

NPHyCo – Safety & Licensing Roadmap

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Work Packages NPHyCo

WP1: Conceptualisation

This Work Package will focus on conceptualisation of the project.

WP2: Technical Roadmap

This Work Package will focus on the technical conditions related to the coupling of a hydrogen production facility to an existing NPP.

WP3: Economic Roadmap

This Work Package aims to develop a business plan for hydrogen produced from nuclear power.

WP4: Licensing Roadmap

This Work Package will focus on licensing requirements.

WP5: Implementation Roadmap

This Work Package will put forward proposals for pilot plant locations and their layout.

WP6: Communication, dissemination & public awareness

This Work Package focuses on communication around the project.

Topic of today



Contents

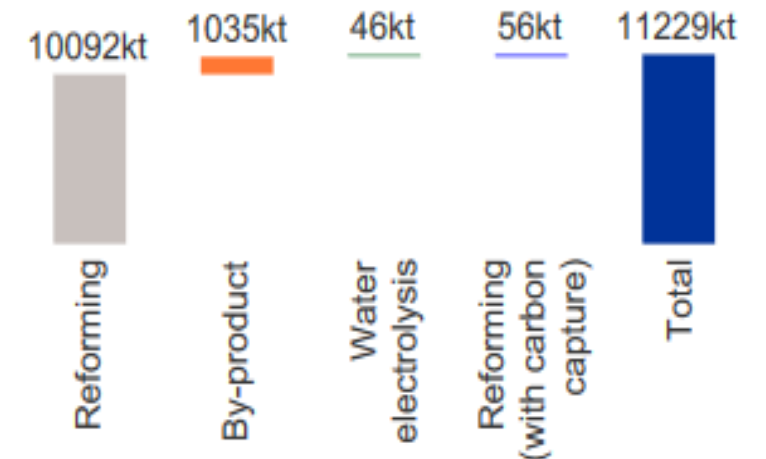
1. Context for Hydrogen in EU
2. Nuclear and hydrogen regulatory framework
3. Safety impact for HPP
4. Overview for Stakeholders
5. Conclusions

1. Context in the EU for (pink) hydrogen

The EU Green Deal: comprehensive framework to achieve carbon neutrality by 2050

- EU Hydrogen Strategy: **10 Mt of renewable hydrogen by 2030**
- Low-carbon hydrogen acknowledged as a transition solution
- EU Taxonomy: Nuclear power is a low-carbon energy source
 - Pink hydrogen awaiting certification as low-carbon hydrogen
- **Low-carbon hydrogen capabilities needed in the short-term**

Total hydrogen production capacity in Europe



Hydrogen generation per source in 2023
[EHO23]



1. European H₂ licensing framework

The European Commission is working on a fully-fledged legislative framework for H₂, covering:

- production,
- consumption,
- infrastructure development,
- market rules for a future hydrogen market,
- as well as binding quotas for renewable hydrogen consumption in industry and transport.

However this framework is not yet active!



2. Licensing framework

- Hydrogen has no specific legislation, it is seen as a dangerous chemical substance falling under **SEVESO directive**.
- Currently no formal EU regulations/ provisions to support the scale-up of low carbon Hydrogen production and/or consumption.
- Co-generation of hydrogen by NPP is (in principle) possible but needs approval by the authority.

2. License documents HPP on-site NPP vs. off-site NPP (no coupled facilities)

HPP off-site / stand-alone	HPP on-site a NPP
Location selection (siting)	n.a.
Environmental impact EIA	Update of NPP EIA for HPP / limited scope?
Industrial emissions	Update of NPP documentation
Safety report HPP	Safety Report HPP + no risk increase for NPP
Explosion protection (ATEX)	Explosion Protection (ATEX)
Occupational Health and Safety	Occupational Health and Safety
Emergency provisions & preparedness	Update NPP emergency preparedness
Construction license/building regulations	Construction license/building regulations
	Update Nuclear License + documentation

