Ammonia

an Energy Buffering Solution for the Future

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Proton Ventures, Netherlands

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Today's talk...

- We start with a quick introduction of Proton
- Ammonia as an energy buffering solution
  - Not just as a fuel, but in fact as a *Working Fluid*
  - There are many experts here in this room, who can do a better job than I while talking about combustion characteristics of ammonia, engine control systems, emissions, etc.
  - But at Proton we see great potential in ammonia as a fuel, due to the **flexibility** it offers when compared to other alternative fuel choices.

Today's talk...

- Yesterday we had a presentation, which was quite interesting, where the presenter spoke about ammonia not just as a chemical NH3,
  - with chemical reactions, combustion characteritics, exhausts... Etc.
  - But NH3 as a fuel... with subsequent interactions with society
- At Proton we find it is important to see ammonia as a fuel, but as part of society.
  - Not just the combustion characteristics are important but equally important is the understanding of the System within which it operates
- What comes first – ammonia, ammonia engine, laws, rules, standards... Top – down or bottom – up?
- Hence we are looking at the entire supply chain – from Well to Wheels if you may, from production to usage, to study how Ammonia as a fuel system will look like

Today's talk

- This will be discussed w.r.t two projects Proton is part of

PAKRI Project in Estonia

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Maasvlaakte 2 Project in the Netherlands

Proton Ventures

Proton Ventures

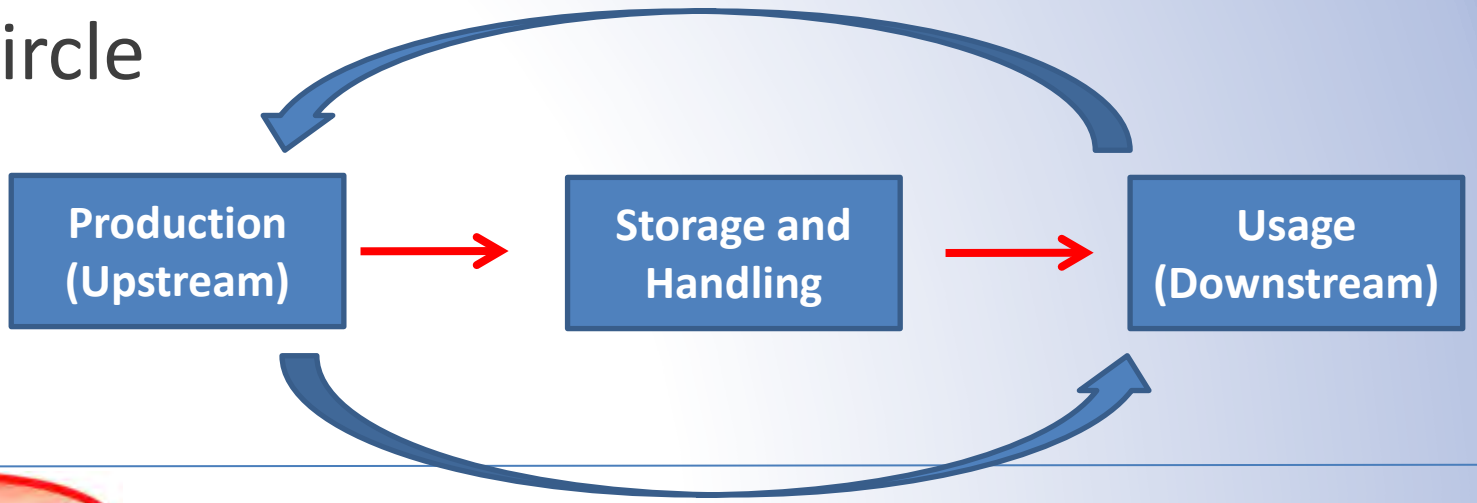
- Recently completed Projects: Ammonia Terminal, Estonia
  - EPC
  - Turnkey solution

Proton Ventures

- Recently completed Projects: Cooling Towers, Netherlands
  - Outsourcing utilities
  - Design, Build, Own and Operate

Proton Ventures

- Proton's New ammonia terminal is coming up in Bulgaria
- So far our focus was on Ammonia storage and handling
- Now we are moving towards completing the circle



