

Covalion – powered by Framatome

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V4+ Conference - Hydrogen: present and future in
mobility

09.06.2022

covalion

- 1. Covalion – Portfolio**
- 2. Hydrogen refueling stations for buses**
- 3. NPHyCo**

We offer a wide portfolio of products and services

Services

Studies & Consulting

EPC System integration

Projects & Service



Products

Customized PEM electrolyzer

LOHC (storage) applications

Hydrogen refueling station

Hydrogen refueling station for buses

350 bar hydrogen refueling station in Germany

Covalion plans, builds and manages hydrogen filling stations - here in Germany

Hydrogen technology for mobility



hydrogen refueling station for currently 4 buses per day

Capacity sufficient for >20 buses per day

At the beginning about 1000 kg hydrogen stationary

Overview

Planing

Construction

Hydrogen refueling station for buses

350 bar hydrogen refueling station in Germany



Hydrogen technology
for mobility

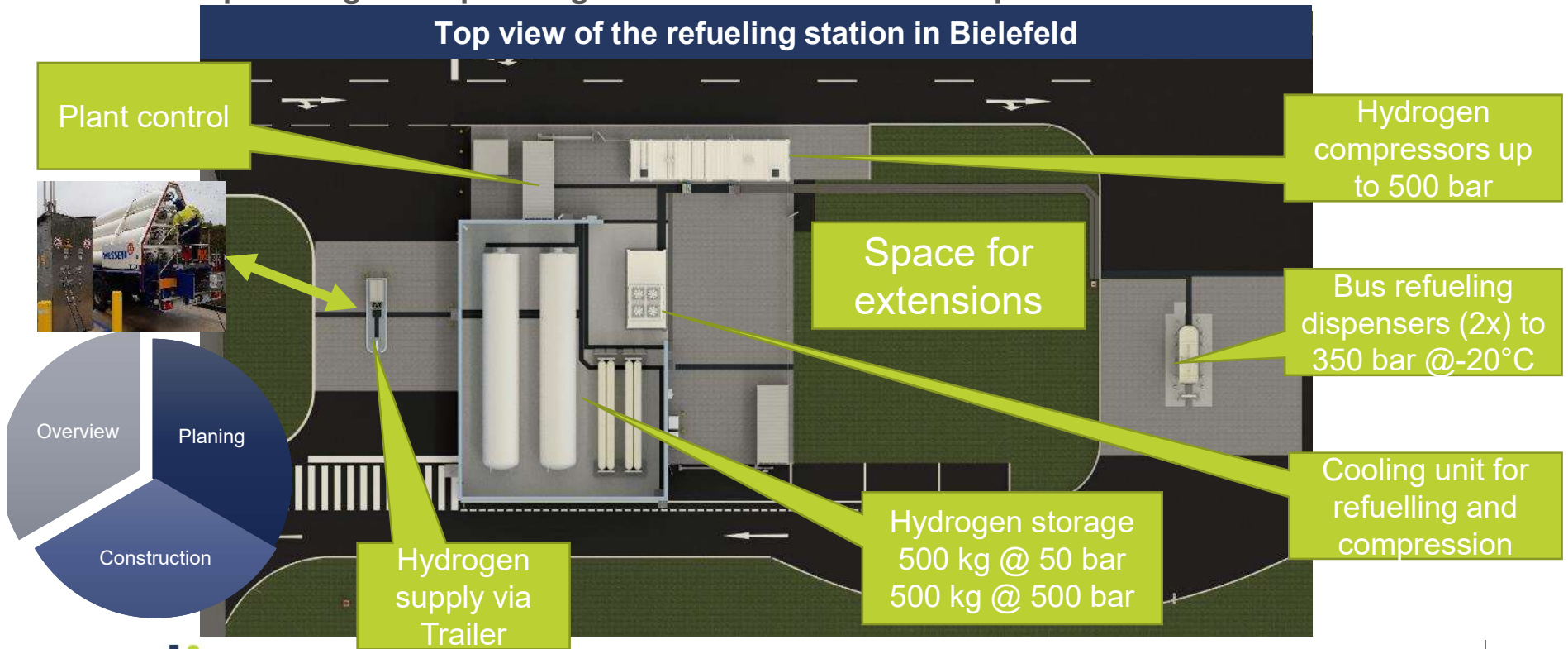


- ▶ Construction work started mid of May 2021 on an undeveloped building site
- ▶ Picture taken mid of April 2022 during commissioning
- ▶ First refueling of buses end of April 2022

