Federal Ministry
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Renewable Gaseous Fuels: Unlocking Greece's Industrial Potential

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Facilitator

AHK Malaysian-German Chamber of Commerce and Industry
Deutsch-Malaysische Industrie- und Handelskammer

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A Brief Personal Introduction

M. Sc. Bijan Sadjjadi-Ortlieb

Background:

- Group Leader Sector Coupling energy systems at Fraunhofer IPA
- Mechanical Engineering, Energy Engineering

Expertise:

- Integrated Energy System Planning for industrial energy systems
- Demand Response for Industrial Flexibility
- Thermal Energy Integration in industrial energy system

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Sector Coupling Energy Systems at Fraunhofer IPA

5

Reasons for sector-coupling energy systems

1. **Increased efficiency**
2. **Flexibility and resilience**
3. **Operational optimisation**
4. **Ecological benefits**
5. **Economic benefits**

- Overall efficiency increases through the coupling of different technologies (e.g. integration of energy storage systems).
- Greater flexibility and increased reliability compared to individual, isolated energy systems.
- Operational optimisation through sector coupling (e.g. peak load smoothing)
- Reduction of greenhouse gas emissions through the integration of renewable energy sources and the production of H2
- Cost savings through interaction with the energy market and more efficient use of resources

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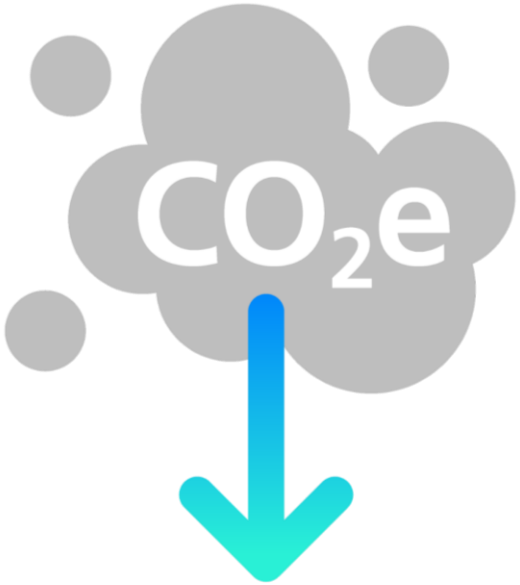
Utilization of Biomass, Biogas, and Woodgas in Industrial Processes



- Biomass: Organic material from plants and animals; renewable and abundant, serving as an alternative to fossil fuels.
- Biogas: Produced by the anaerobic digestion of organic waste; primarily methane (CH_4), usable for heating, electricity, or upgraded to biomethane.
- Woodgas (Producer Gas): Generated through gasification of woody biomass; a combustible gas mixture (CO, H_2, CH_4) suitable for direct heat or electricity generation.

Why Renewable Gaseous Fuels in Industry?

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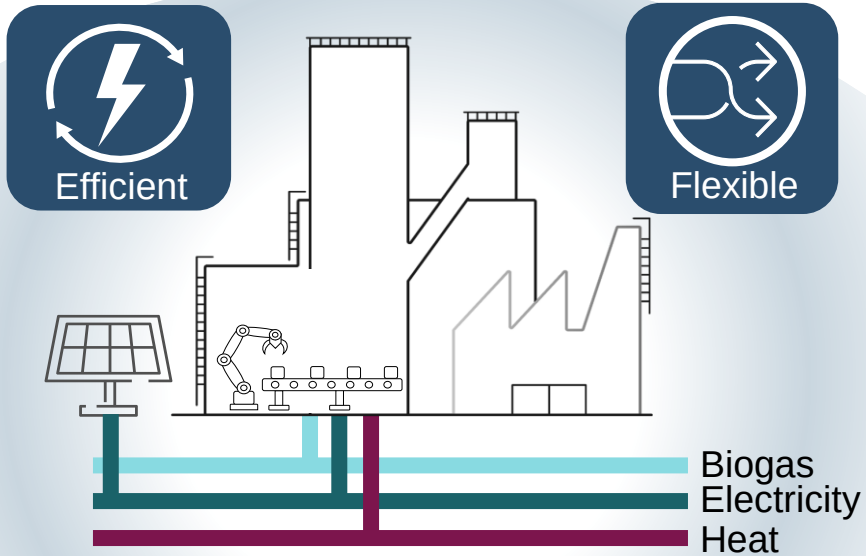
Production is entering the coming decade in an energy-efficient and flexible way

