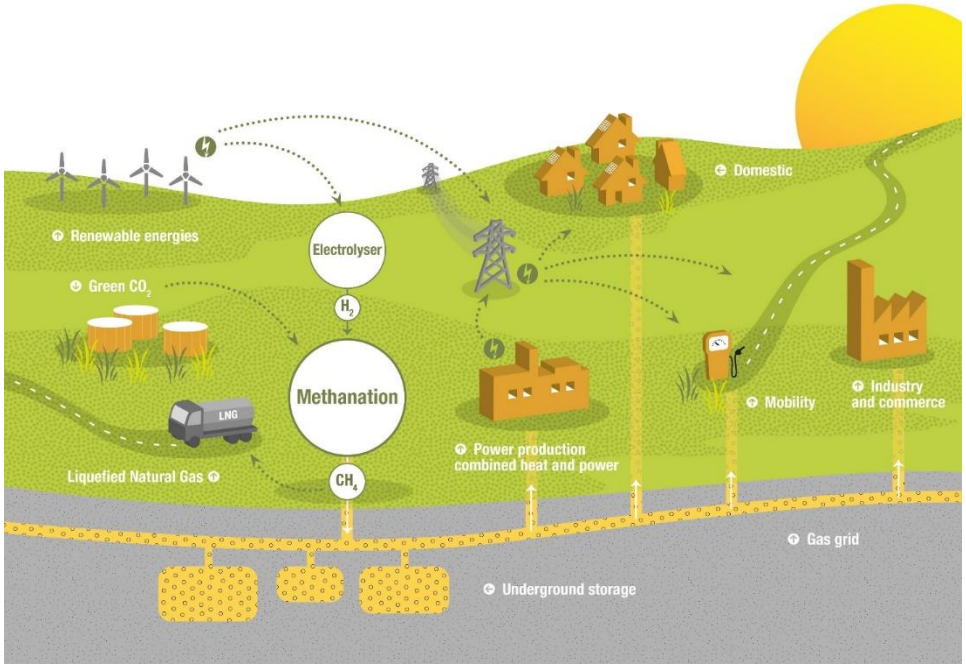
STORE&GO

Demonstrating Opportunities for Power-to-Gas on European Level



Co-funded
by the European Union
under Grant Agreement
no. 691797

Supported by

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Conferedaziun svizra

Under contract number 15.0333

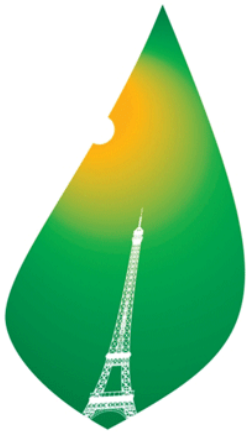
STORE&GO

Innovative large-scale energy **STOR**ag**E** technologies **&** Power-to-**G**as concepts after **O**ptimisation

COP21 – 21st Conference of the Parties

- "…holding the increase in the global average temperature to **well below 2°C** above pre-industrial levels and pursuing **efforts to limit the temperature increase to 1.5°C** above pre-industrial levels."
- **Reduce THG emissions by 95%** in 2050 compared to 1990.
- Need for **CCS** measures
- 100 billion USD / a for **climate protection in third world countries**

COP21 · CMP11
PARIS 2015
UN CLIMATE CHANGE CONFERENCE



Emission Targets EU

	EU		
Targets	2020	2030	2050
GHG Emissions			
Greenhouse gas emissions in comparison to 1990	-20 %	-40 %	-80 to -95 %
Increase of the renewable energy share in energy consumption			
Share of renewable energy in comparison to gross final energy consumption	20 %	27 %	
Reduction of energy consumption and increase in energy efficiency			
Reduction of primary or final energy consumption (PEC/FEC)	20% (increase in energy efficiency compared to business-as-usual)	27% (increase in energy efficiency compared to business-as-usual)	

Emission EU

Country	**1990** (Million tons)	**2015** (Million tons)	**2016** (Million tons)	**2015-16** (Million tons)	**2015-16** (Percent)	**1990-2016** (Percent)
Germany	1.251,6	906,8	909,4	2,7	0,3	-27,3
France	546,4	458,1	458,2	0,1	0,0	-16,1
Italy	518,4	432,9	427,9	-5,0	-1,2	-17,5
Netherlands	220,6	194,6	195,0	0,5	0,2	-11,6
EU-28	5.646,1	4.317,9	4.291,3	-26,7	-0,6	-24,0