Hydrogen refueling station for buses

We provide general planning services across all service phases

Top view of the refueling station in Bielefeld





Development of NPHyCo* projects

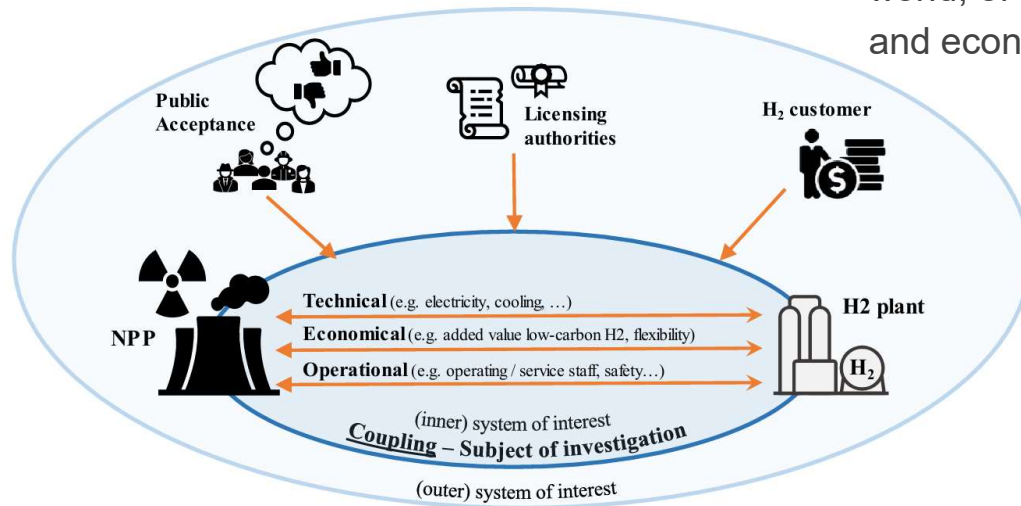
From feasibility study to commercial operation

June 2022

*Nuclear Powered Hydrogen Coproduction

NPhyCo Concept

- **Large scale H₂ generation** projects are new to the world, of high complexity and significant technical and economical risk



- Large scale H₂ generation projects are important for the world to **decarbonize** and achieve **climate goals**, they have high public awareness
 - that offers optimal presupposition for project success at lowest project cost
 - Secures investments and de-risks the project right from beginning
 - We are on your disposal to ensure your project goals

We know both **H₂ generation** and **NPP** + we are **technology independent**

Large electrolyzer

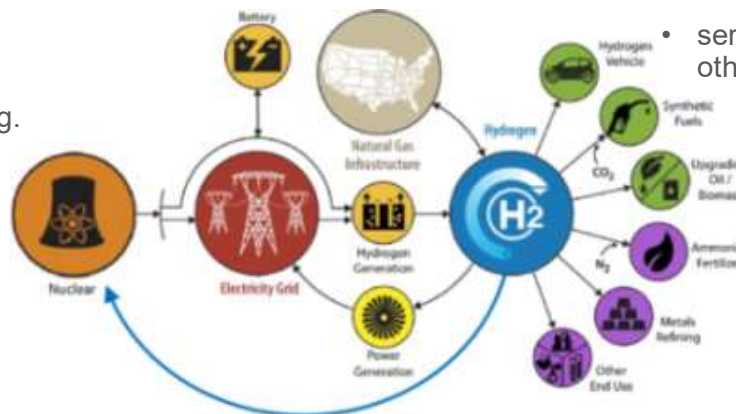
Assumptions

- Hydrogen market in Europe: demand will increase
 - 2030 vision: an installed electrolytic hydrogen production capacity of at least 40 GW¹
- Light water reactors operate often in part-load or load-dependent mode -> their energy production capabilities remain partly unused -> the profitability decreases
- European directives and fundings like e.g. European Green Deal, EU Directive 2014/94 / EC; Renewable Energy Directive (RED II); EU Directive 2018/2001, JIVE-2-Program