Proton Ventures

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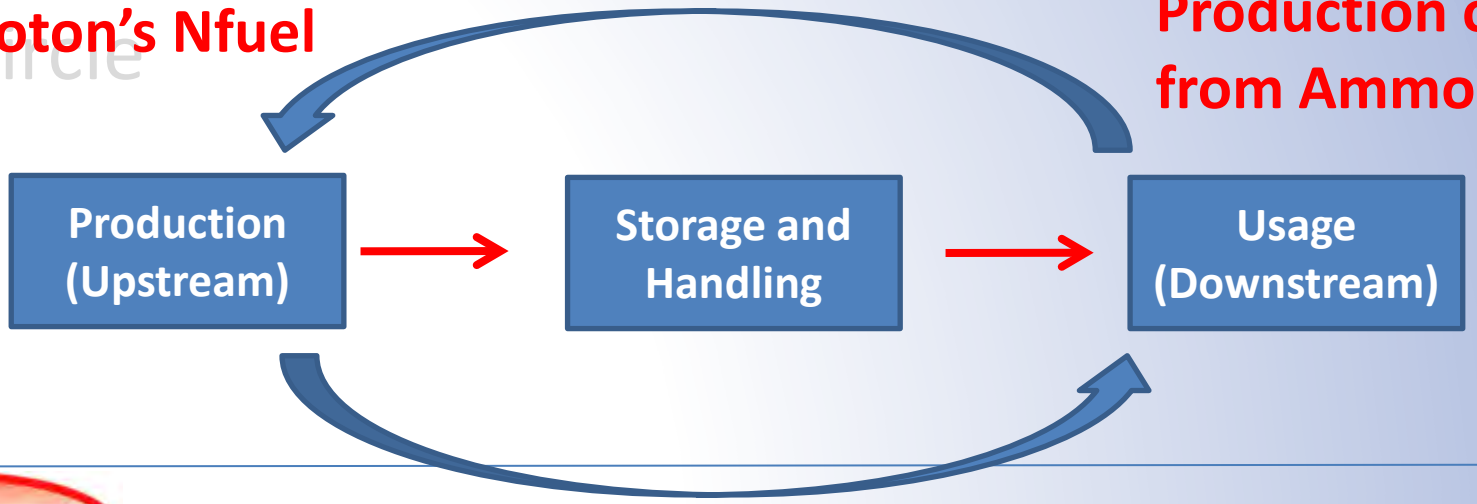
Decentralized Ammonia production via Proton's Nfuel units

On demand Production of Power from Ammonia



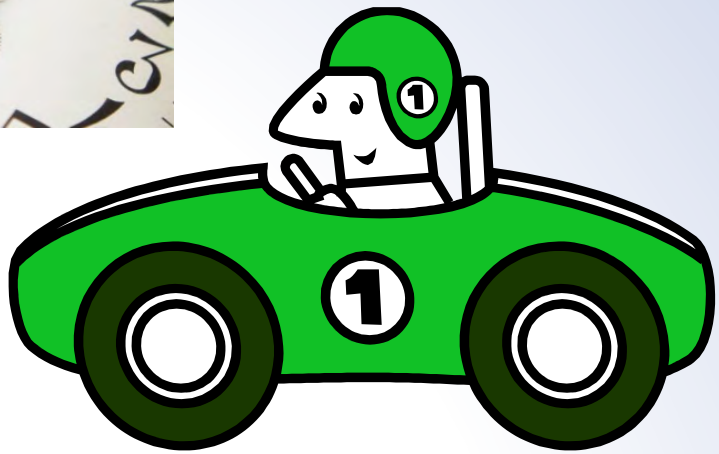
Why Ammonia

- Its strength is its Flexibility potential
  - Fertilizers
  - Nox capture
  - Industrial chemical
  - Fuel
- Infrastructure is available
  - No need to reinvent the wheel
  - Build on existing competencies
- Yesterday's presentation by Bill Leighty spoke about Alaska's stranded energy islands.
  - Why have 3-4 supply chains for different fuels/fertilizers/energy carriers...
  - Why not just 1 that does addesess all the society's needs.
  - Ammonia is not just an energy carrier. But a working fluid.

Ammonia as a Fuel just seems a Smart Option

- No other working fluid has the depth and reach that ammonia has already.

Fossil fuels



A Big Problem …
One day the oil will end

Status quo

- Currently fossil fuels cater to about 80% of the World's primary energy demand, and the remainder of 20% demand is catered by alternative energy resources
  - Wind is an option
  - Solar is an option
- But the problem is fluctuations!!
- Problem is Handling and Transport losses
- Problem is buffering these thin resources that fluctuate

Fluctuations

- Affect availability
  - Demand side has peak-offpeak or seasonal fluctuation

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Fluctuations

- Affect availability
  - Production of renewable energy is characterised by fluctuations

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Grid imbalance

- Fluctuations lead to grid imbalance
  - Leading to energy wastage
  - Curtailment issues
  - Power shortage

Source: Nationalgeographic.com

Energy shortage

- Personally I do not think we have a shortage of energy,
  - but rather problem with logistics
  - We have inefficient transportation systems, where losses can be avoided.
  - There are losses, theft, corruption, rules, laws, etc

Example of India

- 50% of the power is unpaid for
  - Reaches where it shouldnt
  - Leading to Power shortage/frequent power cuts

What is the solution to our energy problem?

