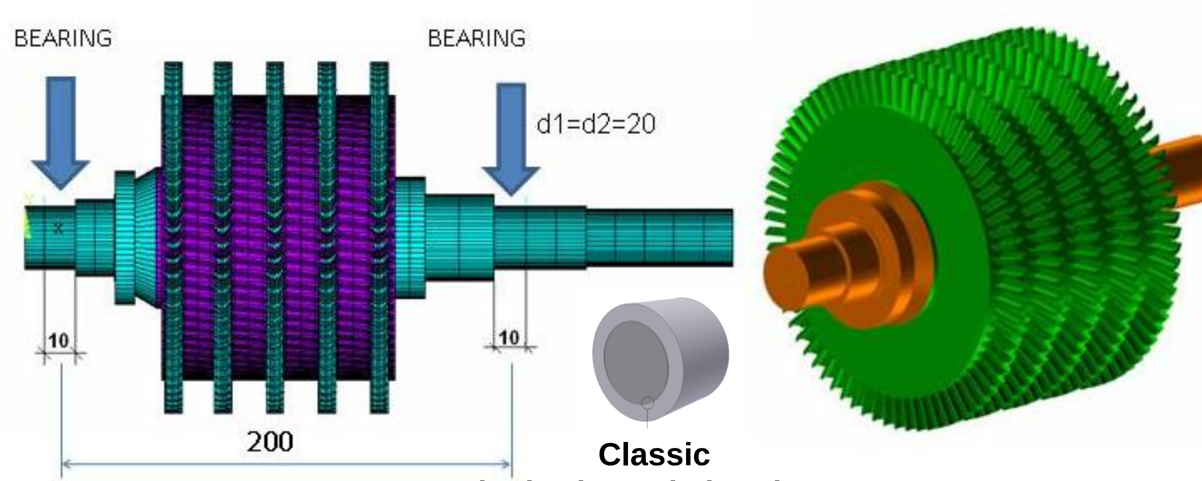




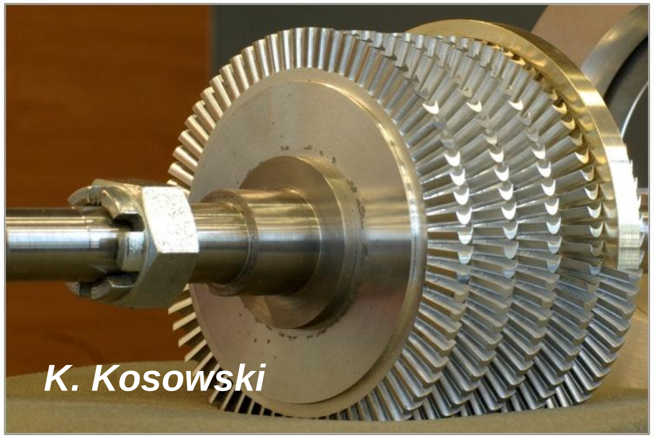
ADVANTAGES:

- ELIMINATION OF ISOLATION PROBLEMS IN BEARING INTERSPACES AND ELIMINATION AN ADDITIONAL SYSTEM FOR LUBRICATION IN BEARINGS
- SMALL VISCOSITY OF LOW BOILING MEDIUM