Solution

- Use of surplus nuclear electrical power for the production of hydrogen
- The hydrogen can:
 - cover the hydrogen demand of the plant itself
 - be profitably sold for use as fuel (mobility) or industrial applications
 - serve as tradable electricity disposal for other grid operators



¹International Hydrogen Strategies - A study commissioned by and in cooperation with the World Energy Council Germany

Advantages by coupled operation of NPP and H₂ plant



Reducing consequences of load-follow operation demands

- **Allowing load-follow operation** without reducing reactor power (electricity redirection to H₂-generation)
- **Reduces wear and tear** on NPP components



Site advantages at NPP

- Cheap and abundant **electricity** available → additional transformer might not be necessary
- **DI-water available** → additional purification for electrolysis might not be necessary
- **Cooling water** circuit available at NPP site

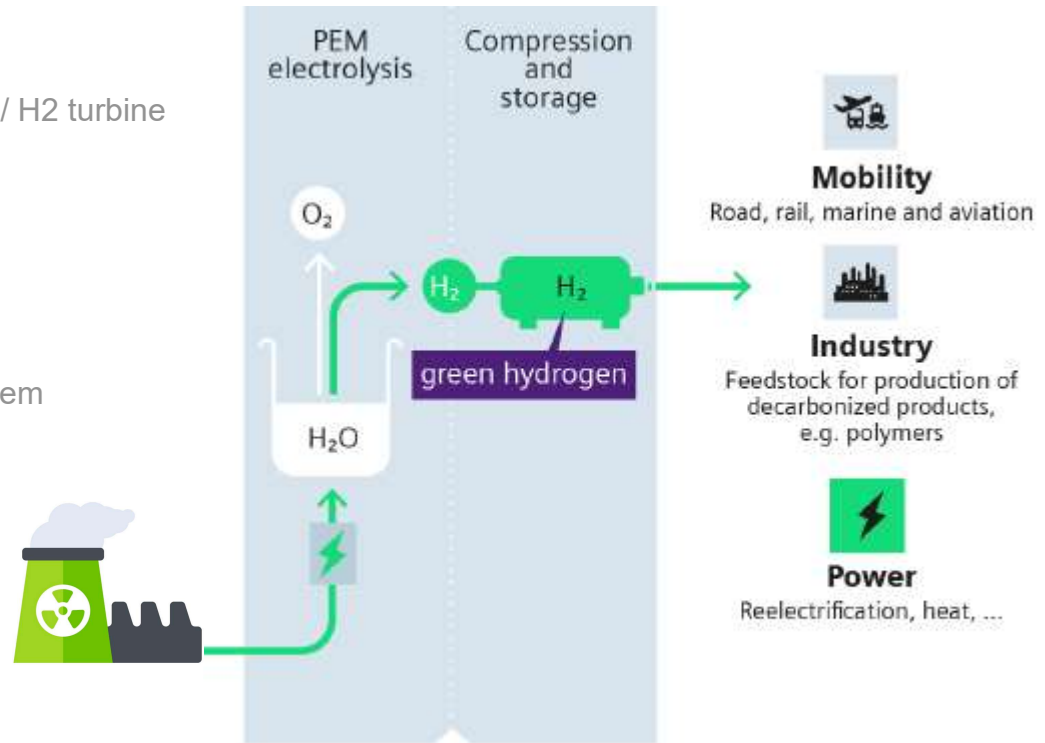


Economic advantages

- **Reduced CAPEX/OPEX** due to existing power, water and gas supplies
- **Diversification of NPP product portfolio** via H₂ business