Energy efficiency and flexibility reduce energy costs and ensure a resilient supply

Energy Efficiency

- More urgent than ever in times of rising energy prices (electricity is becoming a scarce commodity)
- The single most important measure in the transition away from fossil fuels
- Digitalization and modern energy-supply concepts promise significant efficiency gains



Energy Flexibility

- Enabler for increased use of renewable energy and thus CO_2-free production
- Reducing energy procurement costs
- Technical and organizational solutions are ready for deployment in production; the transformation can begin

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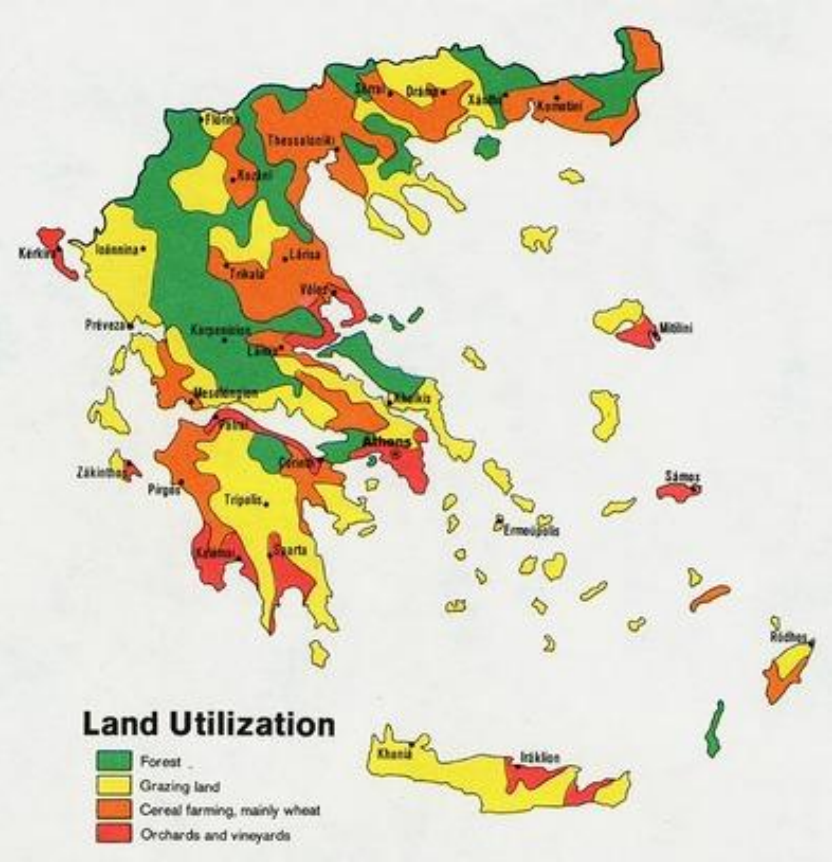
Sustainable Biomass Potential in Greece by 2030



- **Agricultural residues:** Approximately 2.4 million dry tonnes/year
- **Forest biomass (primary production):** Approximately 1.93 million dry tonnes/year
- **Biowastes and post-consumer wood:** Approximately 2.26 million dry tonnes/year
- **Dedicated perennial crops:** Approximately 1.17 million dry tonnes/year

Source: https://s2biom.wenr.wur.nl/doc/S2Biom%20GREECE%20biomass%20potential%20and%20policies.pdf