2. License documents for NPP-HPP coupled

Type of document

MoC plan for each connection, including safety case

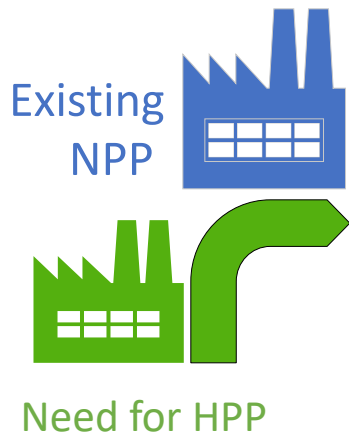
Update of operational & accident procedures

Update of Safety Assessment Report (SAR) + Safety Report (SR)

NPP license update

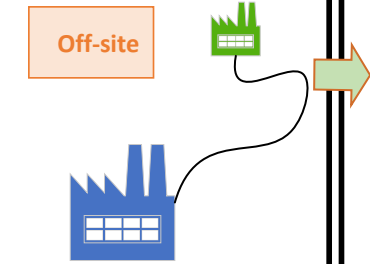
Legend

- Hydrogen
- Nuclear
- Combined



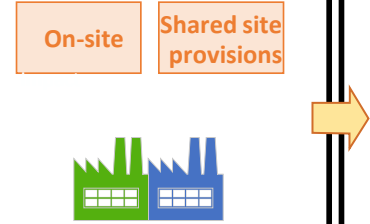
Configuration | **Required license documents**

Minimal integration



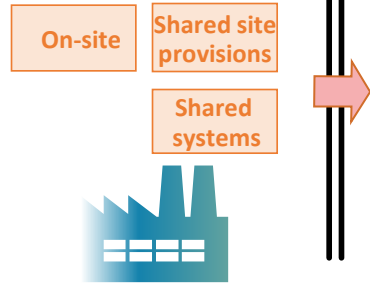
Hydrogen	Nuclear	Combined
HPP licenses	Update SAR ?	
HPP Safety Report		
EIA, emissions		
Land-use / siting		

Limited integration

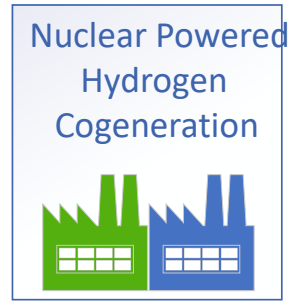


Hydrogen	Nuclear	Combined
HPP licenses	Updated license	EIA
HPP Safety report + impact on NPP	Updated SAR + HPP + modifications	Land-use / siting

Full integration



Hydrogen	Nuclear	Combined
HPP licenses	Updated license	EIA
HPP Safety report + impact on NPP	Updated SAR , incl. HPP modifications	Land-use / siting
	Several MoC's	
	Operational & accident procedures	



3. Safety aspects of Hydrogen

Hydrogen main hazardous properties

- Highly diffusive and prone to leakage (small molecule)
- Highly flammable and explosive (high reactivity)
- Low volumetric energy density (requires compression)