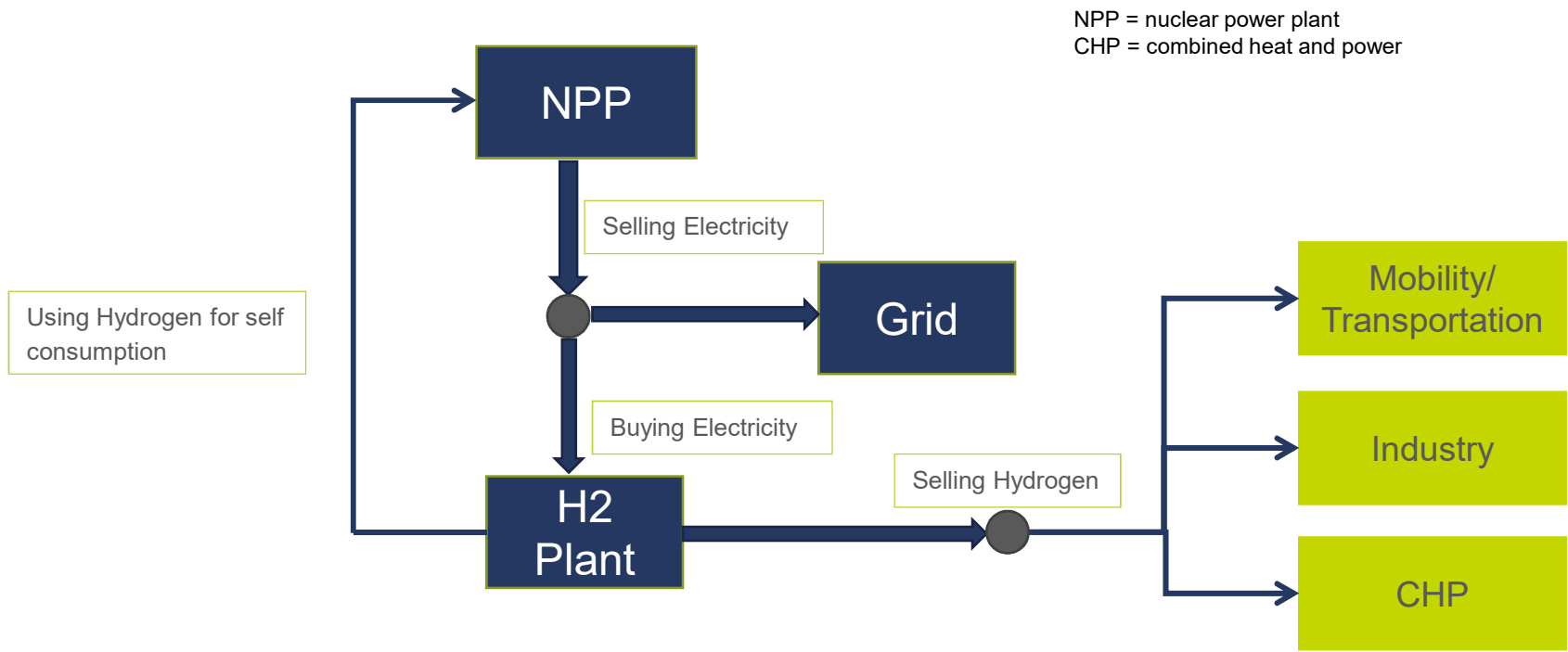
Use of H2

- Grid stabilization e.g. via fuelcell, gas/ H2 turbine
- Hydrogen mobility
 - Buses
 - Cars
 - Trains
- Industry
 - add H2 to the natural gas supply system
 - Chemical feedstock
 - heat