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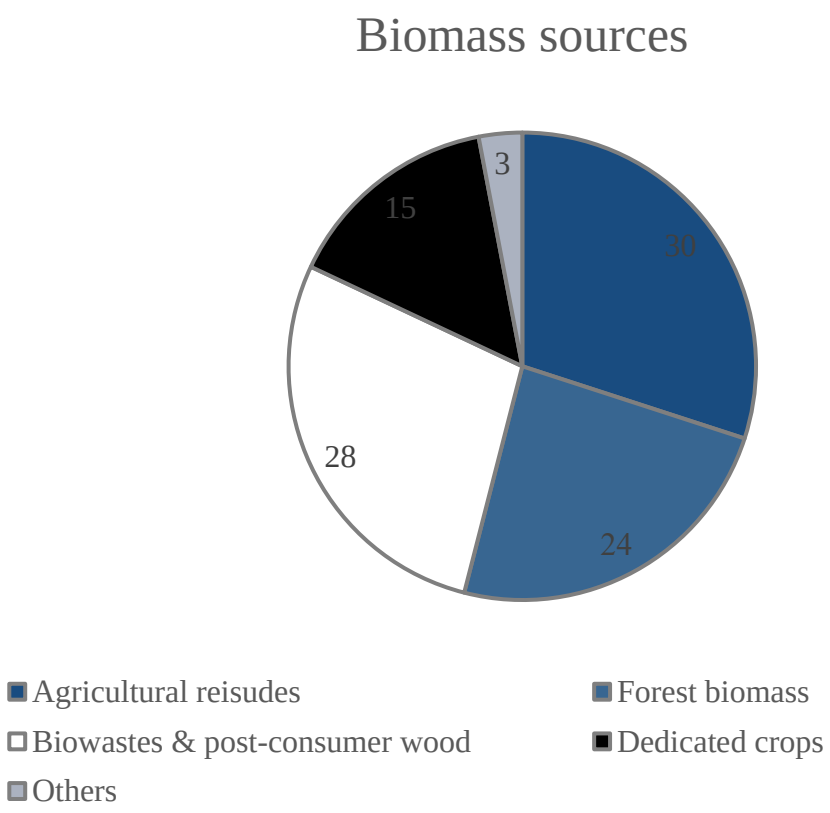
Biogas sources & Biogas Facilities - *Snapshot of Greek biogas infrastructure in 2024.*



- **75** Biogas Plants in Operation
- Total Capacity: **115 MW**
- Agricultural & livestock: **61.6 MW**
- Landfill & renewable energy: **53.3 MW**

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Renewable Fuels from Biomass – Production and Characteristics

🌾 Biomass

- **Sources:**
  - Agriculture residues *(olive pomace, wheat straw)*
  - Forestry residues *(wood chips, bark)*
  - Organic waste *(industrial and municipal)*
- **Energy Content:**
  10–20 MJ/kg
  (Typical composition: cellulose, lignin)
- **Conversion Technologies:**
  - Combustion *(heat)*
  - Gasification *(CO, H_2, CH_4)*
  - Pyrolysis *(bio-oil, char)*

🔋 Biogas

- **Sources:**
  Anaerobic digestion of organic matter *(animal waste, agricultural residues, municipal waste)*
- **Composition:**
  Methane (CH_4) 55–70%, CO_2 30–45%, H_2S (trace)
- **Production Steps:**
  - Anaerobic Digestion *(temperature: 35–60°C, retention: 20–40 days)*
  - Purification and Upgrading *(desulfurization, CO_2 removal → biomethane ≥95% CH_4)*

🌳 Woodgas

- **Sources:**
  Solid woody biomass *(forest residues, wood waste)*
- **Composition:**
  CO (18–22%), H_2 (12–20%), CH_4 (2–5%), CO_2, N_2 (balance)
- **Gasification Technologies:**
  - Downdraft Gasifier
  - Updraft Gasifier
  - Fluidized Bed Gasifier

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Industrial Utilization of Biomass, Biogas, and Woodgas

🏭 Industrial Heat and CHP Generation

- Direct combustion for process heat and steam
- Combined Heat and Power (CHP) *(Efficiency ~85%)*
- Applications in Greek Industries:
  - Food industry *(olive oil, dairy)*
  - Ceramic production
  - Pulp & paper industry

♻️ Biogas Applications

- Biomethane upgrading for natural gas substitution
- Industrial heating *(dairies, meat processing, beverages)*
- Transportation fuel *(compressed biomethane)*

🔥 Woodgas Applications

- Direct thermal use *(ceramic kilns, metallurgy)*
- Decentralized cogeneration (heat & electricity)

Ideal for decentralized energy in rural industry

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Project example from the food industry