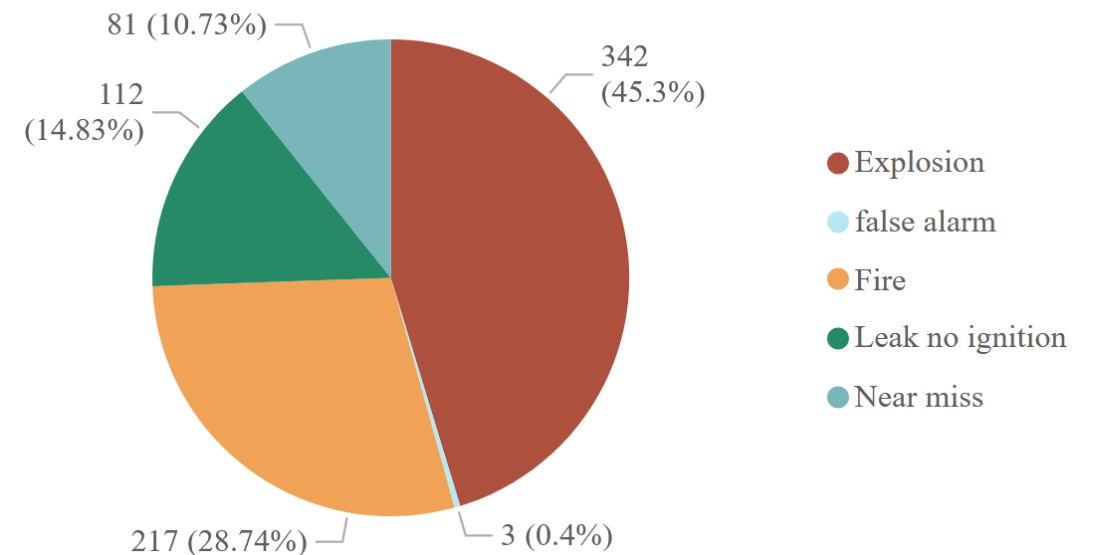
The impact assessment should address

- Fire hazards (heat radiation)
- Explosion hazards (blast pressure wave + fragmentation / projectiles especially from pressurized cylinders)

Determination safety management strategies

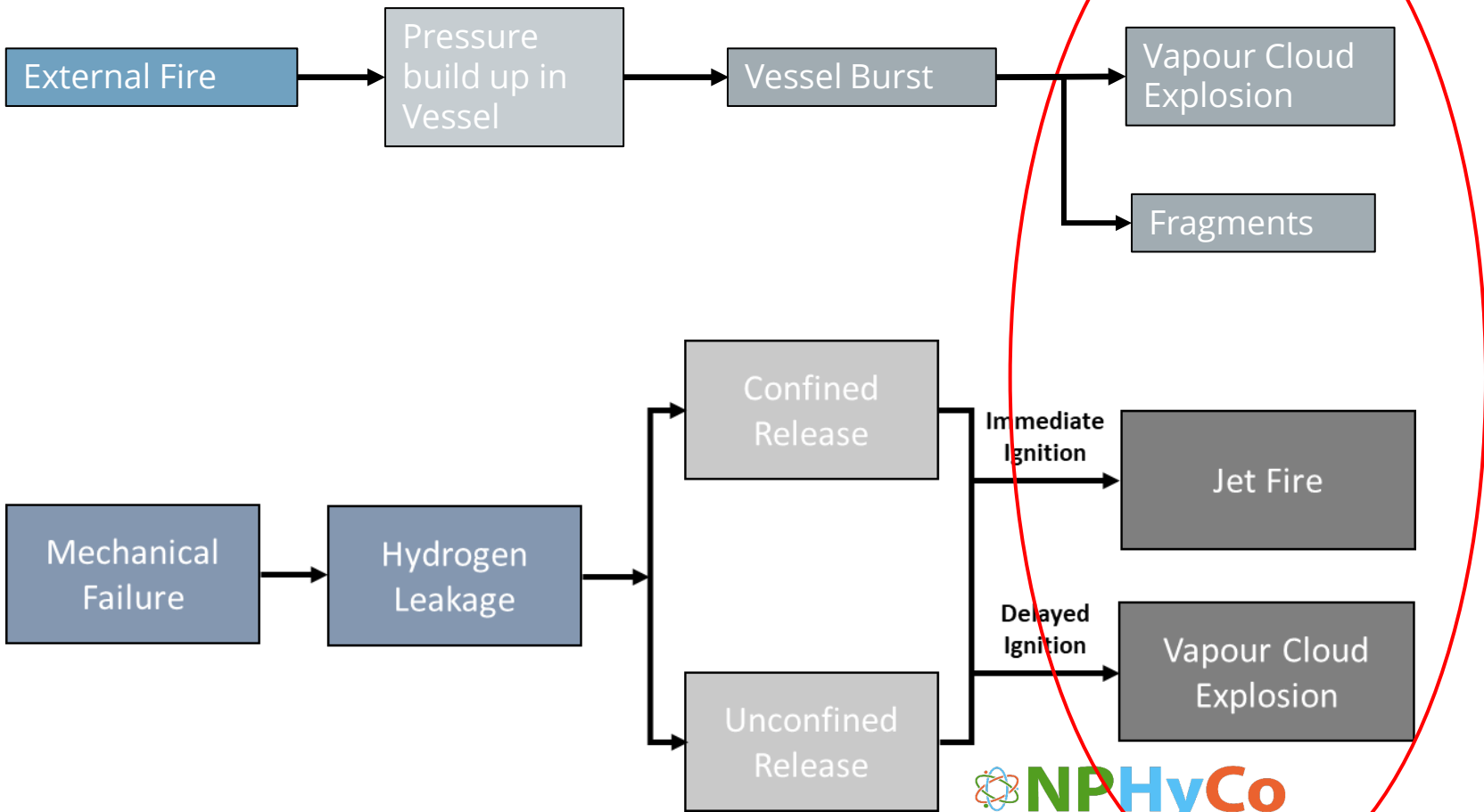
- European ATEX and Seveso directives
- Prevention: 'safe design' and reduction of H2 inventories
- Mitigation: safety distances and physical barriers