Source: SIEMENS Energy

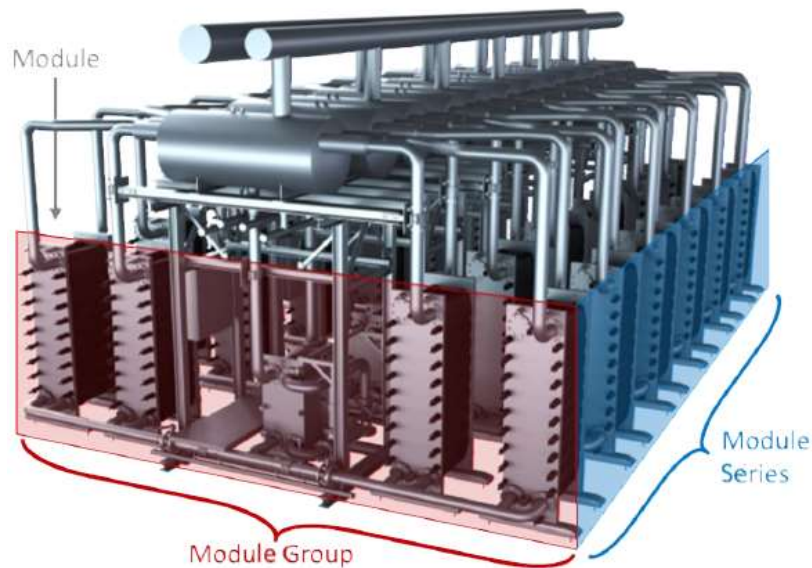
Business Case – Toplevel



Benefit of H2 to NPP coupling

Benefit NPP	Benefit H2 Plant
Use of self produced H2 to cover the H2 demand in the NPP	Use of auxiliary systems already available at the NPP like DI-Water, cooling water, electrical power,
Reduced fire load due to no H2 storage at NPP site	Known safety culture from the NPP personnel
Continuous Operation in optimum load curve which increase the profitability and reduces the costs for maintenance due to reduced load changes to the material	Synergies for service personal with the NPP
Additional income selling H2 to customers	
Easy switching into increased H2 production when prices for electricity are dropping during a day	
Load follow operation just by switching from "Grid" to H2 plant without reducing the reactor power	