Heat pump

NG

Steam Boiler

PV-System

Electrical Grid

Chiller & Compressors

Process heat

Electricity

Compressed Air

Cold

Mozzarella Production – Process Overview

- **Electricity** for pumps, agitators, and packaging machinery
- **Steam or hot water** for heating and pasteurization
- **Compressed air** for cleaning purposes and other process steps
- **Cooling systems** for temperature control and product preservation

Yogurt Production – Process Overview

- **Electricity** for mixers, filling stations, and packaging machines
- **Steam or hot water** for heating and pasteurization
- **Compressed air** for cleaning and process applications
- **Cooling systems** for fermentation control and product storage

High-Bay Warehouse

- **Cooling energy** required for product storage

Wastewater from the Production Process

Waste water treatment

Biogas

CHP 1 CHP 2

Cogeneration of Electricity and Heat

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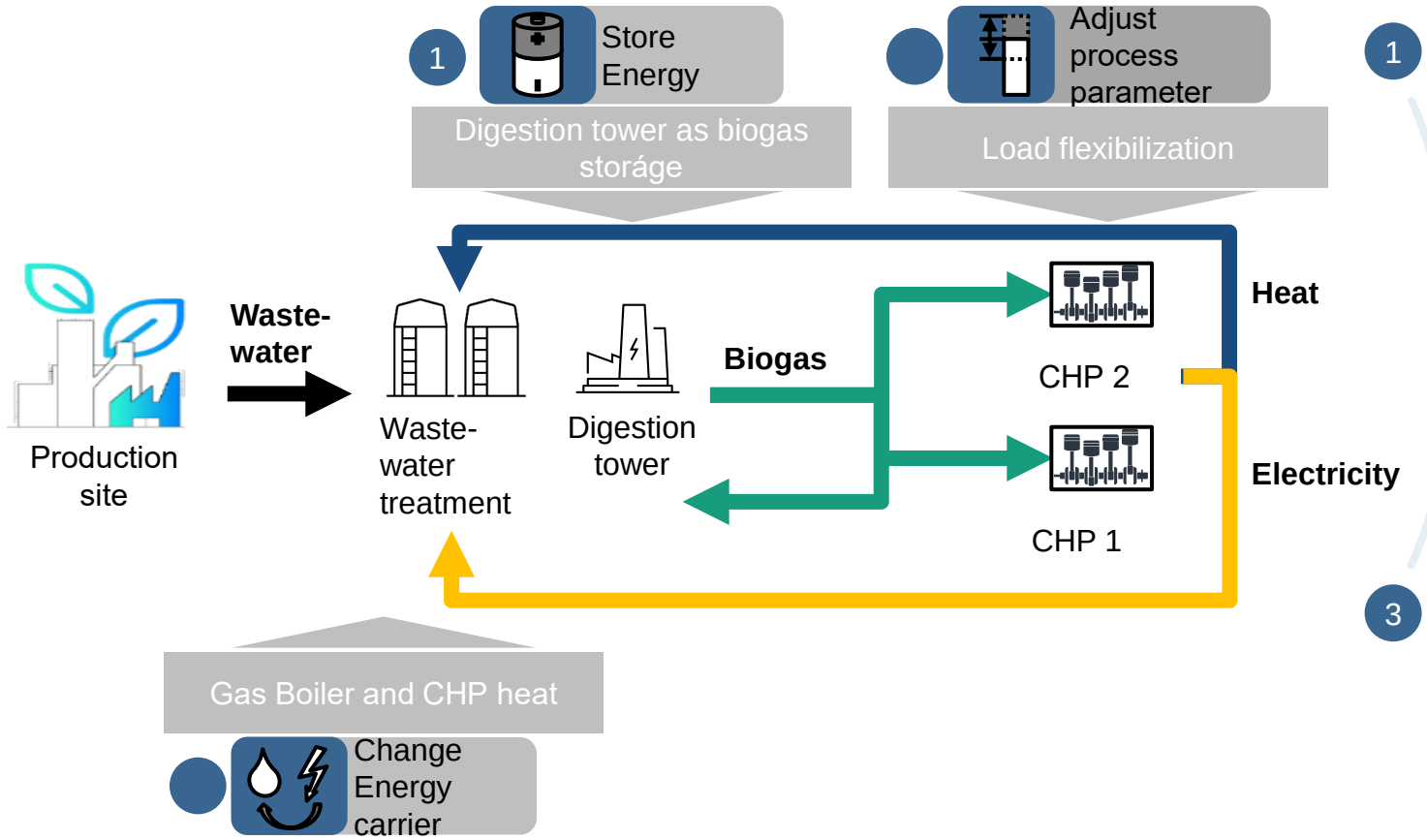
Energy flexible Biogas utilization within the food industry