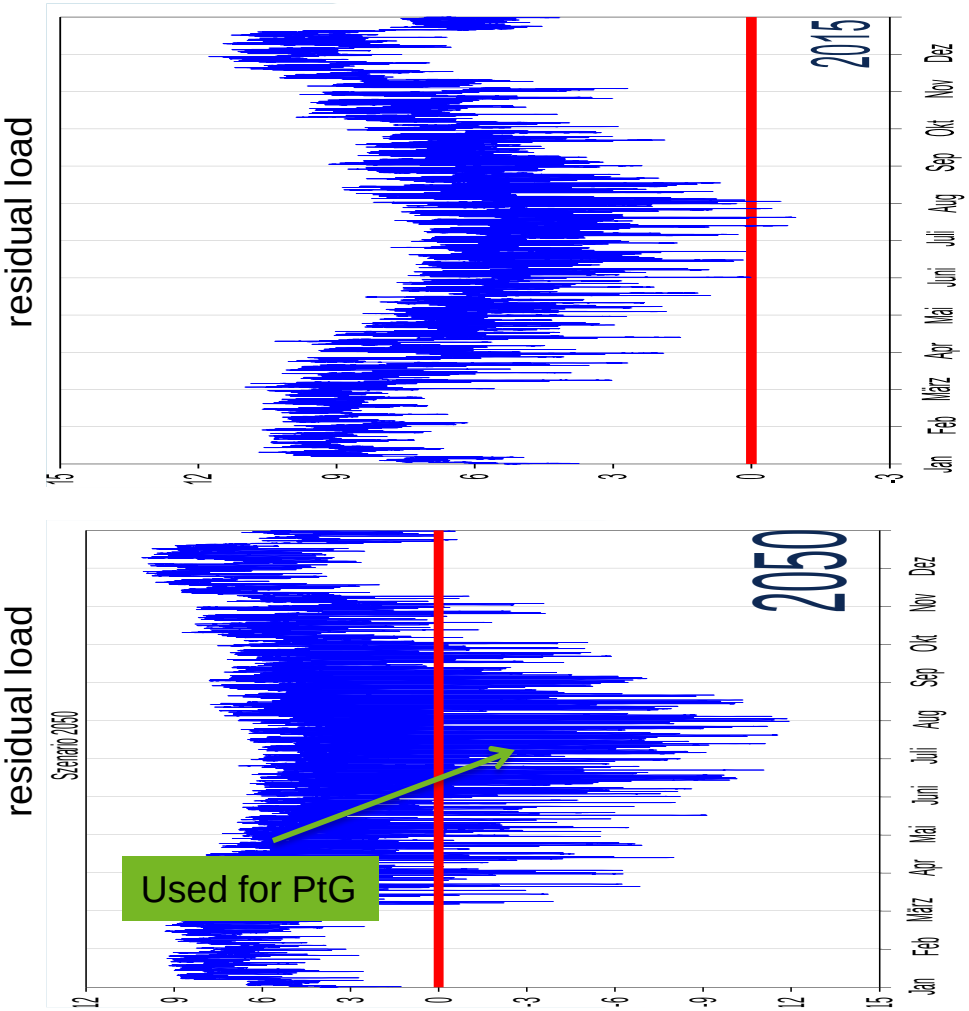
Source: European Environment Agency (EEA), EEA greenhouse gas – data viewer

Increased Integration of Renewables needs Storage for power

- Due to the volatile nature of renewable energy - supply and demand does not always match
- Technology to store power in large quantities is not yet available
- Innovative technologies are required to balance the gap

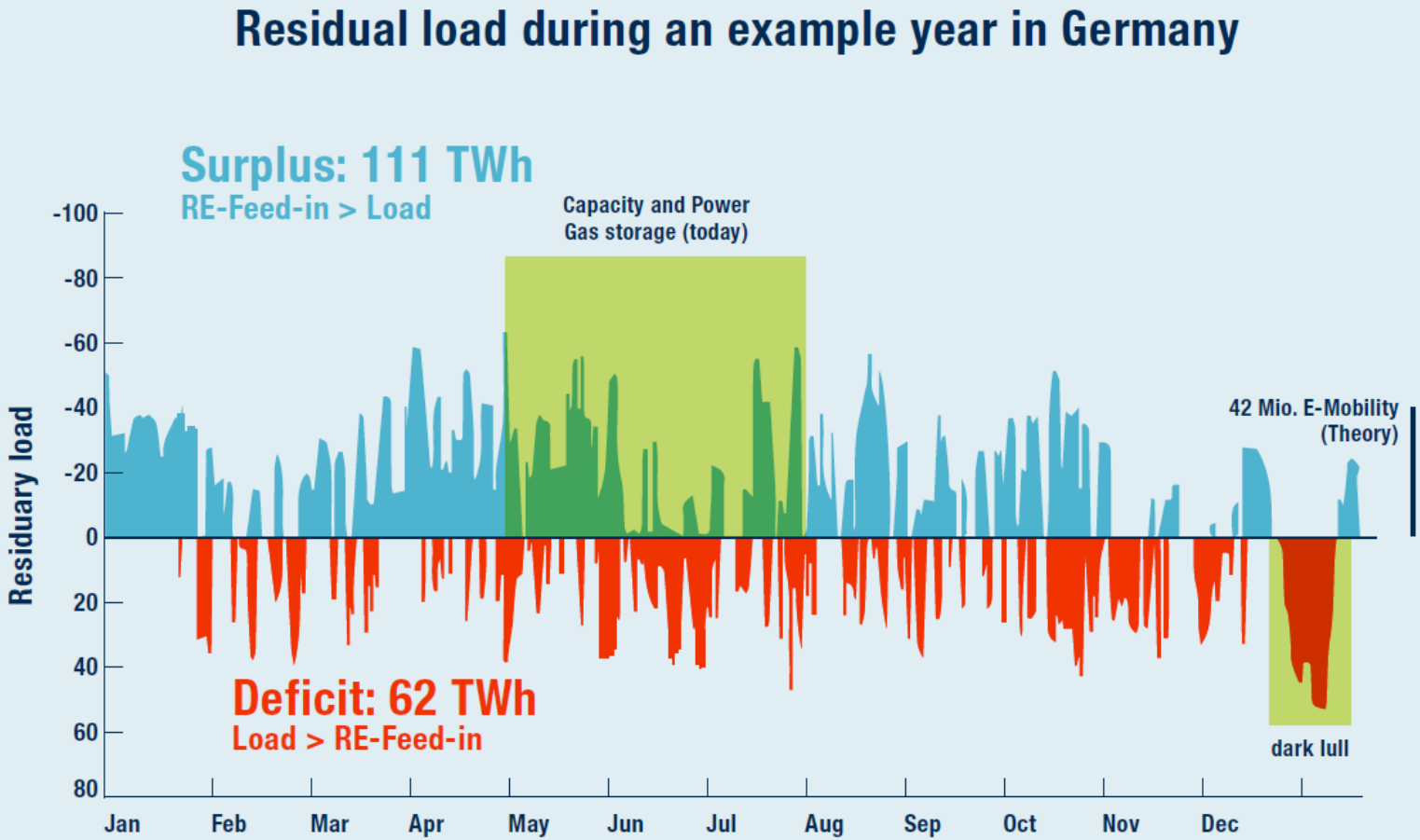
The EU funded STORE&GO project aims at development and operational testing of PtG technologies which can help to fill the gap

Characteristics of Renewables: Load profile



- Supply of renewable power is volatile and excides demand from time to time
- With more renewable energy in the system oversupply will increase
- Without storage capacities, grid operators have to balance the system and have to stop production. The surplus of renewable energy will be lost.
- PtG will enable efficient use of the excess amount of renewable energy by converting it to hydrogen and methane.

