

Integrated Bioenergy Hybrids Flexible Renewable Energy Solutions



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Content

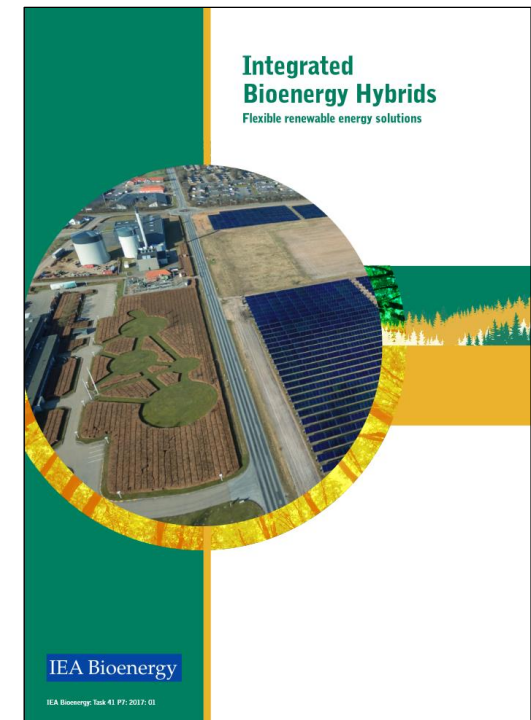
- IEA Bioenergy RES Hybrids project
- Background
- Why integrated bioenergy hybrids?
- Case examples of different hybrid applications
- Key actions in the next five years



Sources: Savosolar & Versowood

Bioenergy RES Hybrids project

- IEA Bioenergy Task 41 Special project (2016)
- The project surveyed the status of bioenergy utilisation as a flexible element in hybrid processes
 - Case study countries: Finland, Germany and Austria
 - Heating and cooling, power and transport sectors



<http://task41project7.ieabioenergy.com/>

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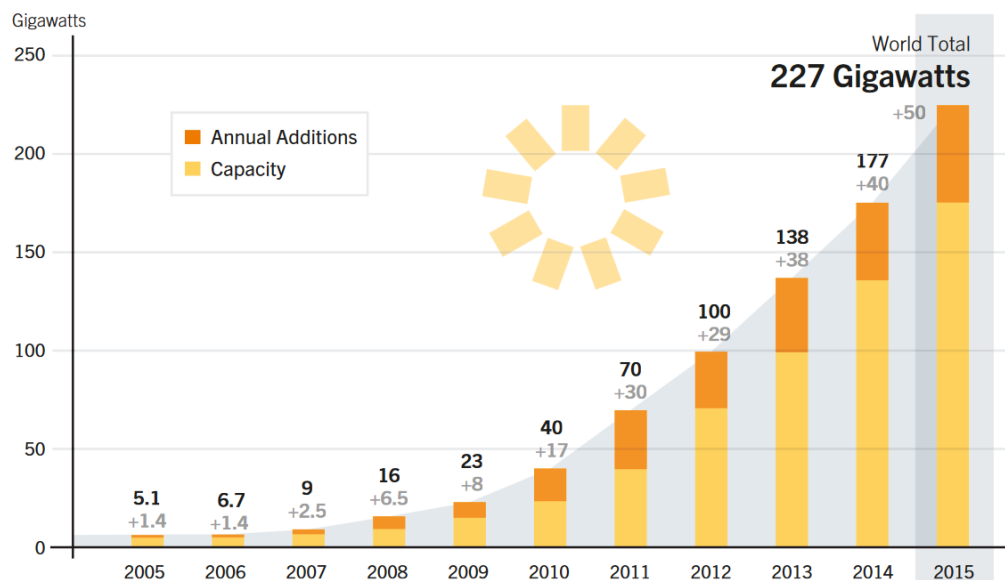
Variable renewable energy increases fast

- Solar and wind energy are increasingly cost competitive with fossil generation
- In OECD countries, electricity demand is stagnating
- Additional VRE puts pressure on existing base load capacity

Key question: How to maintain reliable energy supply while meeting our emission targets?

Significant growth for solar PV and wind

Solar PV Global Capacity and Annual Additions, 2005–2015



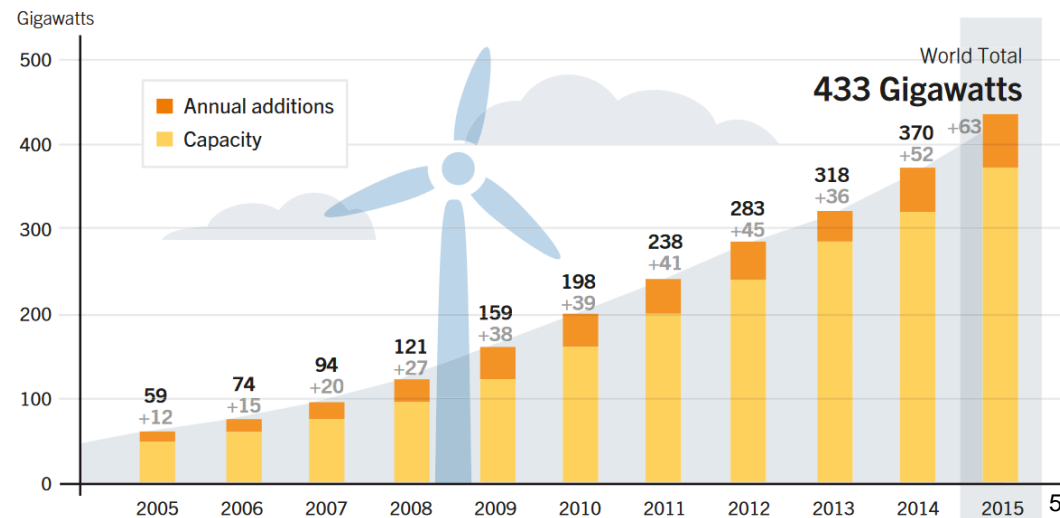
- Wind leading source of new power generation capacity in EU (44%)
- Leading countries in capacity/capita: Denmark, Sweden, Germany, Ireland and Spain