- Reduce our energy usage
  - Thats not gonna happen
- Maybe Recycle, Reuse...
- Bridge supply and demand in a better way

Bridge the energy balance

If not balanced correctly

Surplus

Shortage

Storage

Production (Upstream)

Usage (Downstream)

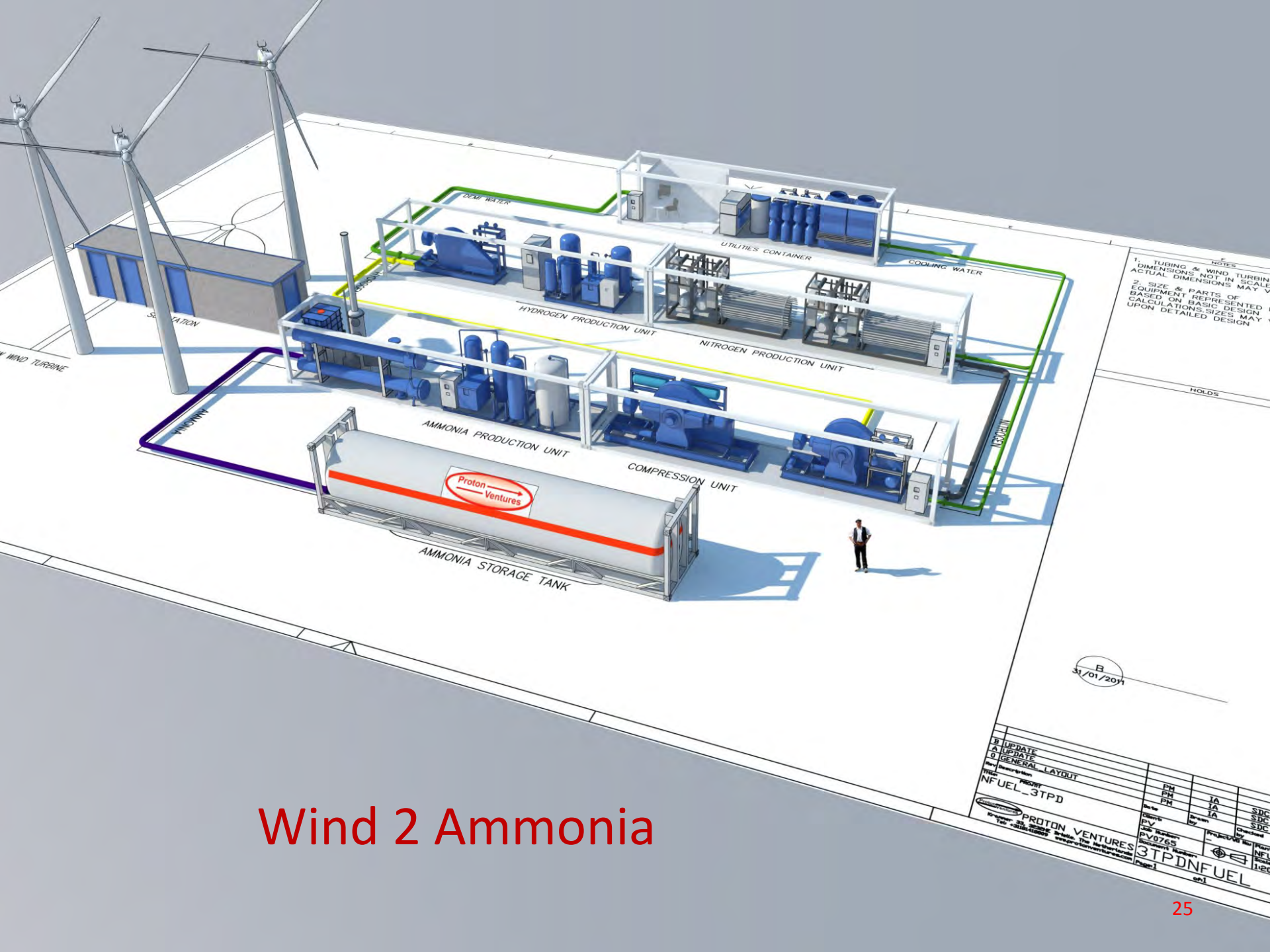
Most important thing about Energy is that it should be **available** when it is needed.