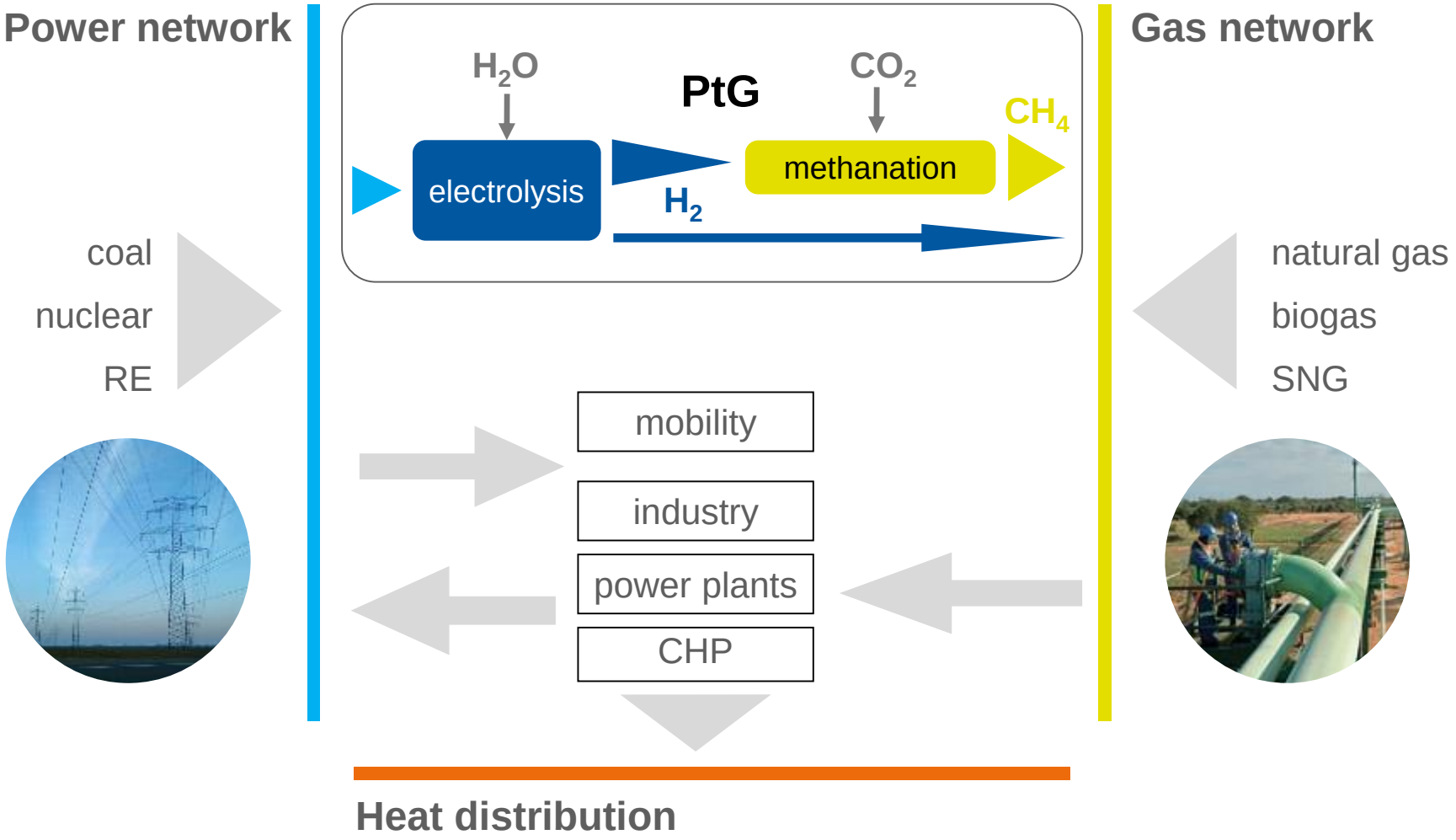
Characteristics of Renewables: Load profile



- Annual surplus of renewable energy 110 TWh > Exceeds the deficit of 62 TWh
- Through the PtG technology it is possible to convert the excess amount of renewable energy into synthetic gas (SNG/ Methane), which can be stored in the gigantic gas network, which offers 230 TWh of storage capacities
- The converted and stored excess energy can then be used – whenever & wherever needed