14/09/2017

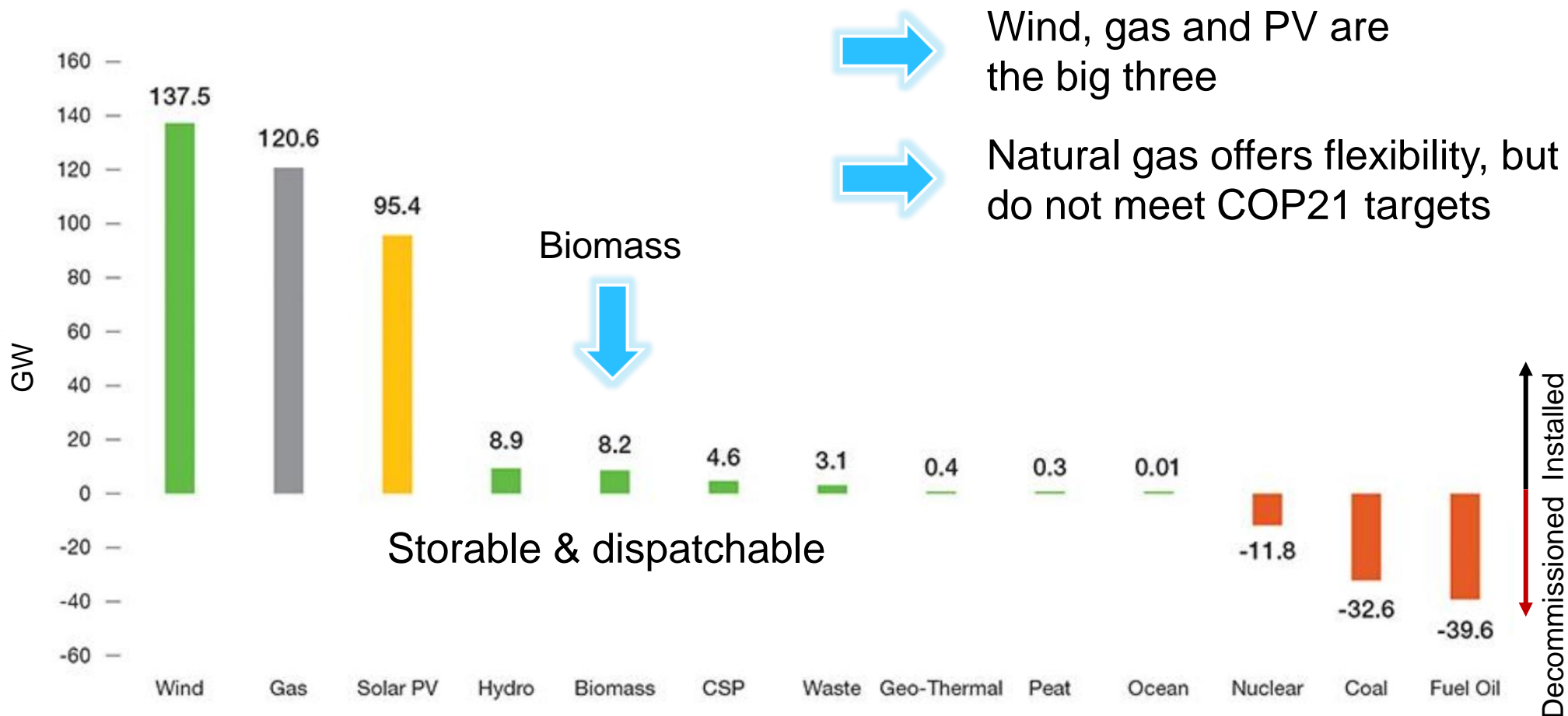
Source: REN21, 2016

- PV capacity addition in EU 7.5 GW in 2015
- Growth leaders in EU: UK, Germany and France
- Solar thermal: Market growth in Denmark +55% in 2015

Wind Power Global Capacity and Annual Additions, 2005–2015



Power plant investments in EU 2000–2015



An aerial photograph of a white wind turbine standing in a lush green field. The field is divided into several sections by dark, hedged boundaries. In the upper left, a green speech bubble contains text. The turbine's shadow is cast onto the field to its left.

\$7.8tn in
renewables
(€7.0tn)

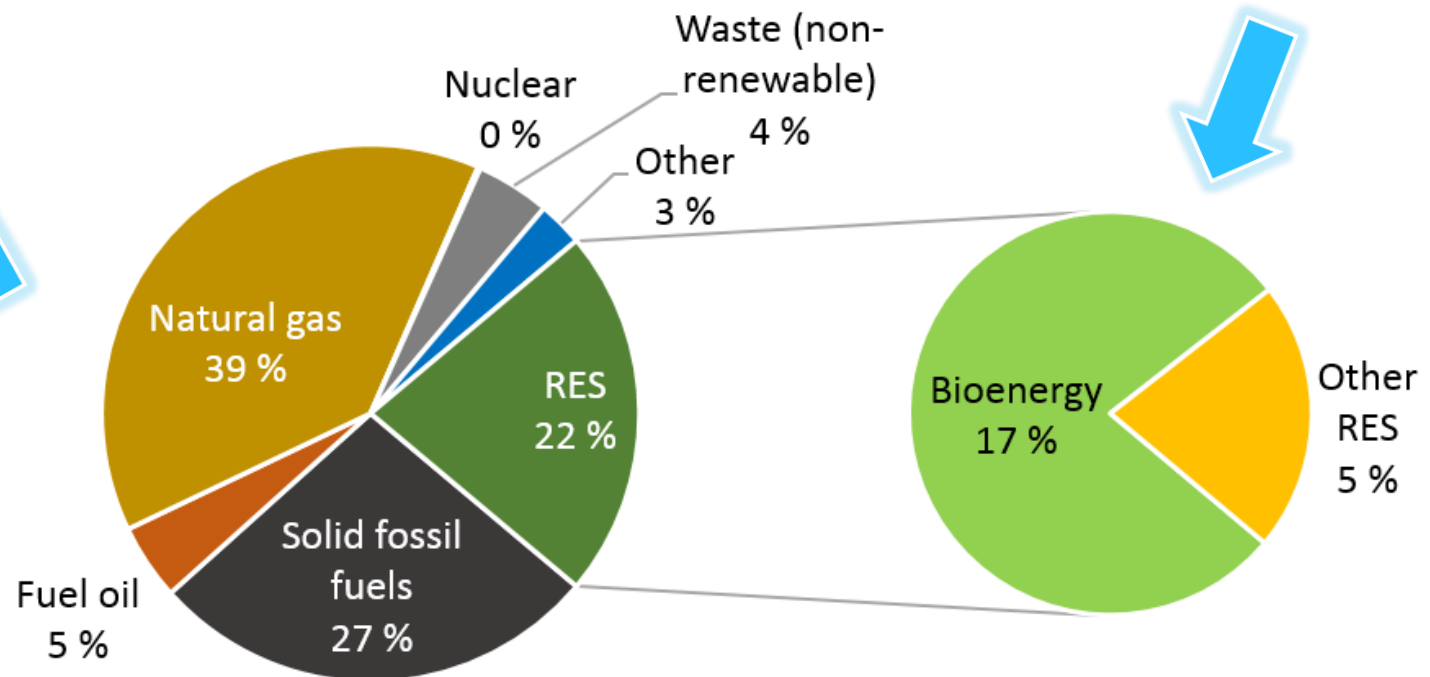
- Clear demand for low-carbon technologies that are able to balance temporal differences between energy supply and demand
- Over the next 25 years, \$11.4tn (€10.2tn) will be invested in power generation (Bloomberg, 2016)