Large Scale PEM Electrolysis Plant

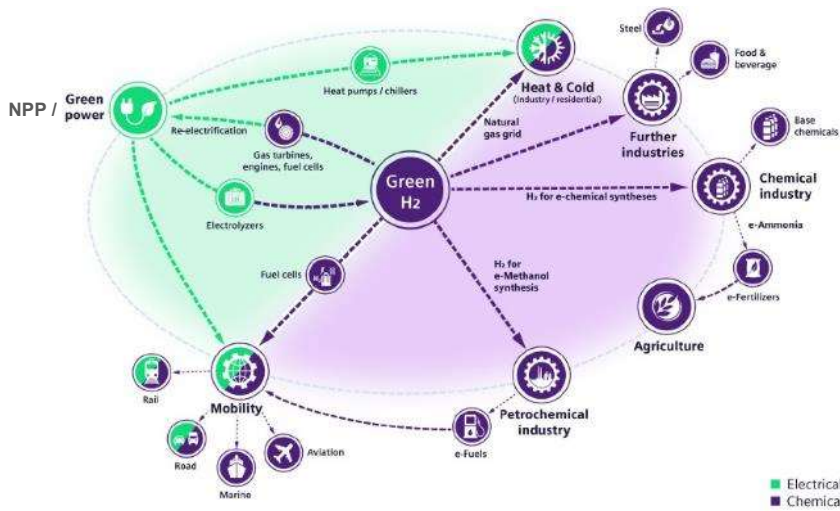


Silyzer 300 PEM module array terminology

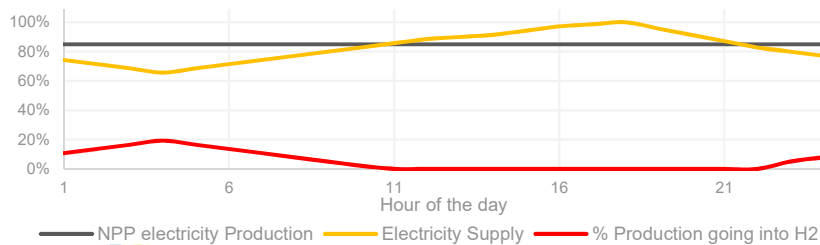
Source: SIEMENS Energy

- Transformer and DC supply
- Scalable Hydrogen Electrolysis System Silyzer 300
- Gas coolers and gas collectors
- Hydrogen Gas Cooler
- Oxygen Gas Cooler
- Process Water Treatment System
- Instrument Air
- Nitrogen
- Control System and Instrumentation & Controls
- Uninterrupted Power Supply

Hypothetical Scenario H2 production as storage



Source: SIEMENS Energy



Plant set up

- An H2 plant is set up close to the NPP
- Excess electricity is used for H2 production via water electrolysis
- The produced H2 is compressed and stored
- The stored H2 is sold to the H2 user

State of the Art

- Alkaline electrolysis (AEL): Long established, mature technology, big scale (>100MW) available
- PEM technology: newer technology, >100MW plants not yet realized, but faster and on smaller footprint than AEL
- No coupling to NPP yet – First-of-a-kind

High Temperature Electrolysis



Source: Sunfire-Hylink SOEC

Hydrogen production	
Net production rate	750 Nm ³ /h
Production capacity dynamic range	5% ... 100 %
Hot idle ramp time	< 10 min
Delivery pressure	0 bar (g)
Hydrogen purity	max. 99,99 %
Power input and electrical efficiency	
System power rating (AC)	2,680 kW
Specific power consumption at stack level (DC) *	3.3 kWh/Nm ³
Specific power consumption at system level (AC) *	3.6 kWh/Nm ³
System electrical efficiency**	84 %
Steam input	
Consumption	860 kg/h
Temperature	150 °C ... 200 °C
Pressure	3.5 bar (g) ... 5.5 bar (g)
Other specs	
Footprint***	~ 300 m ²
Ambient temperature	-20 °C ... 40 °C

* Power consumption at ambient pressure

** Lower heating value of hydrogen referred to AC power input

*** Average space requirement for a 2.68 MW system comprising all auxiliary systems

Why PEM technology and not alkaline?

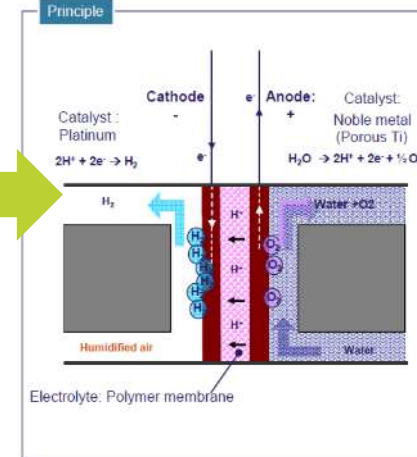
Complete system: PEM electrolyser big
120Nm³/h H₂



PEM stack



Principle



Advantages of PEM electrolysis (vs alkaline):