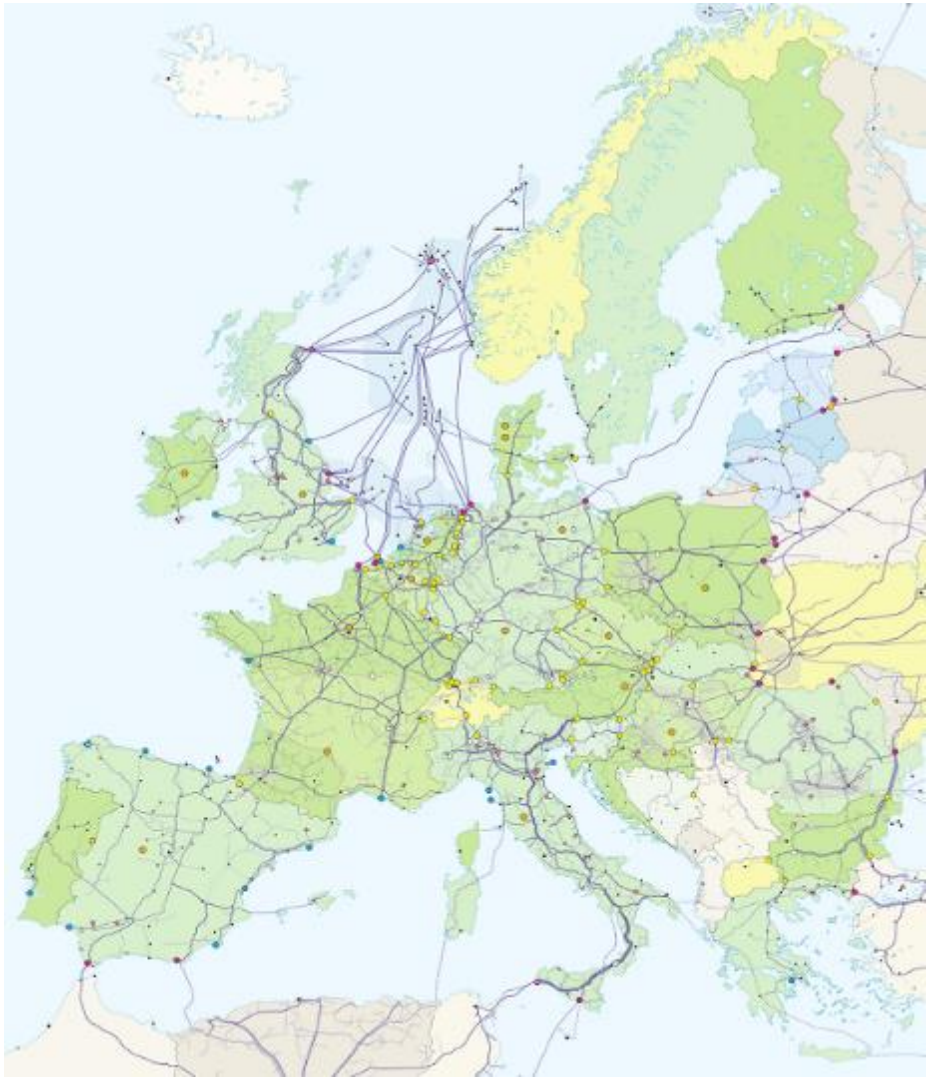
- E-Mobility line illustrates the possible storage potential, if the future electrical car fleet would be used as storage/battery
- Batteries and pump-storage facilities can not offer long term storage for great amounts of energy
- Theoretically, it is already possible today to compensate the load deficit of the en ergy system by enabling the use of surplus energy from renewable energies through PtG

The Role of Power-to-Gas in Future Energy Supply



Energy connectivity through Power-to-Gas

- Europe has a well developed and highly integrated gas supply system
  - 2.2 Mio km of gas pipelines
  - 100 billion m^3 of gas storage
- Highly efficient gas infrastructure to transport energy
- The system can be used to transport and store methane for Power-to-Gas plants



Motivation

To reach the ambitious climate goals we will need innovative technologies, which will be able to unlock the potential of renewable energies in Europe. The PtG technology will provide the necessary tools to address the different challenges our future energy system is facing by producing clean (“green”) gas from renewable power which can

- be stored to support balancing the energy grid and providing gas for backup gas fired power generation
- be used as clean fuel for ships and cars
- be used to fire heating installations
- be used as chemical energy carrier which is needed in many industrial sectors

Power-to-Gas can play a key role as enabler of the energy transition and become a key element of the energy system of the future

One Solution

Power-to-Gas

STORE&GO

Key Facts of STORE&GO

- 27 Partner from 6 European countries
- Duration: 03/2016 - 02/2020
- Construction and operation of 3 PtG demonstration plants
- Extensive accompanying research
- Funding:

Coordinator: DVGW

27 Project Partners will work together in STORE&GO

Project Structure

Management & Coordination *WP 1*

Demonstration Site
PtG concept I *WP 2*
Falkenhagen, DE

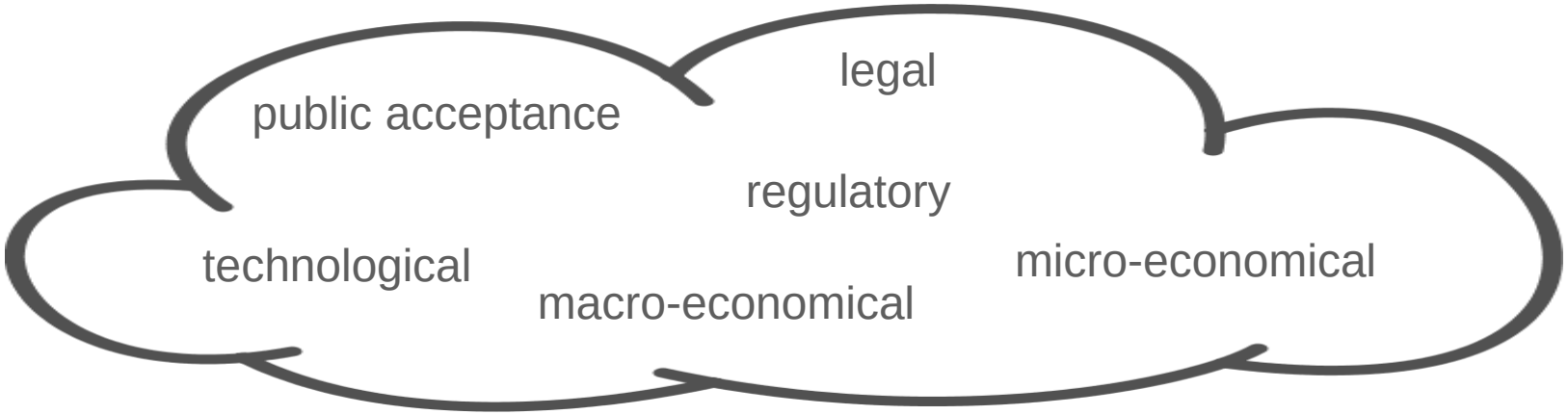
Demonstration Site
PtG concept II *WP 3*
Solothurn, CH