Bioenergy already plays a key role in the European energy system

Heating and cooling represents about half of EU's annual energy consumption

We still use a lot of fossil fuels for heating

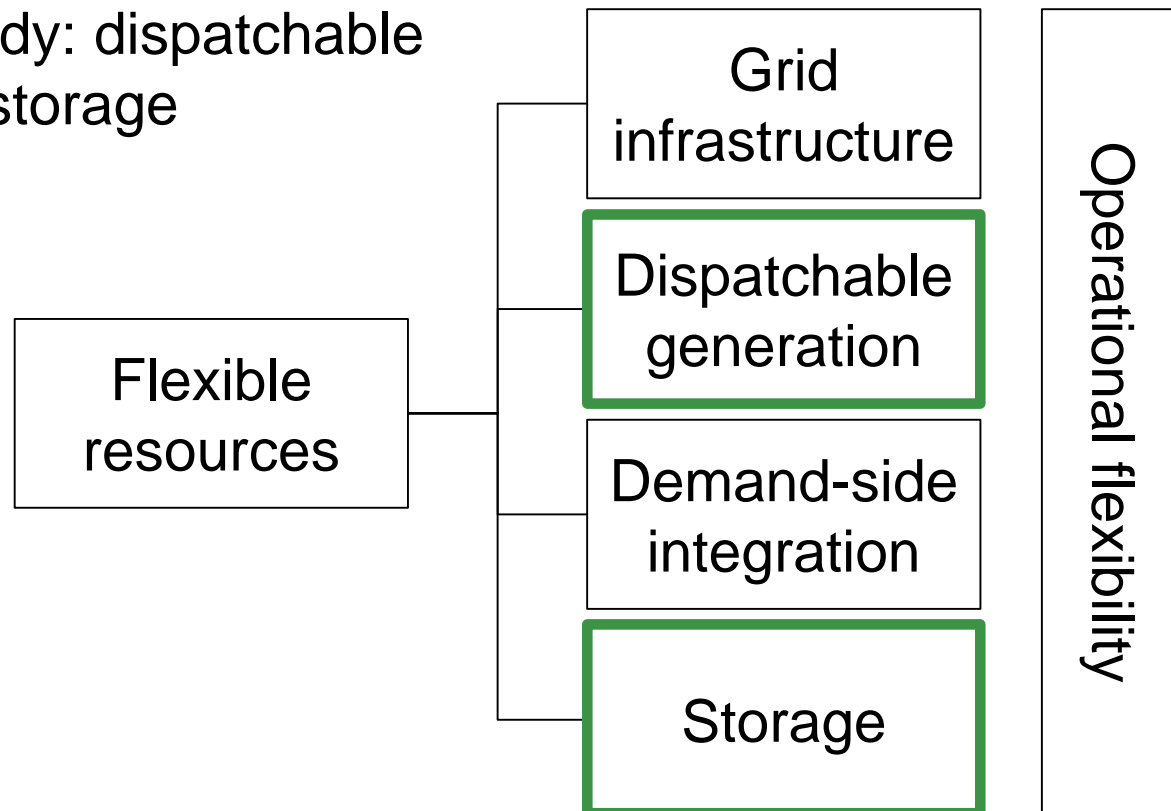
Energy sources in heating in the EU in 2014



Bioenergy has already a huge role

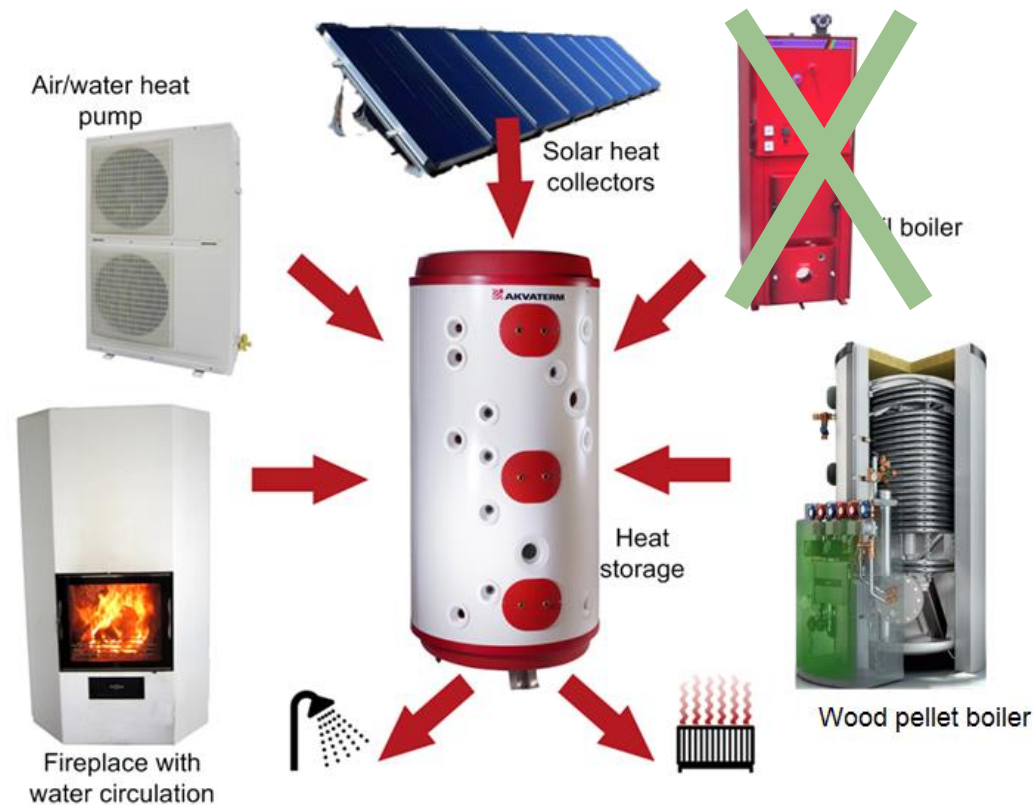
What kind of flexible resources do we need?

- There are five types of flexible resources
- Focus in this study: dispatchable generation and storage



Definition of integrated bioenergy hybrid

- *“Energy conversion process that has at least two energy inputs, one of which is bioenergy”*



Only renewable energy inputs

➡ RES hybrid

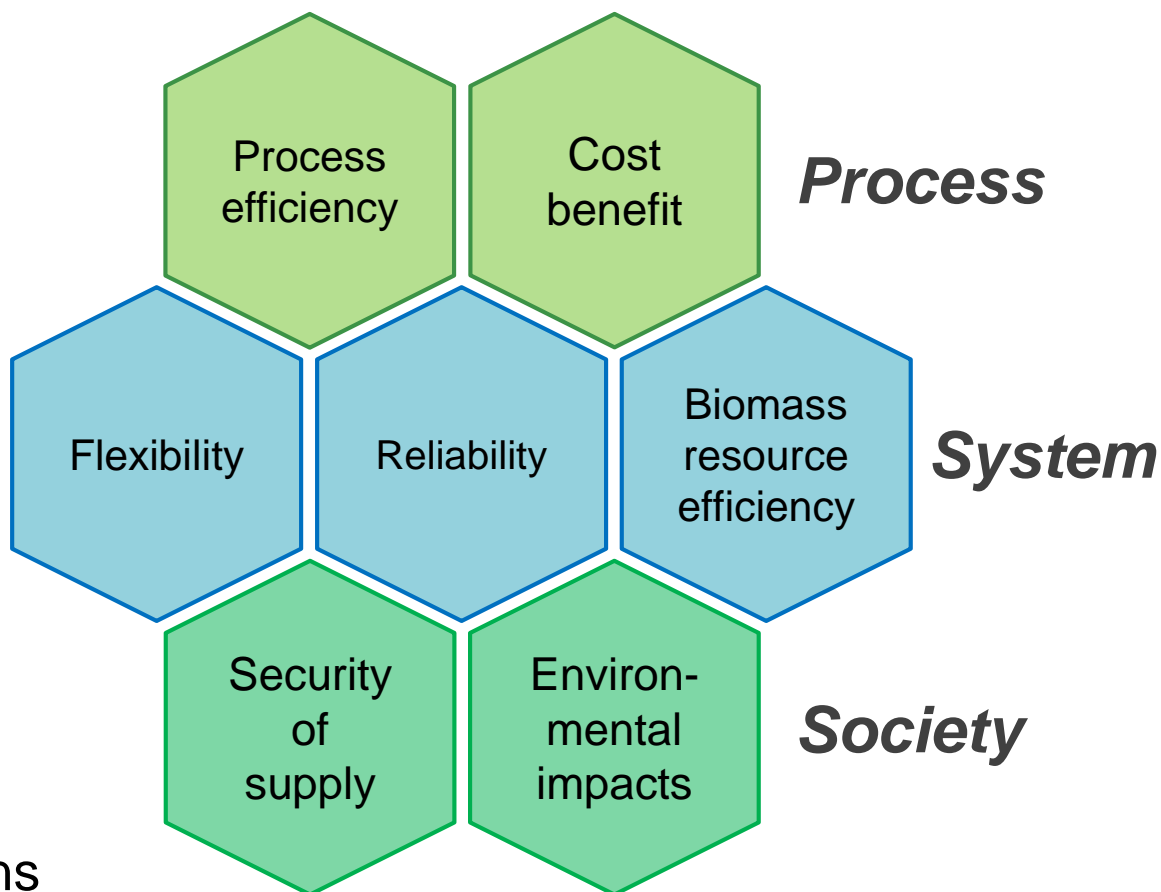
What if we combine different energy sources?