1

Digestion tower as biogas storage

- The storage capacity in the digestion tower is extremely limited

2

BHKW load flexibilization

- Demand-oriented electricity and heat generation through load shifting can only be implemented by implementing a thermal storage.

3

Energy carrier adaptation for heat demand

- The heat demand is primarily met by the waste heat from the CHP unit, while peak loads are covered by the oil boiler. Using biogas in the gas boiler is less efficient than in the CHP unit and currently amounts to only 1% of the total gas volume.

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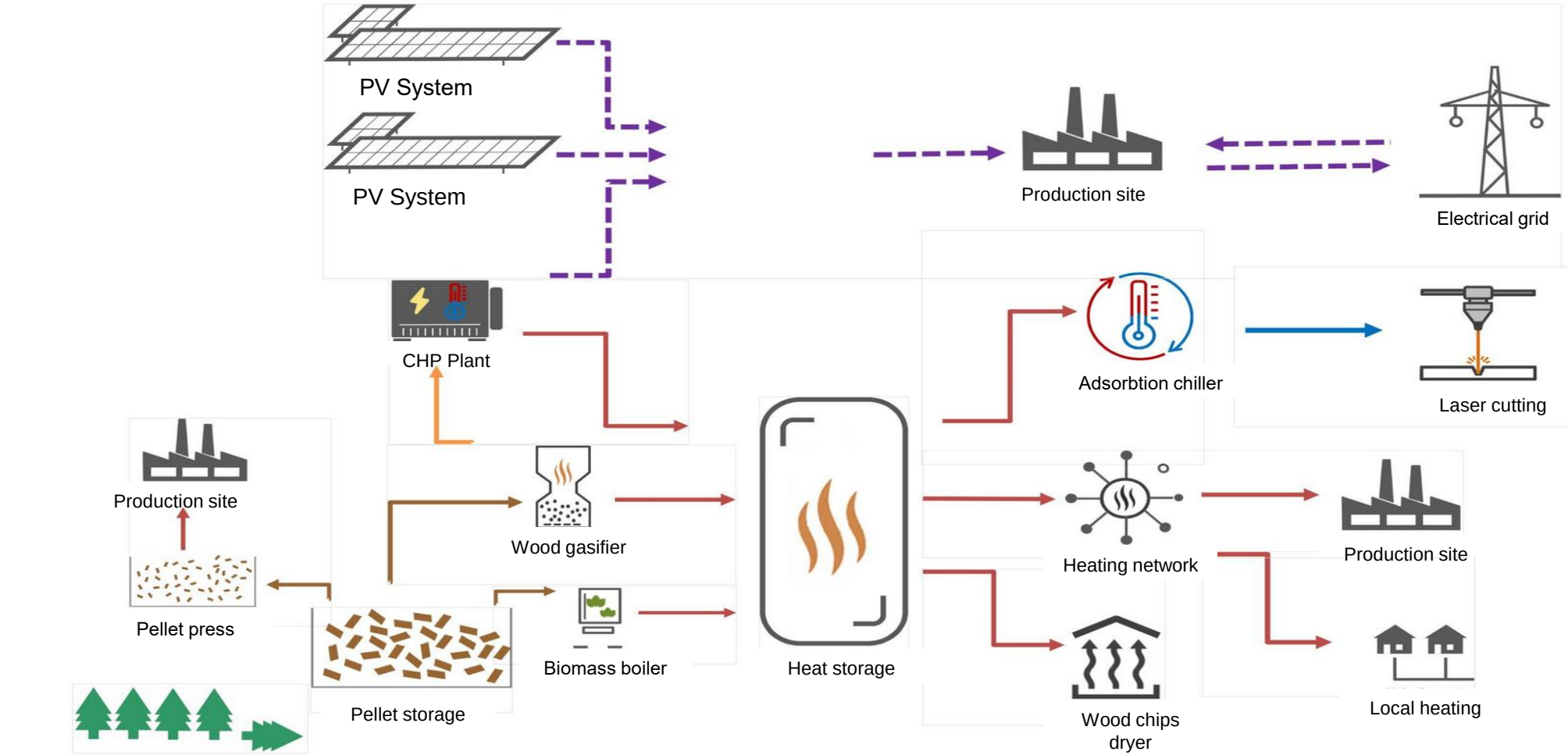
Project example from the metal processing industry