Demonstration Site
PtG concept III *WP 4*
Troia, IT

Cross-cutting activities *WP 5 – WP 8*

Dissemination *WP 9*

Cross-cutting-Activities



Analyse

- access 3 demo sites
- Societal costs
- Legal obstacles
- Regulatory obstacles

Evaluate

- Compare technologies
- Validate models
- Risks and opportunities

Propose solutions

- Business models
- Roadmap PtG
- Promote technology

Cross-cutting-Activities

- Techno-economic analysis of storage demonstration operation
  - Environmental impacts
  - Optimized Operation schemes for gas grids
  - Economic analysis
- Integration of PtG concepts in electricity grid management and power supply
  - Opportunities and options for PtG in the power system
  - Impact analysis of PtG
- Reducing barriers
  - Licensing modalities
  - Regulatory regimes
  - Analysis on future technology options and on techno-economic optimization
- Market uptake
  - Analysis of future demand of ‘green gases’
  - Potentials across the EU
  - Economic costs and benefits of the PtG large-scale storage option

Public relations and dissemination is an important part of the project

- Website with a variety of freely accessible reports (www.storeandgo.info)
- Various online publications and stakeholder information (www.openaccessgovernment.org)
- BRIDGE (www.h2020-bridge.eu)
  - Advisory platform of the European Commission from 36 projects in the field of storage and smart grids
- Political Dinner on October 17th, 2018 in the European Parliament
- Educational Training programme and public events
- Participation in conferences, trade fairs, expert discussions

Three demosites will prove the operational reliability of PtG

Demo Site Falkenhagen

Person:	**Helge Föcker**
Phone:	+49 201 94614 552
E-Mail:	Helge.Foecker@uniper.energy

Demo Site Solothurn

Person:	**Andrew Lochbrunner**
Phone:	+41 32 626 95 05
E-Mail:	Andrew.Lochbrunner@re-gioenergie.ch

Demo Site Troia

Person:	**Diego Arnone**
Phone:	+39 091 751 17 34
E-Mail:	Arnone@eng.it

Facts and Figures of the demosites

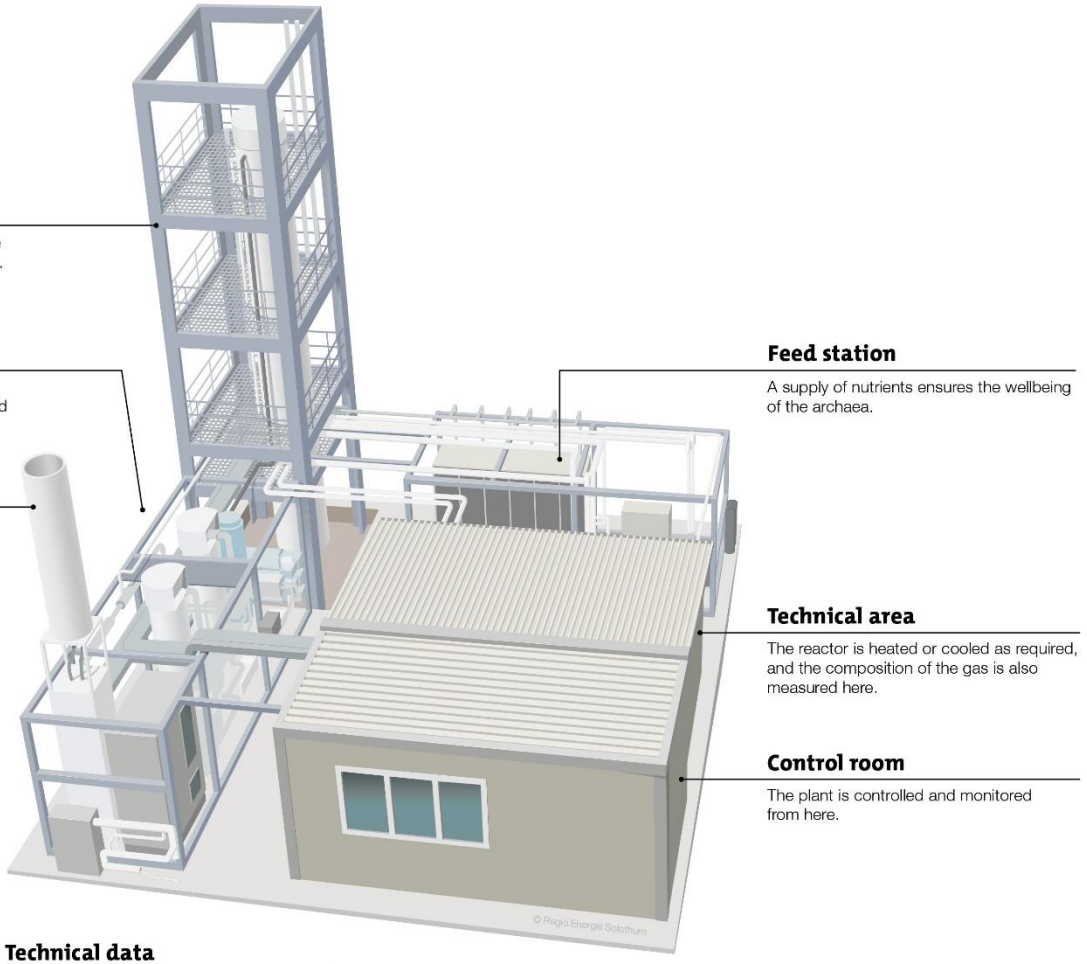
	Demo site Falkenhagen/Germany	Demo site Solothurn/Switzerland	Demo site Troia/Italy
Representative region with respect to typical generation of renewable energies (RES)	Rural area in the North East of Germany with high wind power production and low overall electricity consumption	Municipal area in the Alps region with considerable RES from photovoltaics (PV) and hydro power	Rural area in the Mediterranean area with high PV capacities, considerable wind power production, low overall electricity consumption
Connection to the electricity grid	Transmission grid	Municipal distribution grid	Regional distribution grid
Connection to the gas grid	Long distance transport grid	Municipal distribution grid	Regional LNG Distribution network via cryogenic trucks
Plant size (in relation to the electrical power input)	1.000 kW	700 kW	200 kW
Methanation technology to be demonstrated	Isothermal catalytic honeycomb/structured wall reactors	Biological methanation	Modular milli-structured catalytic methanation reactors
Carbon dioxide (CO_2) source	Bioethanol plant	Waste water treatment plant	CO_2 from atmosphere
Heat integration possibilities	Veneer mill	District heating	CO_2 enrichment
Existing facilities and infrastructure	2.000 kW alkaline electrolyser, hydrogen injection plant	2x175 kW PEM electrolyser, hydrogen injection plant, district heating, combined heat and power plant	1.000 kW alkaline electrolyser