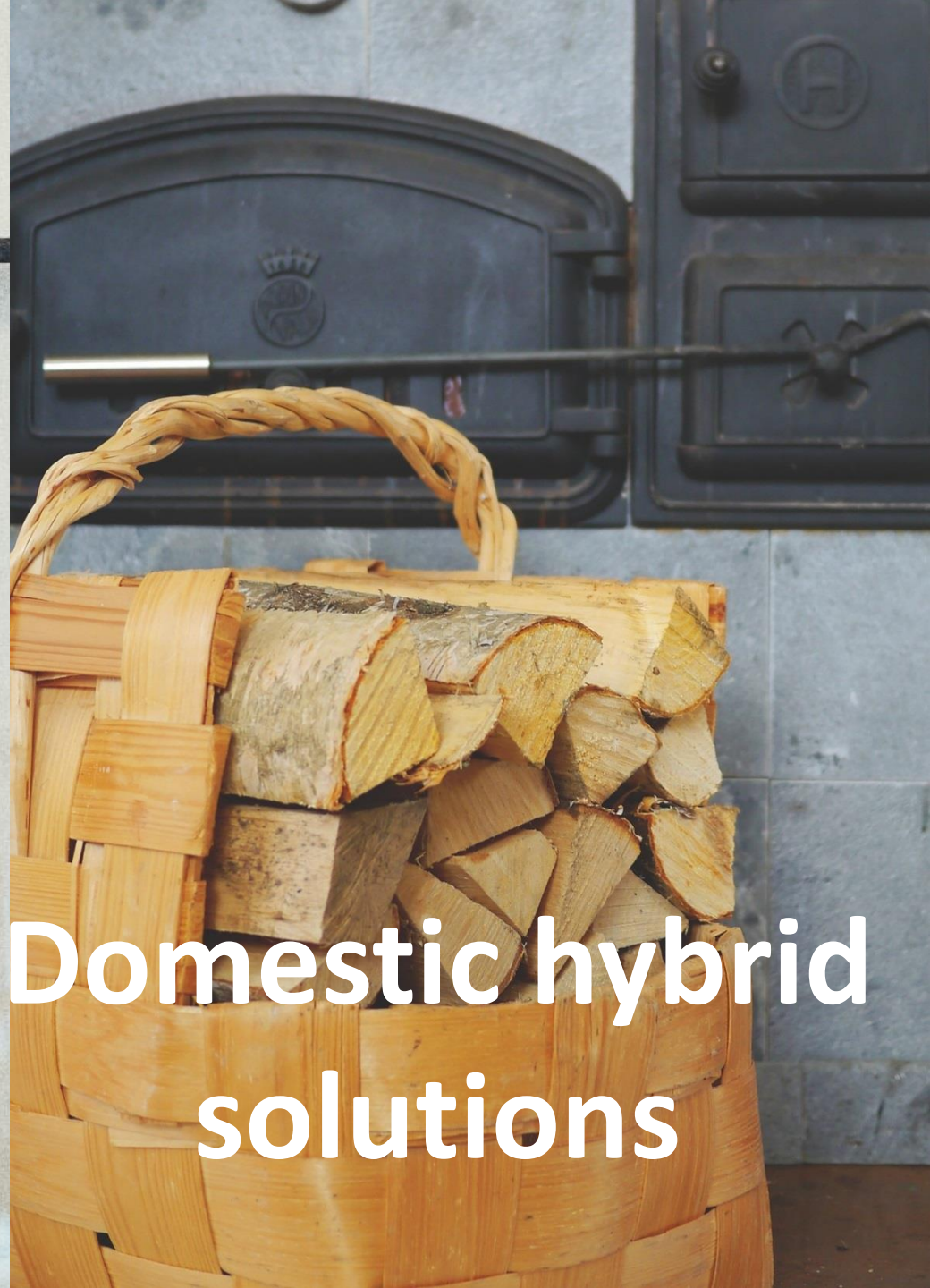
- Hybrid system is designed to use different energy sources to their fullest potential

*“The whole is greater than the sum of its parts”**

Classification

- Domestic applications
- Farm-scale applications
- Industrial applications
- Utility and district applications
- Biomass based storage solutions



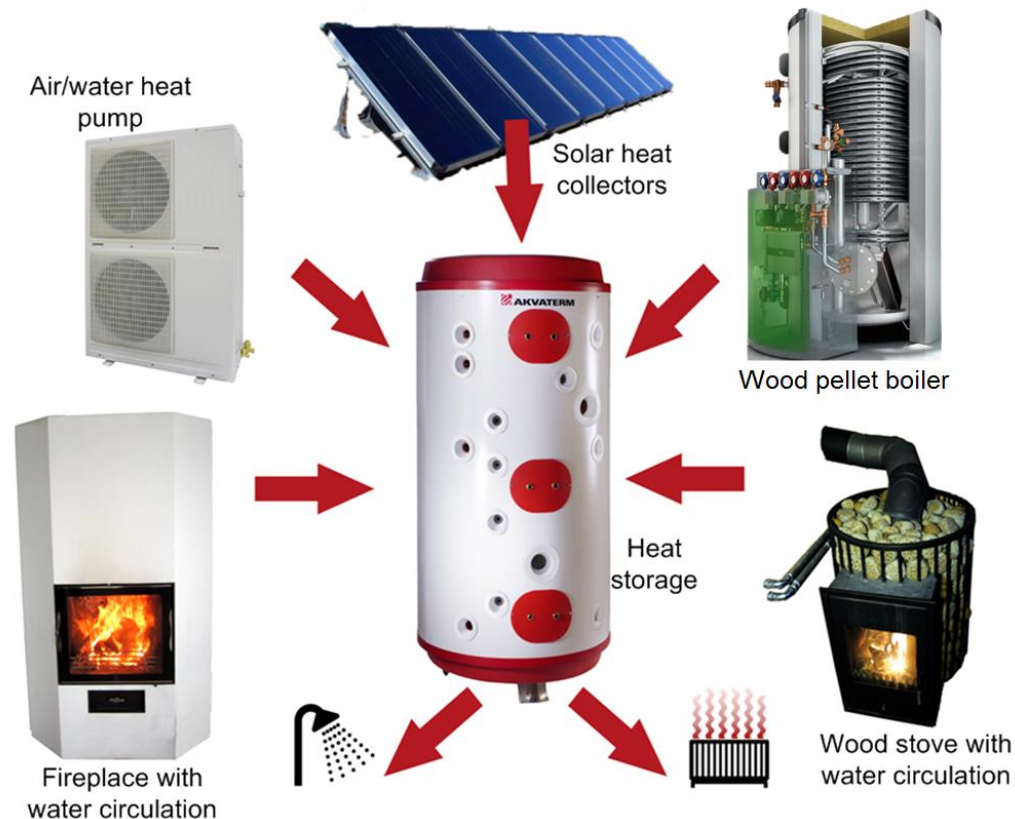


Domestic hybrid
solutions

Domestic hybrid heating systems

A standard technology

- Hybrids mainly found in the heating sector
- Flexible and robust integration
- Biomass and ground-source heat alternative base load producers
- In Germany, 60% of all pellet boilers and stoves combined with solar energy
- Investments fully market driven