Nature of consequences



Statistics HIAD 2.1 EU Database, worldwide hydrogen-related incidents for 2010 – 2023 [HIA24]

3. Identification of Relevant Accident Scenarios



- Possible events :**
1. **Fragments + VCE**
 2. Jet fire (immediate ignition)
 3. Vapour cloud explosion (delayed ignition)

3. Safety Distances for Vessel Burst / Fragments

Fragment shape	Explosion energy to fragments			
	20 % (recommended)		10 %	
	Velocity (m/s)	Range (m)	Velocity (m/s)	Range (m)
Hemispherical cap (tumbling)	145.72	431.10	103.04	323.33
Hemispherical cap (no tumbling)	145.72	564.10	103.04	324.36
Cylinder body (edge on)	145.72	326.51	103.04	37.29

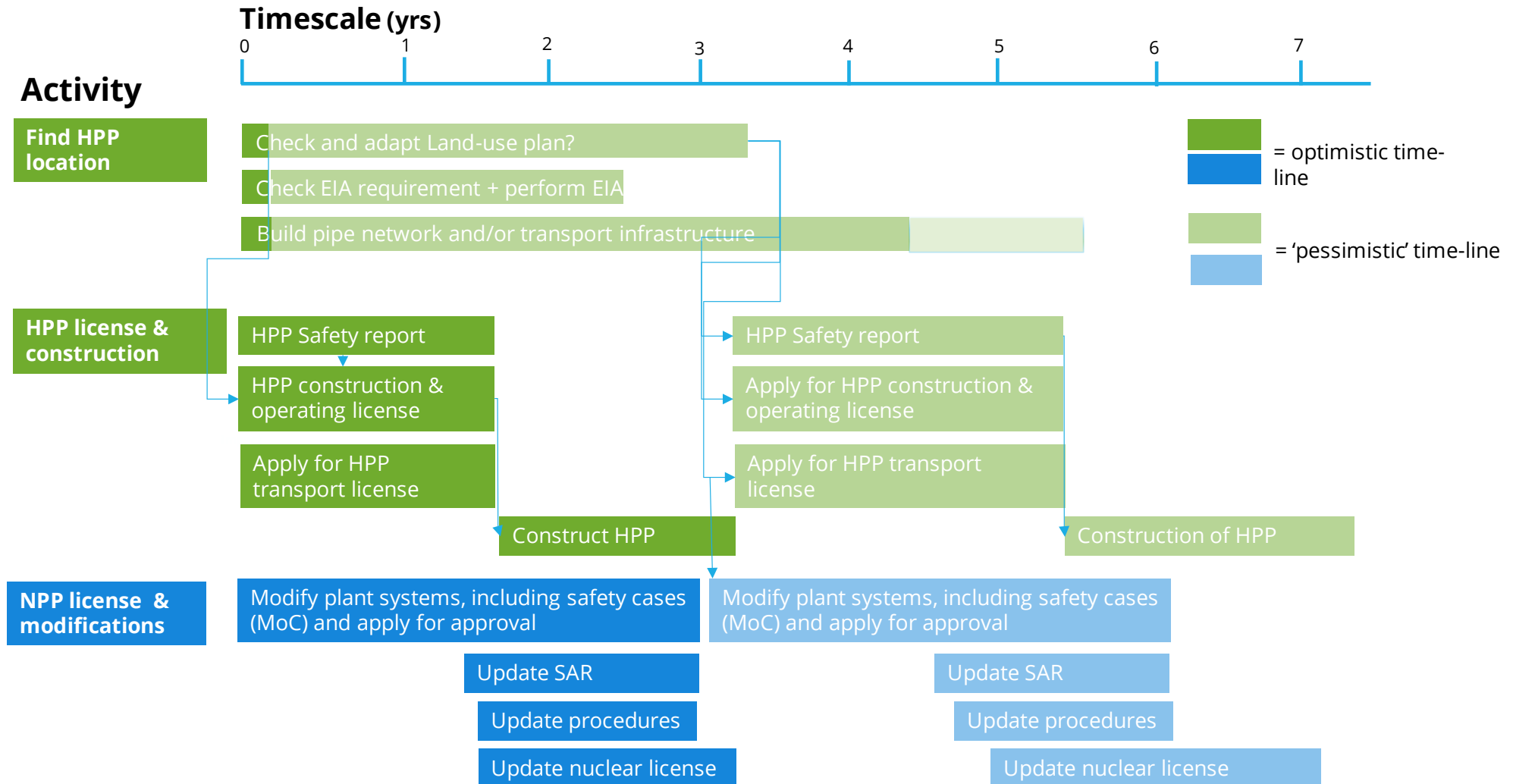
- Safety distances for vessel burst are smaller than for a Vapour Cloud Explosion