Small footprint

Quick response

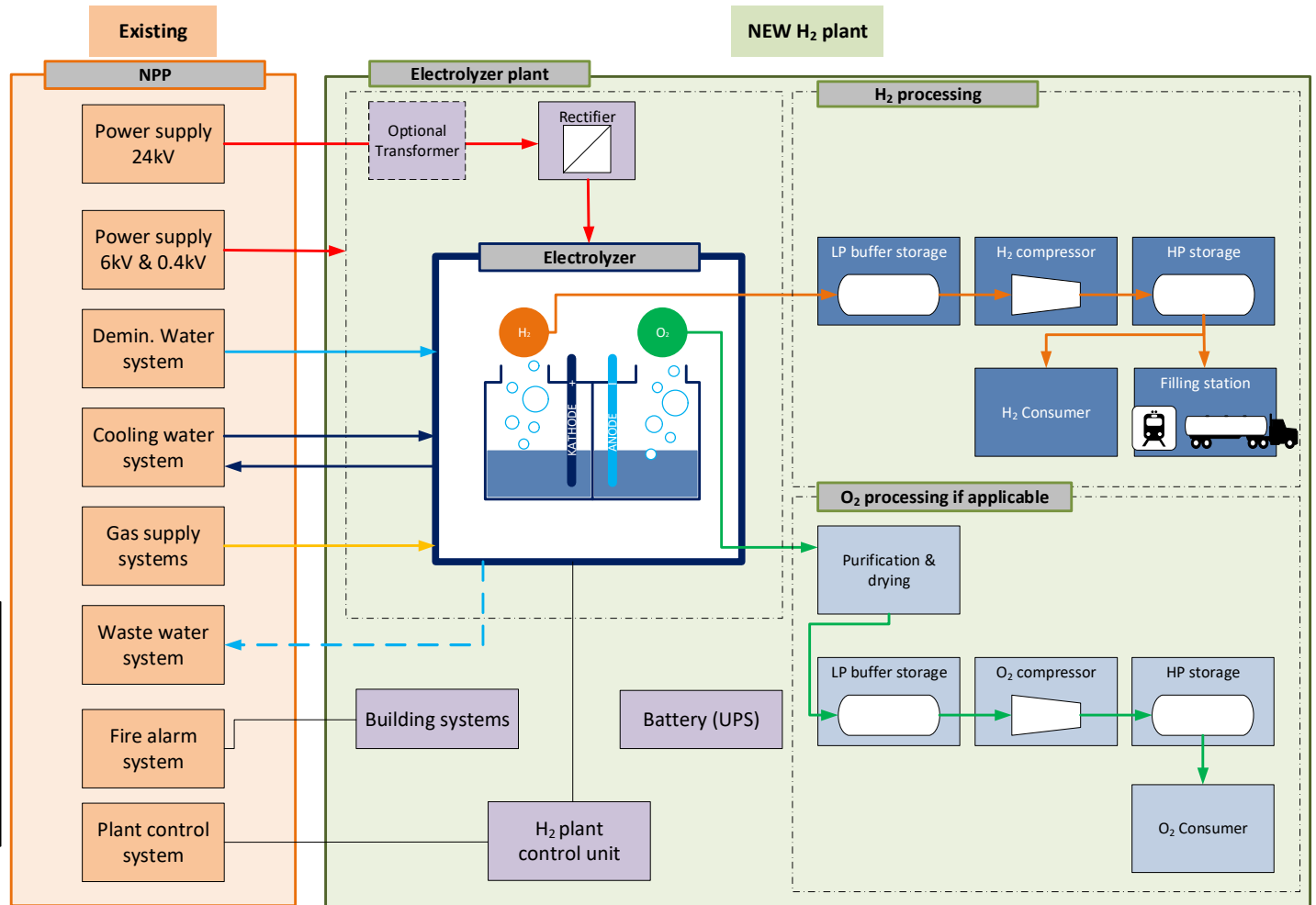
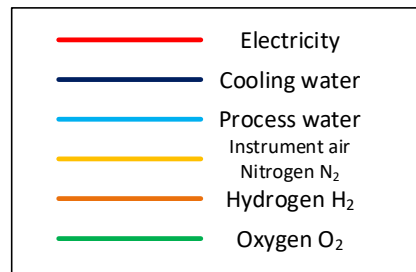
Part load capability: 10% to 150% of nominal capacity

High purity: up to 99.999%

No lye (KOH)