Demosite Solothurn, Switzerland

- Plant size: 700 kW
- Biological methanation
- CO_2 from waste water
- Hydro and PV power
- Urban gas distribution grid

Demosite Solothurn, Switzerland

Demosite Solothurn, Switzerland



Technical data

Opened	January 2019
Reactor volume	3.5 m³
Operating temperature	62 °C

Input	
Hydrogen	120 Nm³/h ≙ 425 kW
Carbon dioxide	30 Nm³/h

Output	
Renewable gas	30 Nm³/h ≙ 325 kW
Waste heat	100 kW

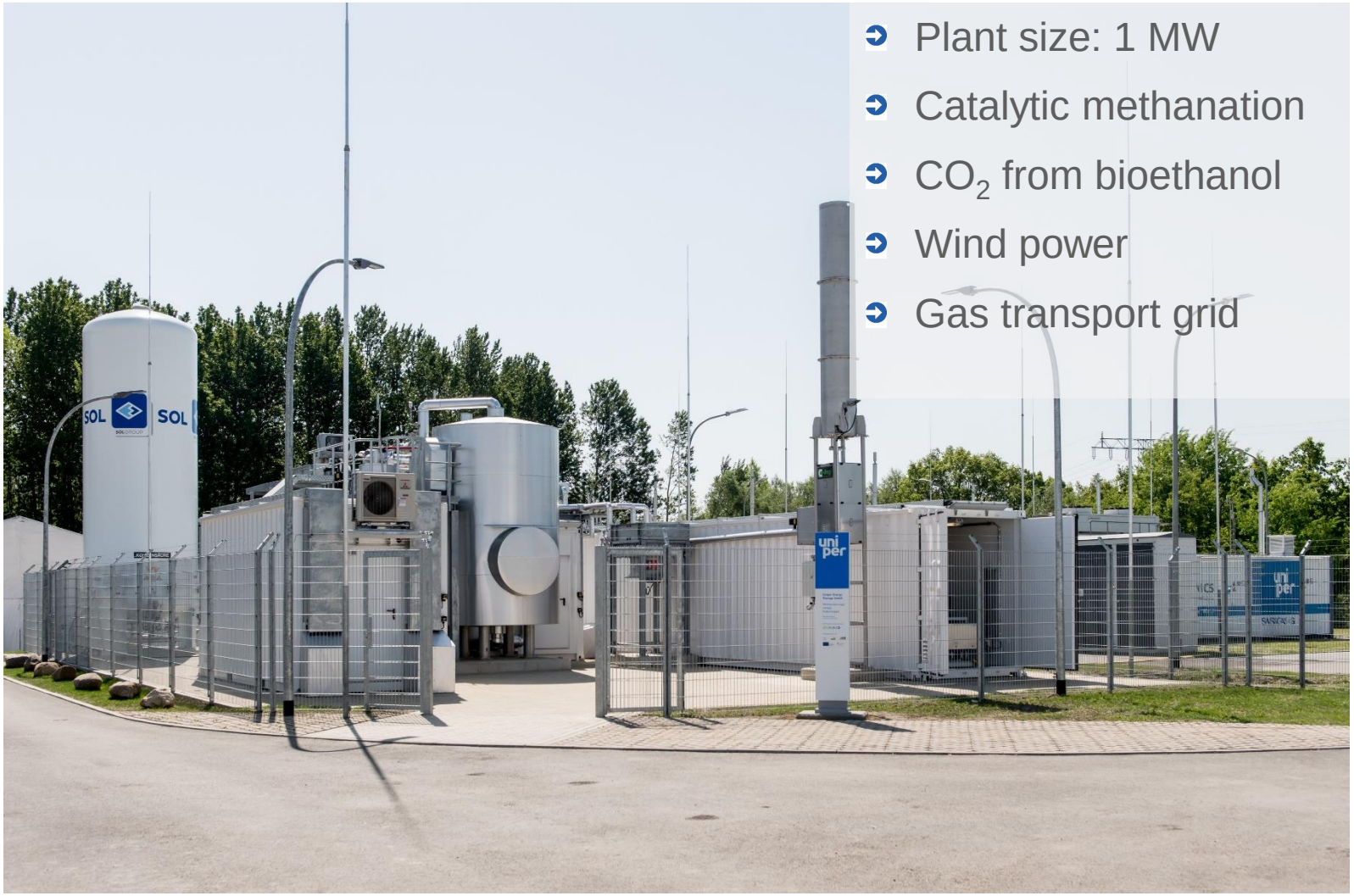
Demosite Troia, Italy

- Plant size: 200 kW
- Catalytic methanation
- CO_2 from air
- Wind and PV power
- Liquefaction to “LNG”