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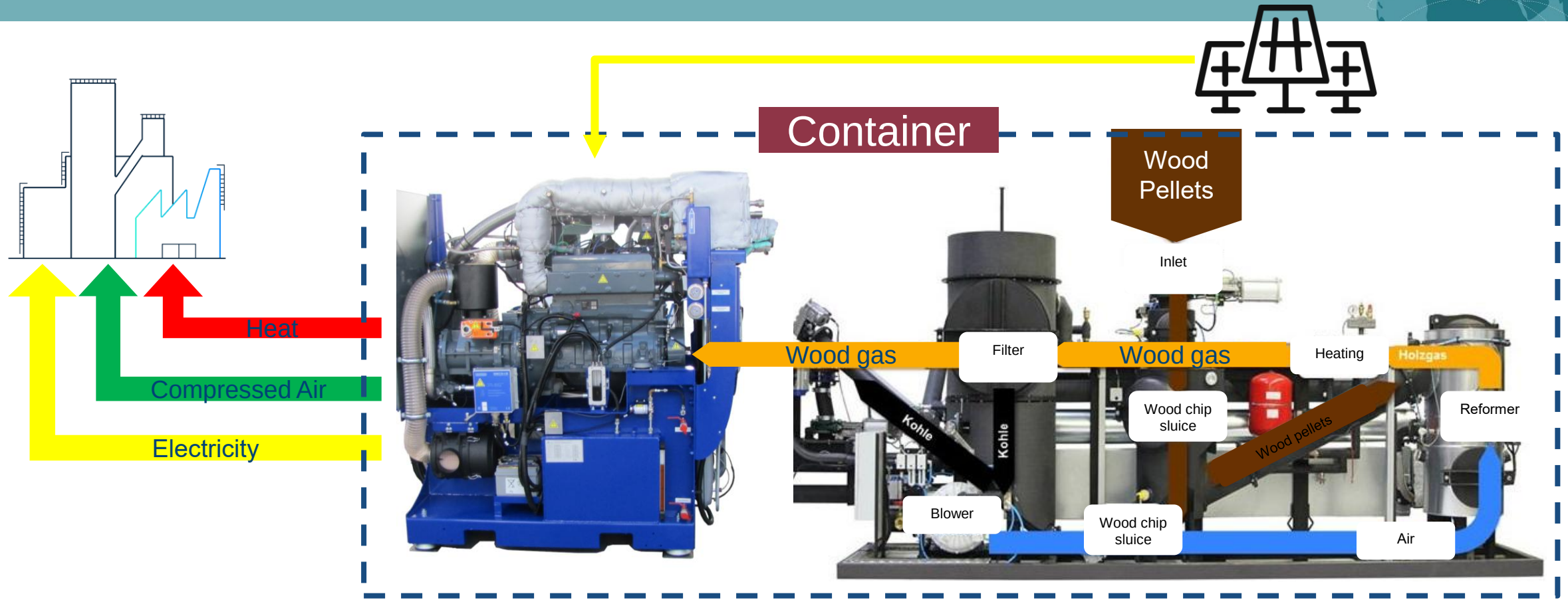

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Project example: Production of wood houses

Description

- Worlds largest factory for the production of residential homes
- Over 20,000 housing units per year
- Expectations for the new production:
- Green energy (sustainable energy supply, no reliance on fossil fuels, CO_2 neutrality)

https://www.ipa.fraunhofer.de/de/referenzprojekte/energiesystemplanung-fuer-eine-green-factory.html