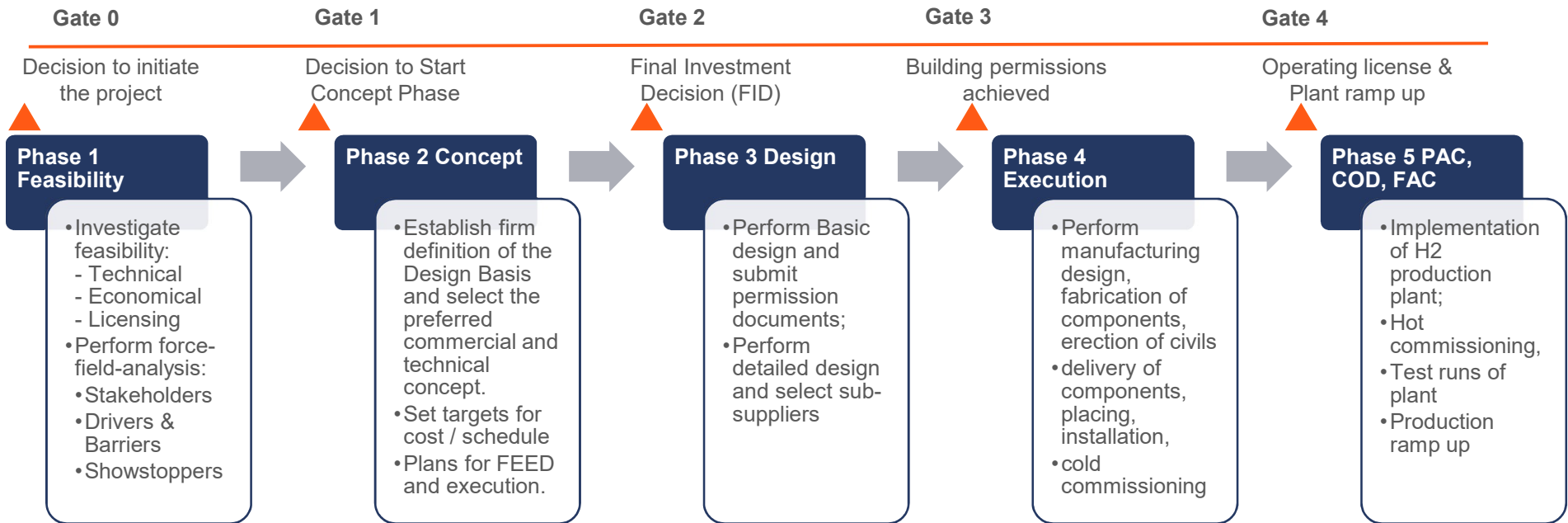
Simpler balance of plant → easier maintenance

NPHyCo Interfaces H₂ plant - NPP



Project Development

From Feasibility Study to COD for a new built H2 plant coupled to NPP



Why to chose Framatome as architect engineer?

Our USP: We know both H₂ generation AND NPP + we are independent

- Long term, trustful and worldwide partnership with NPP
- Decades of experience in planning, designing and execution power plant projects of **large size** and high degree of **complexity**
- All needed engineering disciplines and technical expertise as well as test facilities and laboratories if needed is available inhouse, utilizing Framatome's worldwide subsidiaries and footprint.
- Continuous learning and improvements



VVER reactors in Europe

Balakovo	4x 1000
Kalinin	4x 1000
Kola	4x 440
Kursk	4x 1300 construction (existing 4x RBMK 1000)
Leningrad	2x 1200 + 2x 1200 construction (existing 2x RBMK 1000)
Novovoronezh	1x 440, 1x 1000, 2x 1200
Rostov	4x 1000
Smolensk	4x 1300 construction (existing 3x RBMK 1000)
Khmelnitzky	2x 1000
Rovno	2x 440, 2x 1000
Saporoshje	6x 1000
South-Ukraine	3x 1000
Ostrovetz	1x 1200 + 1x 1200 construction
Kozloduy	2x 1000
Lovisa	2x 440
Hanhikivi	1x 1200 construction
Bohunice	2x 440
Mochovce	2x 440 + 2x 440 commissioning
Dukovany	4x 440
Temelin	2x 1000
Paks	4x 440 + 2x 1200 scheduled
Metsamor	2x 440

- VVER 440
- VVER 1000
- VVER 1200
- VVER 1300



Currently 65 units in operation

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Thank You