Source: EkoLämmöx, ÖkoFen Pelletsheizung

→ The role of biomass depends on the household's heating behaviour

→ Largest potential outside the district heating network

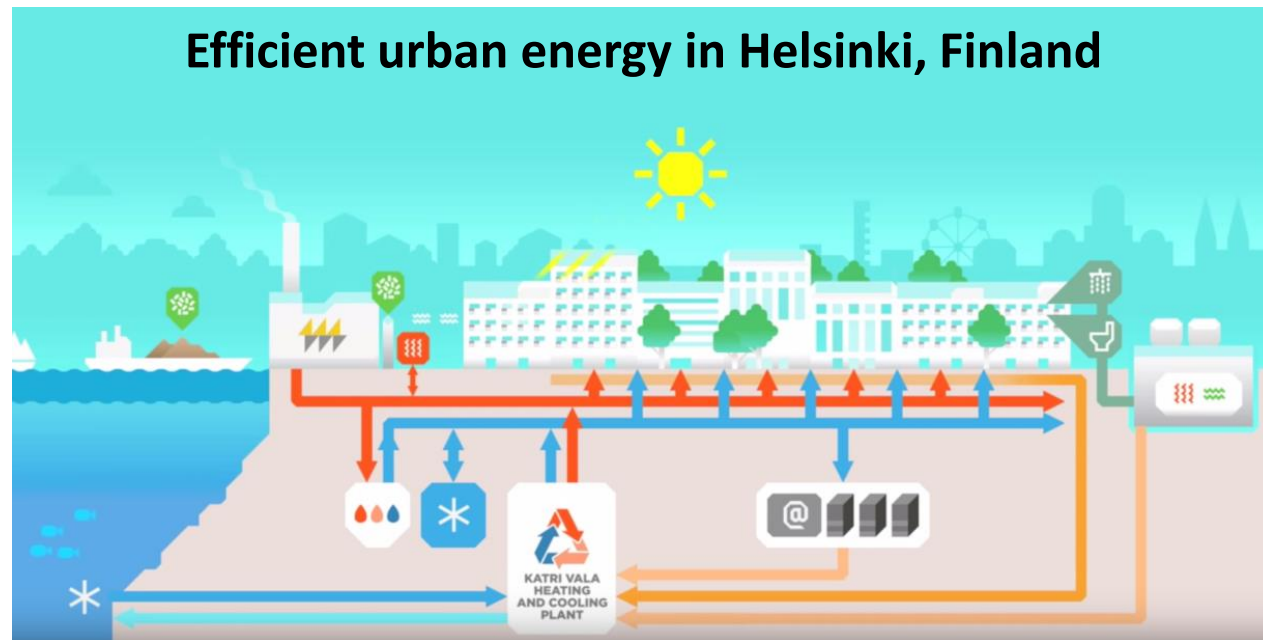
An aerial photograph of a suburban neighborhood. The image shows a dense arrangement of houses with various roof colors, including red, brown, and grey. Many houses have swimming pools in their backyards, which are visible as bright blue rectangles. The houses are interspersed with green lawns and mature trees. A road with a crosswalk is visible on the left side of the image. The overall scene depicts a typical residential district.

**From households
to districts**

District heating and cooling networks

Trigeneration of heat, power and cooling with high efficiency

- 90% of DH produced by CHP
 - Co-combustion of wood pellets and coal
 - Distributed heat generation based on biomass
 - Biogas product for DH
- 7% of DH produced by heat pumps station
 - Waste heat utilisation
 - Passive solar thermal



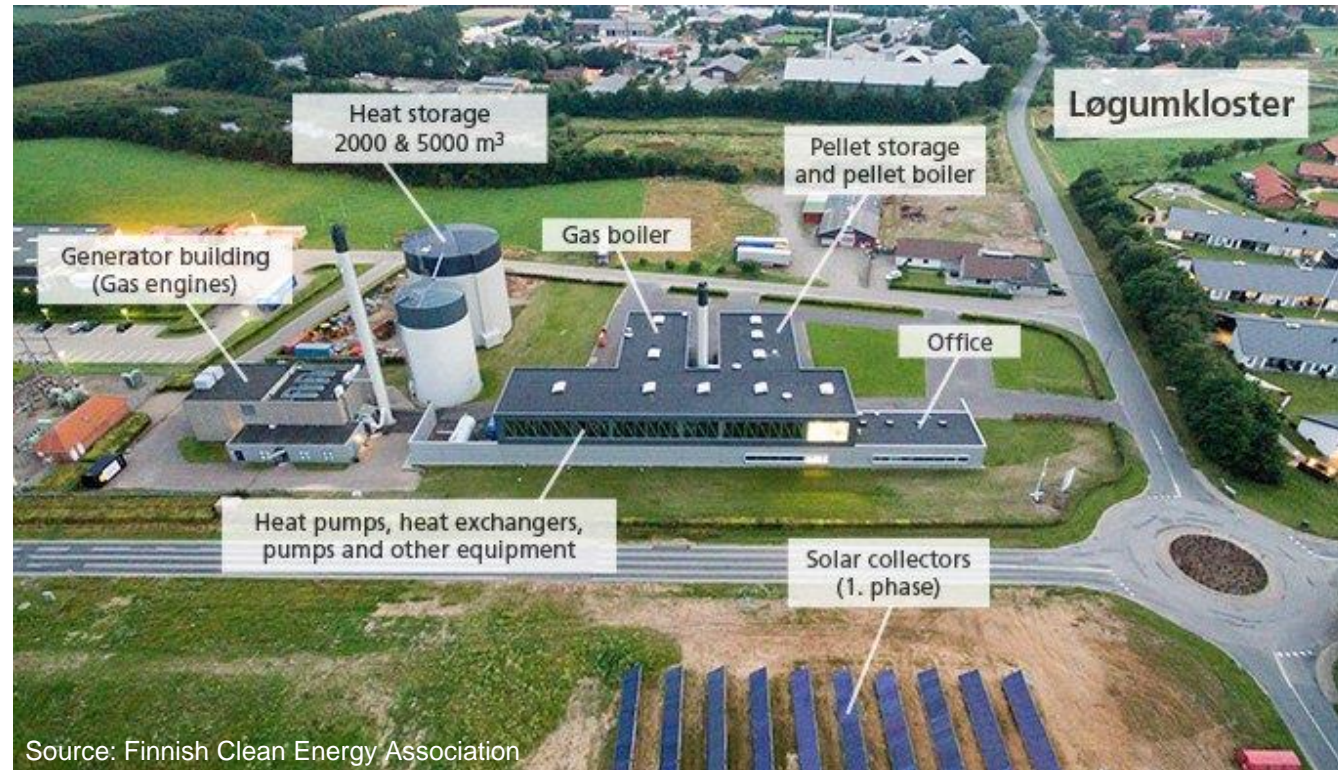
Source: HELEN, Helsinki, Finland

- RES potential in district networks is high – District cooling further increases it
- Biomass a fast way to increase RES share
- Heat pumps improve the system efficiency and allow balancing in the power sector