Objective

- Development of an energy concept (CO_2-neutral, self-sufficient, with a high share of renewable energy)
- High share of renewable energy and on-site generation
- Autonomous, CO_2-neutral energy supply
- Assessment of future energy requirements in single- and two-shift operation
- Validation of solutions using energy-price scenarios

Benefits

- Planning certainty
- Lower energy costs
- Enhanced supply security
- Utilization of wood waste
- Independence from fossil fuels

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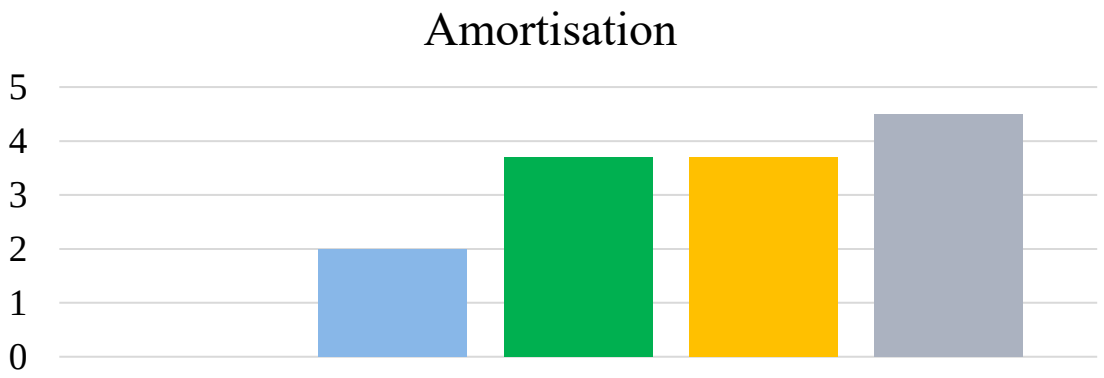
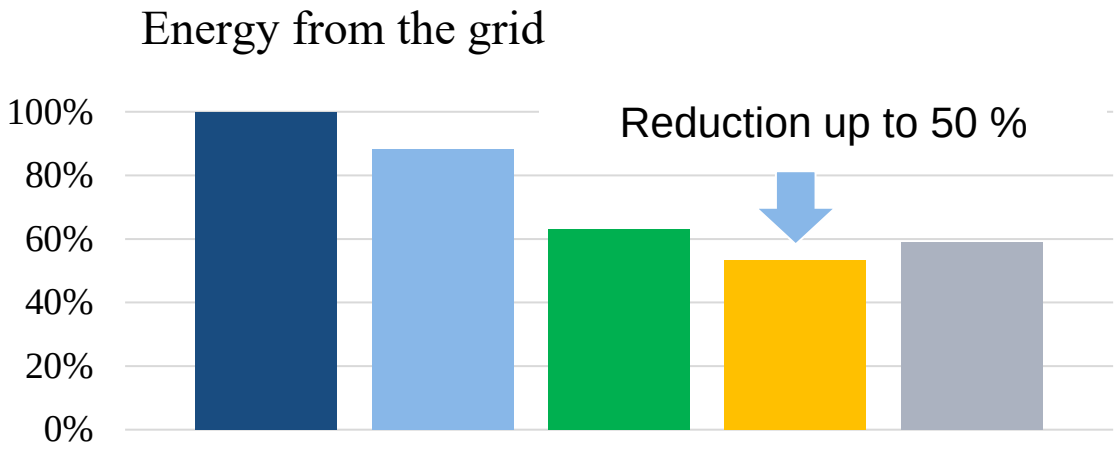
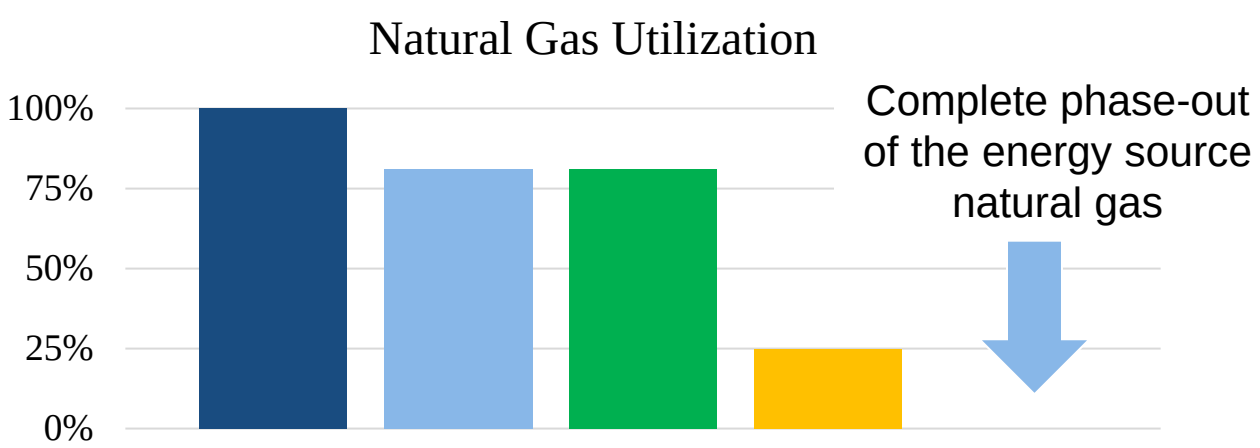
Project example: Production of wood houses – Techical and economic KPIs