3. Safety Distances (Vessel burst - VCE)

Minumum separation distance	Meters	Models
30 kg of hydrogen at electrolyser facility	151-165	Baker-Strehlow (10 kPa) and Brode (5 kPa)
1000 kg of hydrogen at electrolyser facility	488-520	Baker-Strehlow (10 kPa) and Brode (5 kPa)
5000 kg of hydrogen at storage facility	820	Baker-Strehlow (10 kPa) and Brode (5 kPa)
15000 kg of hydrogen at storage facility	1180-1200	Baker-Strehlow (10 kPa) and Brode (5 kPa)

- Safety distances for the electrolyser itself are in the order of a few hundred meters
- Safety distances for the hydrogen storage can amount upto 1200 meters.
- Large hydrogen storage should preferably be located outside the NPP site.
- (Pipe line transport will reduce the required size of the hydrogen storage significantly.)

4. Licensing time-line (indicative)





4. Overview for Stakeholders

Next figure gives a schematic overview of the main parameters, aspects and processes for stakeholders involved in decision making for HPP-NPP-coupled production.

Incentive to invest in NPP-HPP Coupling

NPP-HPP Business Case Envelope

- NPP-Owner Mission, Strategy, Legal & Financial Constraints

External Economic Drivers

Revenues

- Electricity price (trends)
- Hydrogen price (trends)
- Other incomes (O₂, CO₂ monetization, E-dispatching)

Determining factors

- Competitors and Alternatives
- Location factors (e.g. infrastructure, legislation)
- Delivery and Customer factors (e.g. distance)

Internal Economic Drivers (Owner NPP)

- e.g. Size and Characteristics of Site (units and facilities)
- e.g. Investment Willingness and Capacity

Assessing Economic Performance NPP-HPP Combinations

Determination of Consequences

- Licensing
- Modifications
- Operability

Determine and Assessing Integr. Scenarios

- Technical
- Safety

Selecting HPP Technology

- Capacity
- Product grade
- Maturity

Result of investment



Finance-, design-, license-process; construction & commissioning

HPP-NPP configuration and boundary conditions

- Capacity
- Technology
- Integration grade
- Flexibility features
- Future readiness
- Location
- Products
-

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5. Conclusions

1. Safety, Licensing and Technical Design are no showstoppers for HPP-NPP coupling or shared systems.
2. The main determining criterion for sharing systems is economical / financial.
3. Shared systems may complicate and prolong the licensing process but could create financial benefits.
4. Large storage of hydrogen creates large safety distances and will complicate siting and licensing. Operation- & distribution solutions that require no or small storage amounts are strongly preferred from safety and licensing point of view.

Thank you for your attention!

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