District heating: Biomass-solar hybrid

Løgumkloster hybrid plant in Denmark

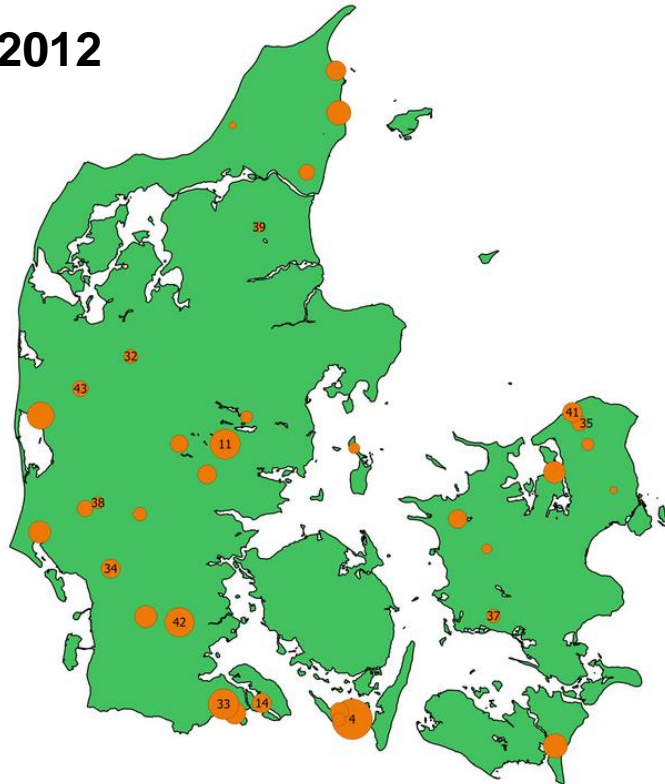
- Typical combination:
 - Wood pellet/wood chip boiler
 - Solar thermal
 - Heat pump
 - Heat storage
 - Natural gas
- Annual solar fraction typically ~25%




- Biomass plant can be shut down for summer periods
- Heat pumps allow efficient utilisation of solar thermal energy
- High system efficiency through optimised operation and control of different sources

Solar district heating in Denmark

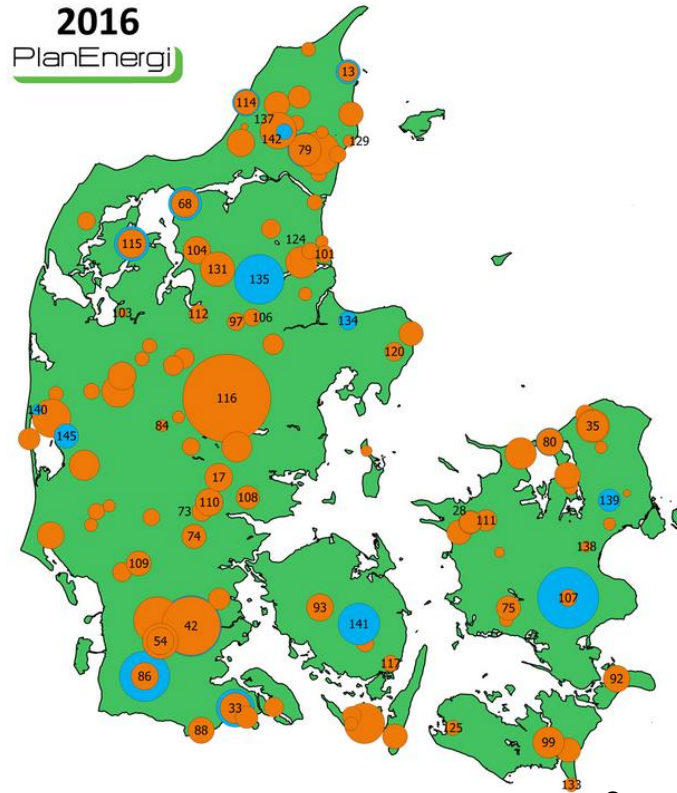
2012





 In operation
Total collector area (in operation): 279 475 m²

4.6 x

2016
PlanEnergi



 In operation	Total collector area (in operation): 1 302 331 m ²
 Planned / planned expansion	Total collector area (planned): 269 189 m ²

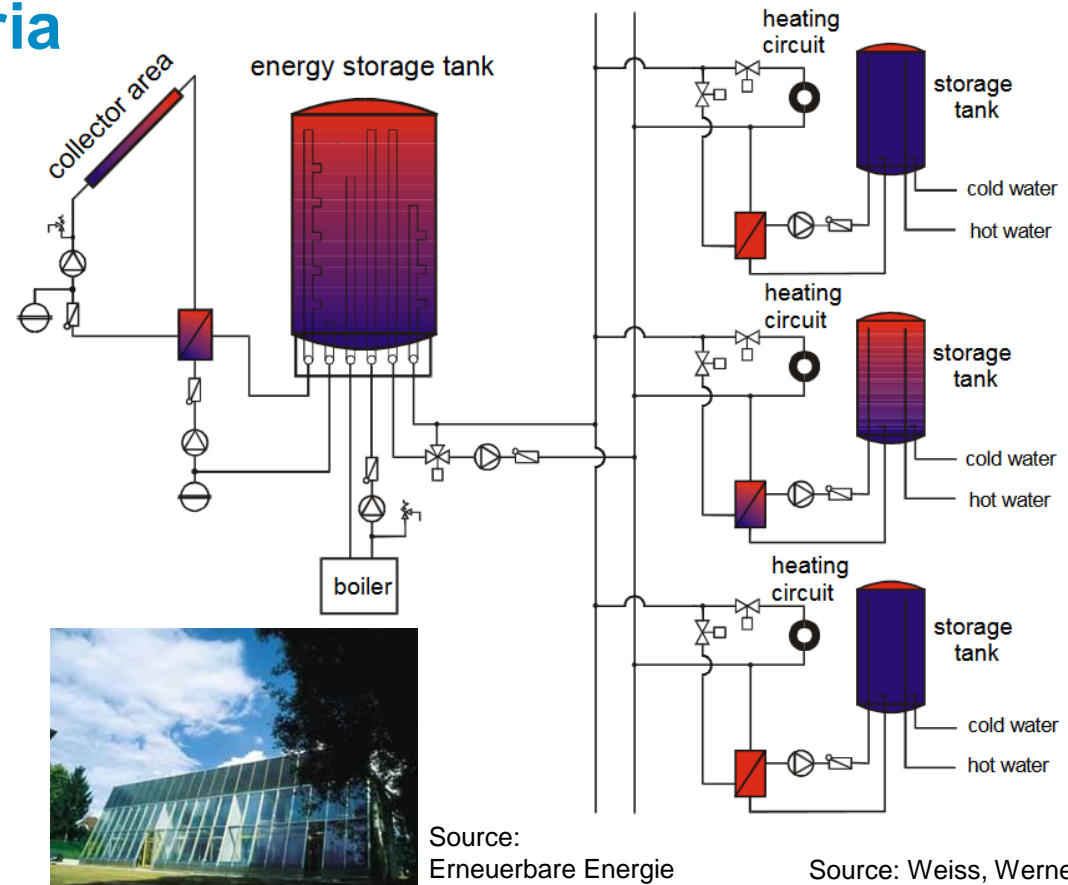
Source: PlanEnergi

→ Solar thermal utilisation creates potential for hybrid district heating systems

Regional heating: Biomass-solar hybrid

Solution in Gleisdorf, Austria

- An office building and several low-energy houses
- Heat supply
 - ~50% solar heat
 - ~50% wood pellet boiler
 - 14 m³ heat storage tank
- Two temperature levels
 - Space heating: 40 °C
 - Domestic hot water: 65 °C



- Fully renewable heat with cost benefit compared to household scale systems
- Biomass balances the system on multi-day level
- Several renewable district heating demonstrations in Austria and Germany

District heating: Biomass-solar hybrid

Pilot in Finland

- First biomass-solar hybrid pilot replacing fossil based DH unit in Finland
 - Wood pellet boiler, 500 kW_{th}
 - Solar thermal collectors, 8 kW, 12 m²
 - Electric heater, 70 kW
 - No heat storage
- Solar collectors to preheat the return water
 - → High solar thermal efficiency
 - Annual solar production 3–4 MWh, focused on summer period



Source: Kari Vesterinen, Savon Voima Oyj

→ Solar thermal replaces use of wood pellets – Biomass storability is utilised

→ No fossil fuels needed during the summer period

A large, polished wooden barrel, likely for industrial use, is the central focus. It has a metal band and a handle. The background is a blurred workshop or factory setting with various equipment and materials.