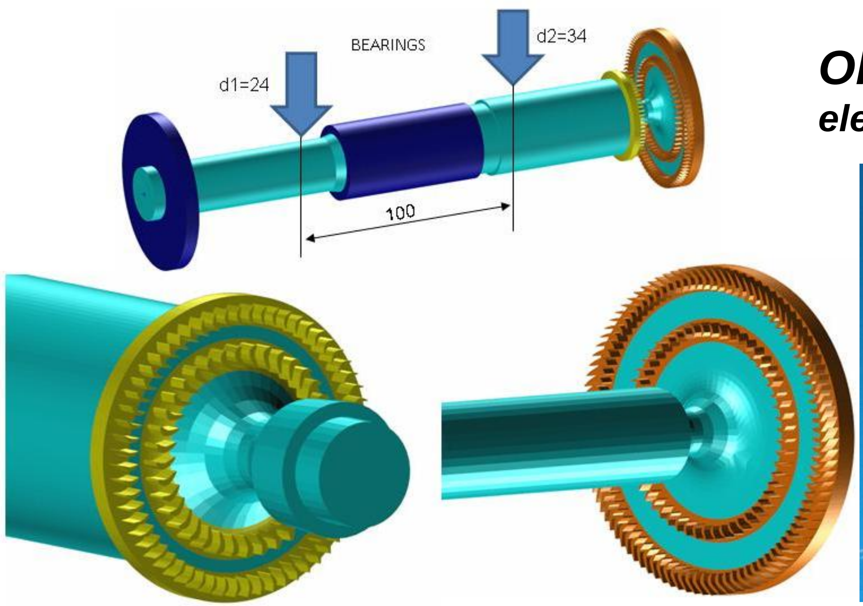
OBJECT OF INVESTIGATIONS



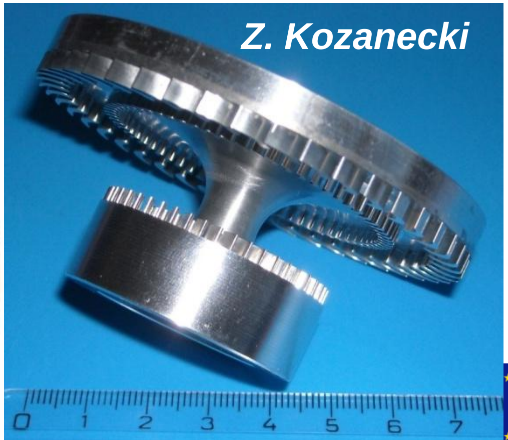
Classic hydrodynamic bearings



Object 1. ***Five - stage axial microturbine rotor of electric power of 3 KW and rotor speed 8 000 rpm (for low-boiling agents ORC). Bearing journal diameters: d1=d2=20 mm. Model MES: 380 000 DOF***



Object 2. ***Four - stage radial microturbine rotor of electric power of 3 KW and rotor speed 23 800 rpm (for low-boiling agents ORC).***



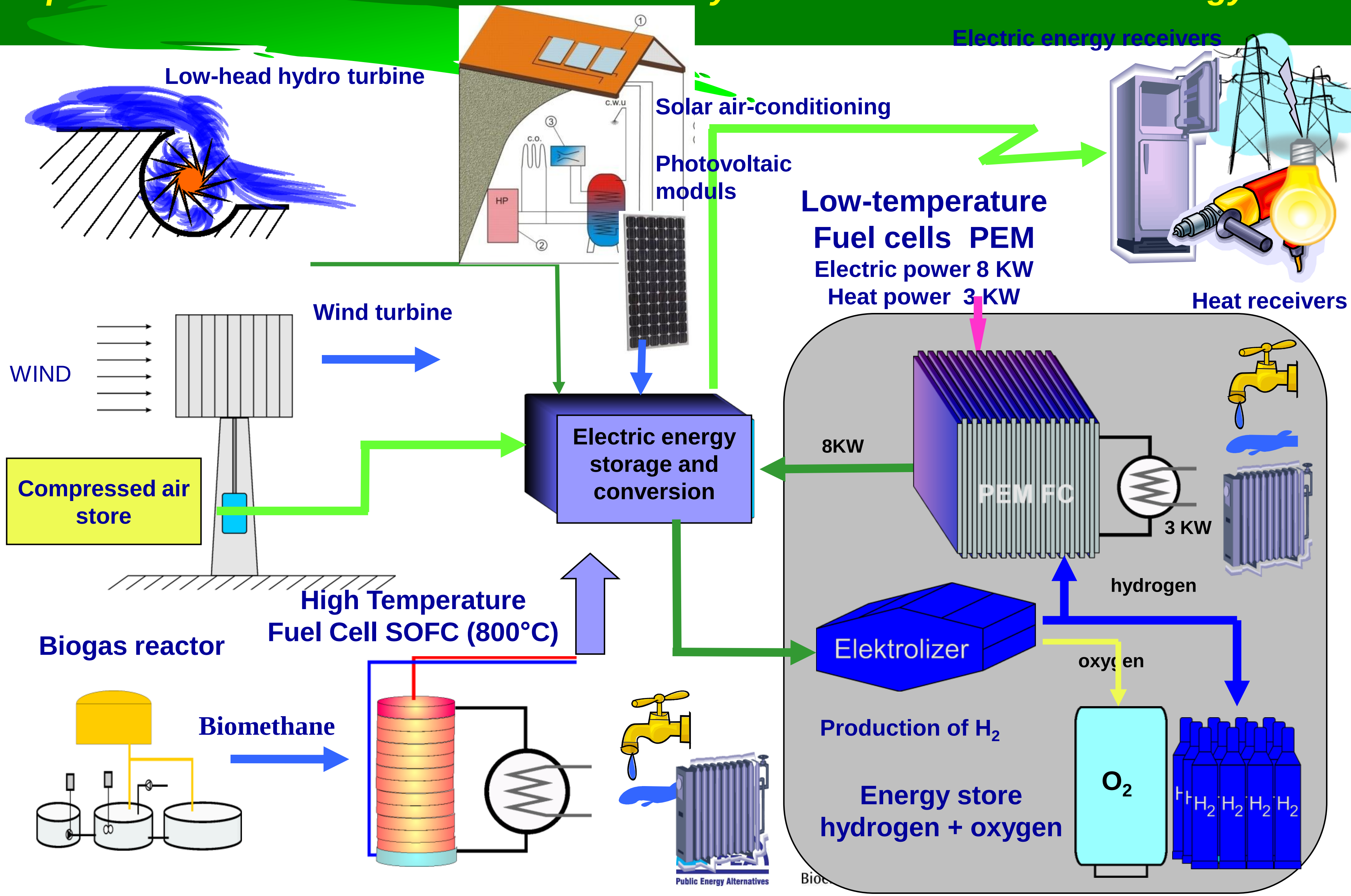
Bearing journal diameters:

d1=24 mm, d2=34 mm.

Model MES: 200 000 DOF

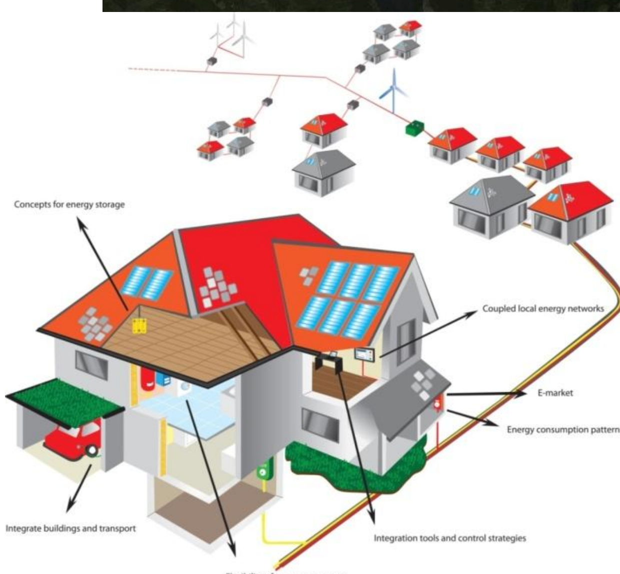
Hybrid systems:

photovoltaic + wind turbine + low-head hydro turbine + fuel cells + energy store



Opracowanie koncepcji oraz modelu technicznego i biznesowego sieci inteligentnej (Smart Grid) na poziomie średniego napięcia (SN) w kontekście współpracy lokalnych źródeł energii w sytuacjach normalnej pracy oraz awarii sieci (możliwość pracy wyspowej).

PILOTAŻ NA PÓŁWYSPIE HELSKIM



PEA Public Energy Alternatives
Bioenergy Promotion
Baltic Sea Region Programme 2007-2013

Sustainability principles

Are bioenergy always sustainable ?

- Biodiversity – keeping biodiversity and landscape value
- Resource efficiency – efficient use of natural resources, biowastes
- Energy efficiency – energy balance and avoiding of fossil fuels
- Climate mitigation efficiency - greenhouse gas emissions
- Social aspects – food production
- Economic issues – increase rural activity

Sustainability principles

Problems:
with **biodiversity principle**: biomass production and extraction shall not endanger biodiversity at the landscape level; special considerations to threatened species shall be taken at the local level.

Biogas sector in Germany
+ largest biogas production in EU (~7000 installations by the end 2011)
+ but 'great sin' concentration on agricultural (not utilization) installations, leading to maize monoculture (even above 50% of arable land in some regions)
+ negative effects for some species (e.g. bees pandemic) and landscape value

The Latest Research: Affects of Monoculture on Bees
results: less apples and honey on our table

Sustainability principles

Co-combustion (co-firing) - problems:
with **energy efficiency, climate mitigation and economy principle**

Caused by willingness to fulfil EU target of 20% of renewables in energy mix (at any cost)

Co-combustion in large, centralised installations leads to:
+ lower efficiency of combustion process
+ logistic problems (multi-mln tonnes business)
+ losses of emission savings by long transport of not very heavy materials
+ biomass market distortion and degeneration
+ losses of economy in rural area
+ unreasonable (unsustainable) transport of biomass from Africa and South America (rain forest decay, etc.)
+ biomass regional business !!!!

Bioenergy Promotion

<u>The sustainable business opportunities</u>

+ as the heat utilisation is often a problem;
wherever there is a heat demand the CHP system should be considered.

+ wherever there is a waste biomass available the biogas (fermentation) or syngas (**pyrolysis**) installation should be considered, e.g.
  - manure and
  - fader or bones utilisation,
  - potatoes chips waste,
  - waste products from ethanol production (distillers grains, swill),

+ local utilisation of municipal waste

Distributed waste-utilisation systems
- cascading biomass systems, system thinking and symbioses
- dry and wet fermentation systems

Bioenergy Promotion