Demosite Troia, Italy

Inauguration Event, September 2018

Demosite Falkenhagen, Germany

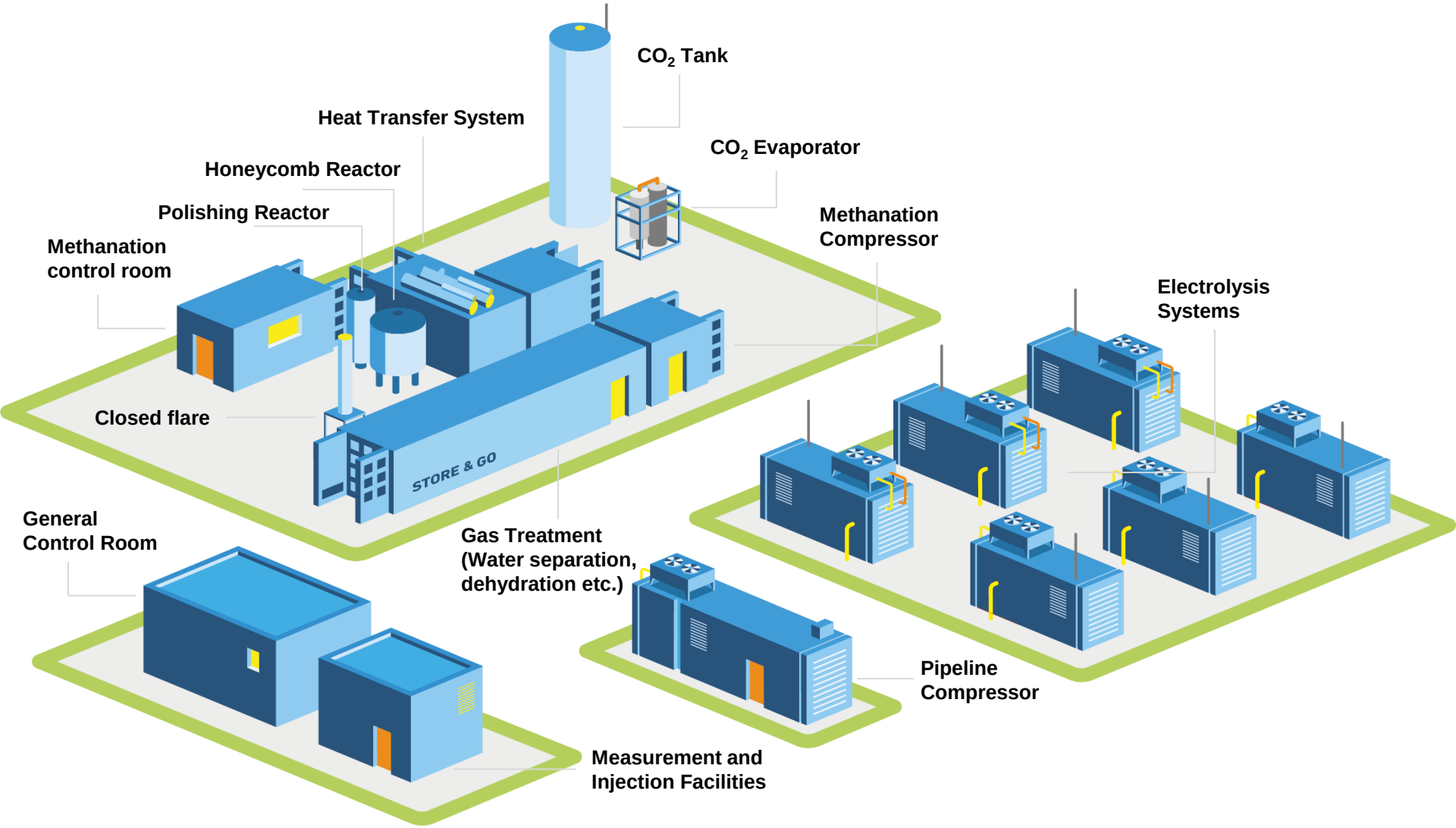


- Plant size: 1 MW
- Catalytic methanation
- CO_2 from bioethanol
- Wind power
- Gas transport grid