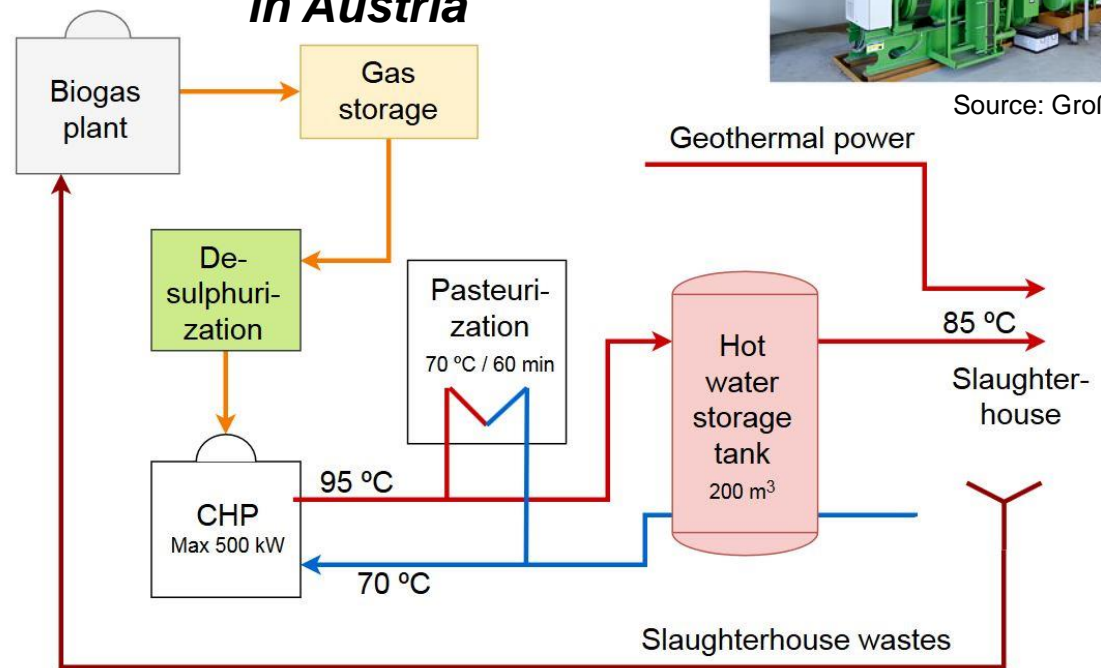
Profitability in industry

Industrial applications

Local biogas utilisation

- Heating and cooling sector
 - Bioenergy
 - Ground-source heat
 - Waste heat recovery
 - Solar heat and electricity
- Großfurtner's slaughterhouse
 - ~80% of the heat from biogas CHP
 - Rest by ground-source heat

Großfurtner's slaughterhouse in Austria



Source: Großfurtner

Source: IEA Bioenergy Task 37

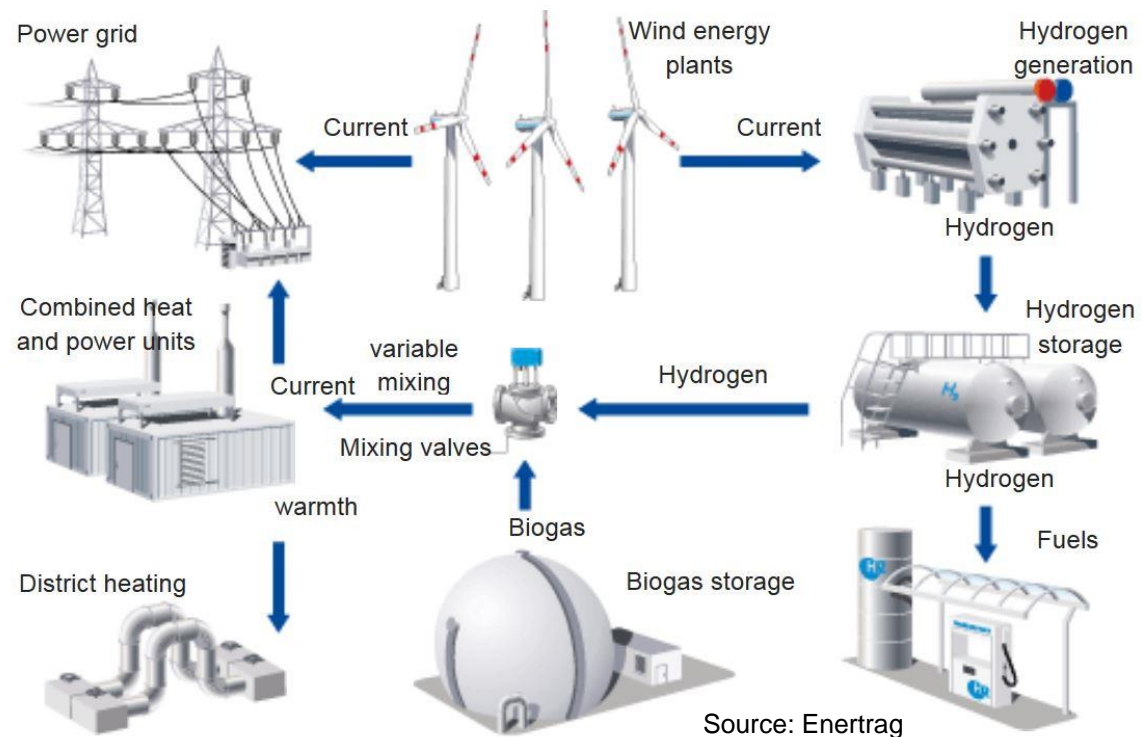
- Key drivers security of supply and costs – Cooling demand increases
- Biogas for heating, power and mobility
- New local networks and businesses

Industrial applications

Virtual power plants and Power-to-Gas concepts

- Biogas and biomethane + wind power close to the market in Germany
- Surplus wind power into electrolytic hydrogen
 - Flexible storage option
 - Heat and power
 - Mobility
- → Chemical storage of variable renewable energy (VRE) into biofuels