- Reference
- 1.Energy concept: efficiency improvement
- 2.Energy concept: efficiency improvement + PV
- 3.Energy concept: efficiency improvement + PV + alternative fuels
- 4.Energy concept: efficiency improvement + PV + alternative fuels + electrification of heat supply

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Summary

🔄 **Biomass, Biogas, and Woodgas – Potentials for Greece Renewable energy carriers:**

- Diverse local resources (agricultural, forestry, and organic waste)
- Key to decarbonizing industrial processes

⚙️ **Technical Conversion Processes**

- **Biomass:** Combustion, gasification, pyrolysis
- **Biogas:** Anaerobic digestion, biogas upgrading (biomethane)
- **Woodgas:** Gasification (downdraft, updraft, fluidized bed) and gas cleaning

🏭 **Industrial Applications**

- **Food industry (dairy):**
  Use of biogas (from dairy waste) for process heat and combined heat and power (CHP)
- **Metal industry (metal processing):**
  Use of woodgas from wood residues for heat supply in industrial furnaces (decentralized systems)

📈 **Recommendations and Outlook**

- Expand infrastructure and targeted funding
- Strengthen collaboration between industry, research, and policymakers
- Accelerate pilot projects and scale-up of successful solutions

Thank you!

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Group Leader Sector Coupling energy systems

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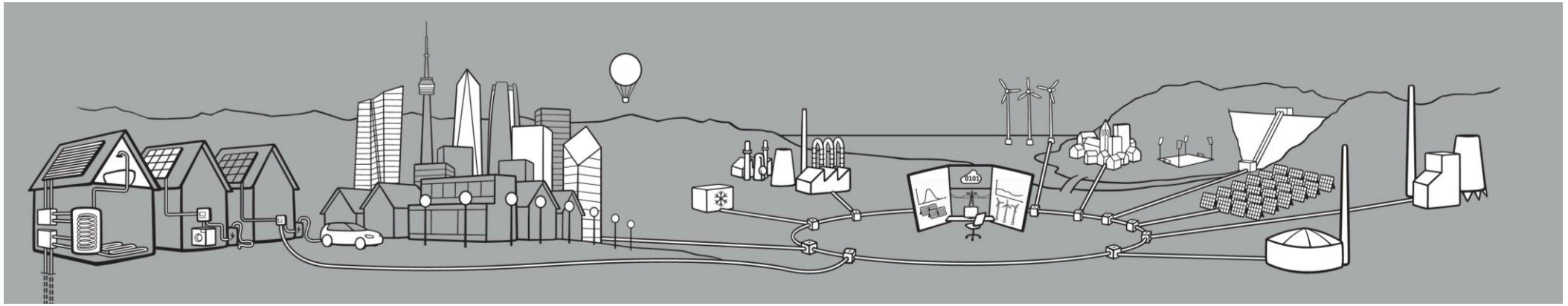

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