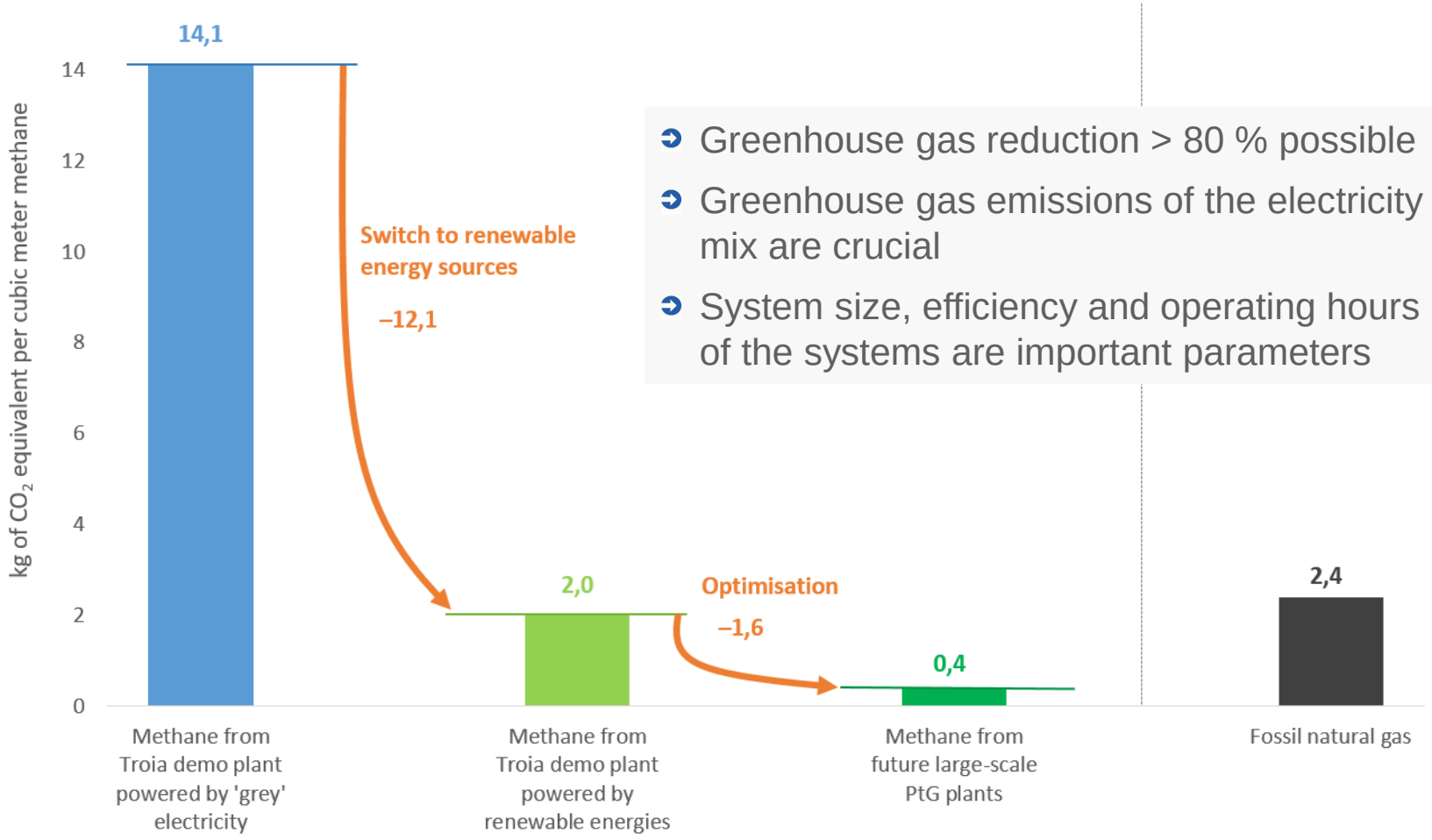
Demosite Falkenhagen, Germany

Inauguration Event, May 2018

Demosite Falkenhagen, Germany

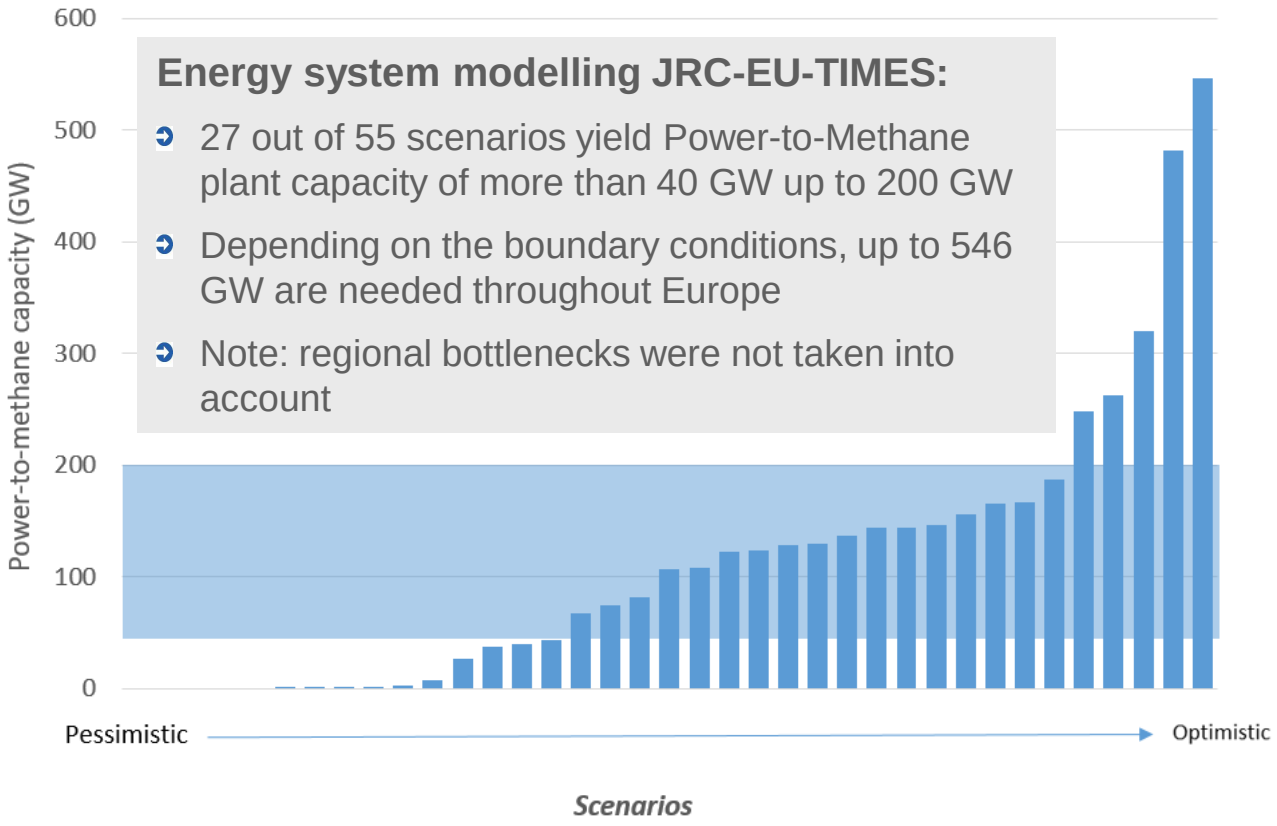


First results: CO_2-Footprint (Troia, Italy)



- Greenhouse gas reduction > 80 % possible
- Greenhouse gas emissions of the electricity mix are crucial
- System size, efficiency and operating hours of the systems are important parameters

First results: The role of PtG in the future energy system



First Results – PtG Legal and Regulatory Framework

- Key questions for a supportive regulatory framework for PtG
  - What is a PtG plant – a unit that converts energy, stores energy or produces chemicals? (double taxation destroys business case)
  - Which is the energy conversion / energy storage step? Up to hydrogen or up to the final chemical energy carrier, e.g. methane?
  - Who may operate a PtG plant – network operators or utility companies?
  - What defines a gas as renewable?
  - How can electricity and heat from renewable gases can be accounted for as renewable?
  - Gas quality standards vary across Europe. Which actions have to be taken to harmonise them?
  - Legal framework still treats separately the electricity world and gas world. Instead how can the energy system be treated holistically in the future?

Key Findings

- With power-to-methane gas, the carbon footprint can be lowered by more than 80% compared to natural gas
- Energy system analysis shows: 27 out of 55 investigated scenarios display a PtG capacity demand of 40 GW up to 200 GW in Europe.
- High generation potential for renewable gas within EU
- The current political framework is not ready for market uptake of power-to-gas and does to support the implementation of PtG

Thank you for your attention!