Enertrag virtual power plant in Prenzlau, Germany



→ Resource efficiency in biomass use and flexible storage solution

→ Ancillary services for power grid

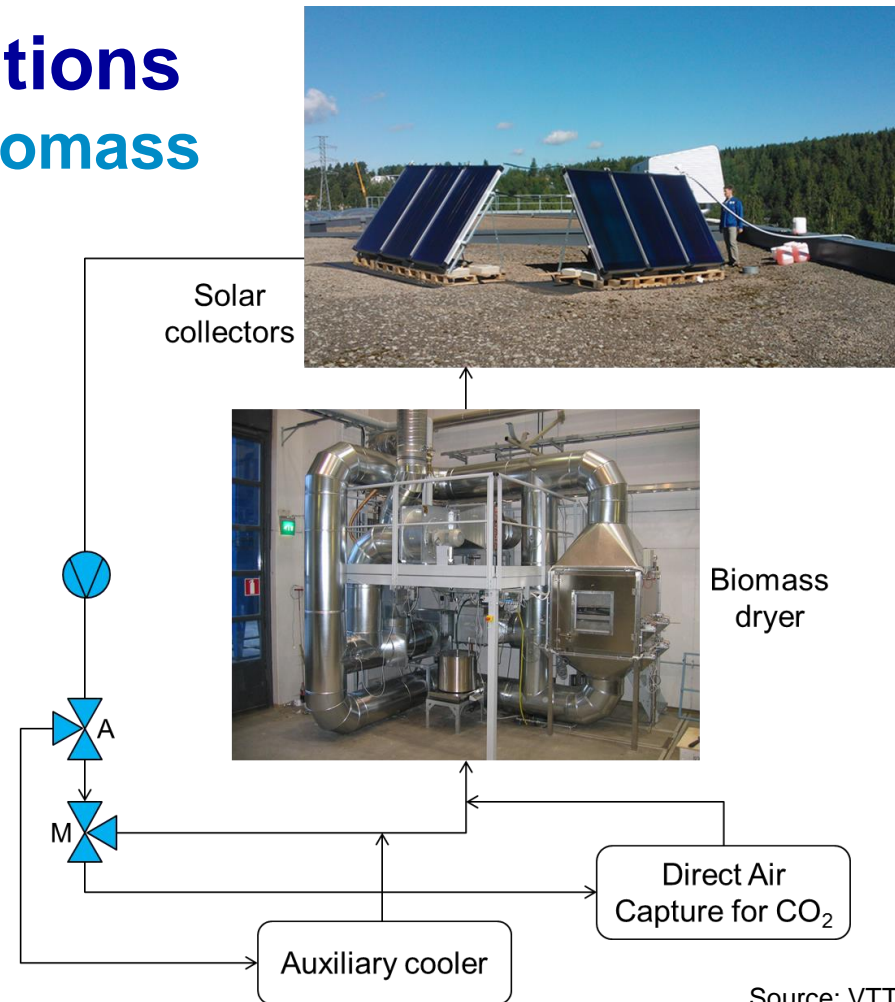


Long-term energy storage

Biomass based storage solutions

Solar enhanced drying of solid biomass

- Decentralised biomass drying at biomass production sites can create new business opportunities
- VTT's pilot wood chip dryer:
 - Research on efficiency, controllability and economics



Source: VTT

- Low-cost and long-term (seasonal) storage application for solar energy
- Good quality biomass for thermo-chemical conversion processes
- Feasible logistic chain with enhanced efficiency

A photograph of a wind farm with several white wind turbines standing in a grassy field. The sky is blue with scattered white and grey clouds. The foreground is filled with green grass, some of which is out of focus.

Hybrid technology developments

Summary of technology developments

Status and future trends

	Domestic scale	Utility scale and districts	Industrial scale	Farm-scale
On market/ Implemented	<ul style="list-style-type: none"> • Biomass + solar thermal • Biomass + ground-source heat • Biomass + waste heat recovery • Biomass + electric heating • Biomass + DH • Biomass + PV 	<ul style="list-style-type: none"> • Biomass + waste heat recovery • Biomass + passive solar energy 	<ul style="list-style-type: none"> • Biomass + ground-source heat • Biomass + waste heat recovery • Biomass + PV 	<ul style="list-style-type: none"> • Biomass + ground-source heat • Biomass + PV • Biomass + wind • Biogas production
Ongoing developments	<ul style="list-style-type: none"> • Standardised interfaces • Optimised control algorithms • Bidirectional DH 	<ul style="list-style-type: none"> • Biomass + solar thermal • Biomass + geothermal • Waste heat utilization from new sources • Low-temperature grids • Prosumer integration • Hydrogen enhanced biofuels 	<ul style="list-style-type: none"> • Biogas economy • Hydrogen enhanced biofuels • Virtual power plants • Biomass + solar thermal 	<ul style="list-style-type: none"> • Biomass + solar thermal • Biomass drying • Liquid biofuel production

More details: Country reports

Bioenergy RES Hybrids in Germany

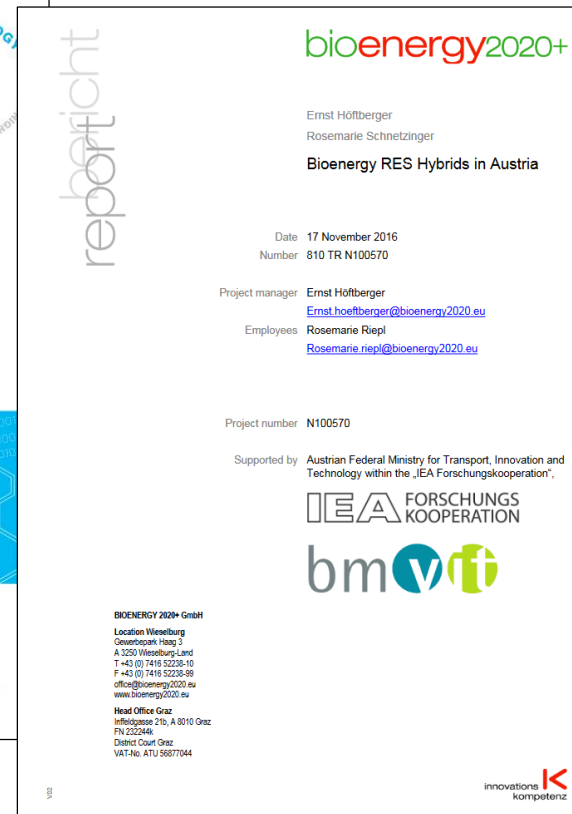
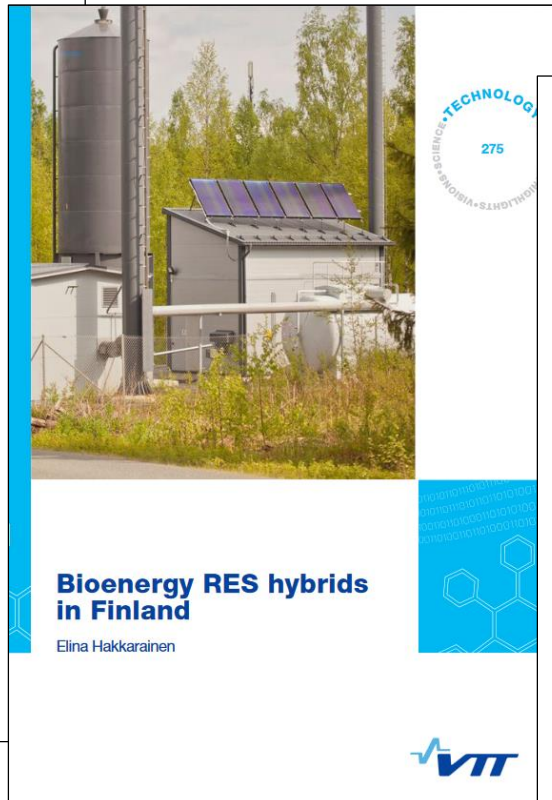
Report for

IEA Bioenergy

05th October 2016

Prepared by:
Andreas Ortwein
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Fouzi Tabet
Volker Lenz

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Key actions in the next five years

#1

An online
"knowledge library"

#2

Methods to assess
the economic
feasibility of hybrids

#3

Standardisation
of interfaces

#4

Developing
optimised
control systems

#5

Improving flexibility of
bioenergy technologies

#6

Developing novel
integrated bioenergy
hybrid concepts

Thank you for your attention!



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