Lightning has tremendous energy content,

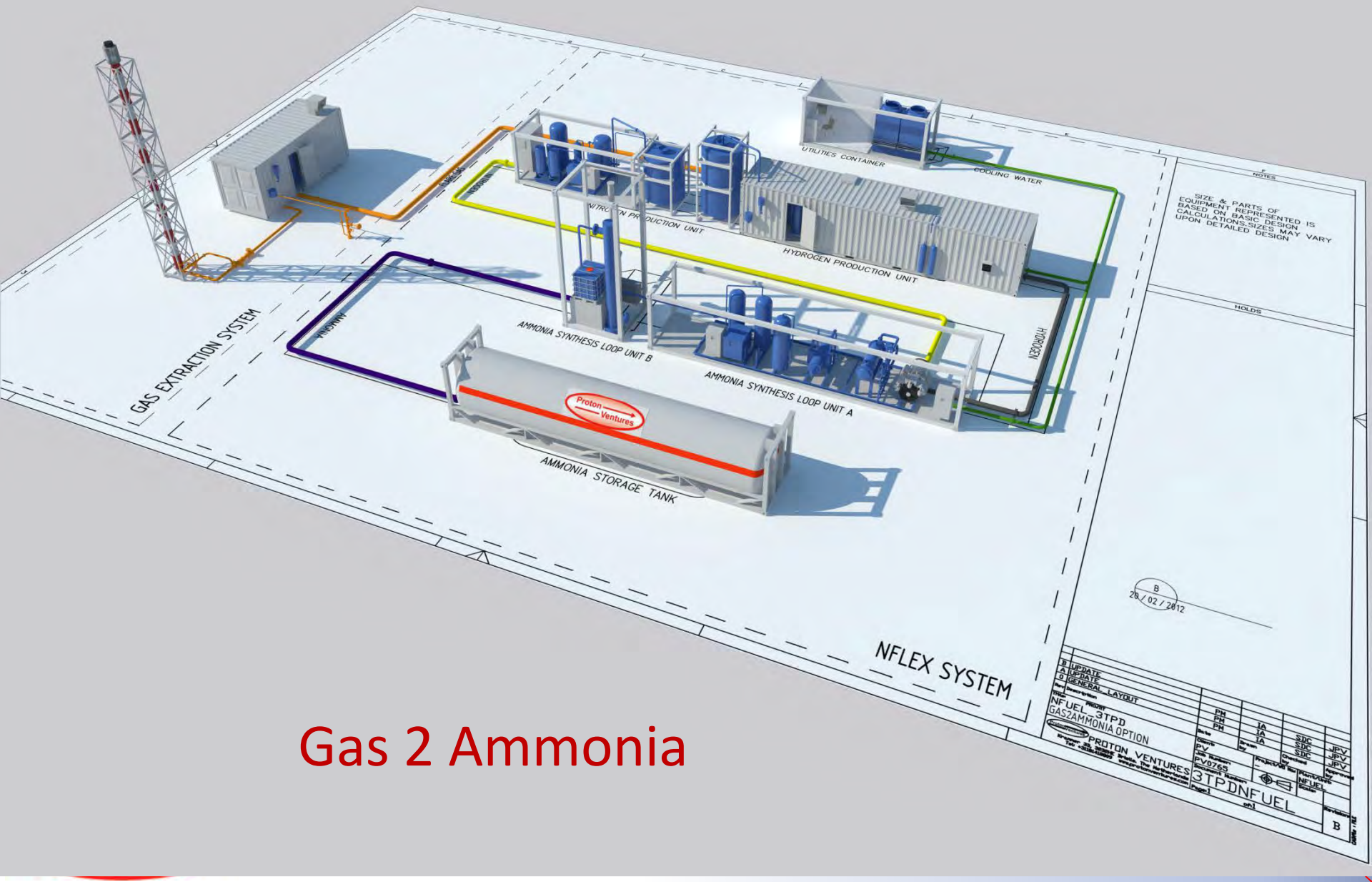
However, it cannot be stored and made available when needed? Then whats the use?
It would be great if we could harness it... But we are not there yet. Until then we have an option

Proton's NFuel concept

- NFuel concept is based on decentralized production of Ammonia from (decentralized) energy sources to ***store*** RENEWABLE ENERGY
- And use this ammonia to produce power on demand.

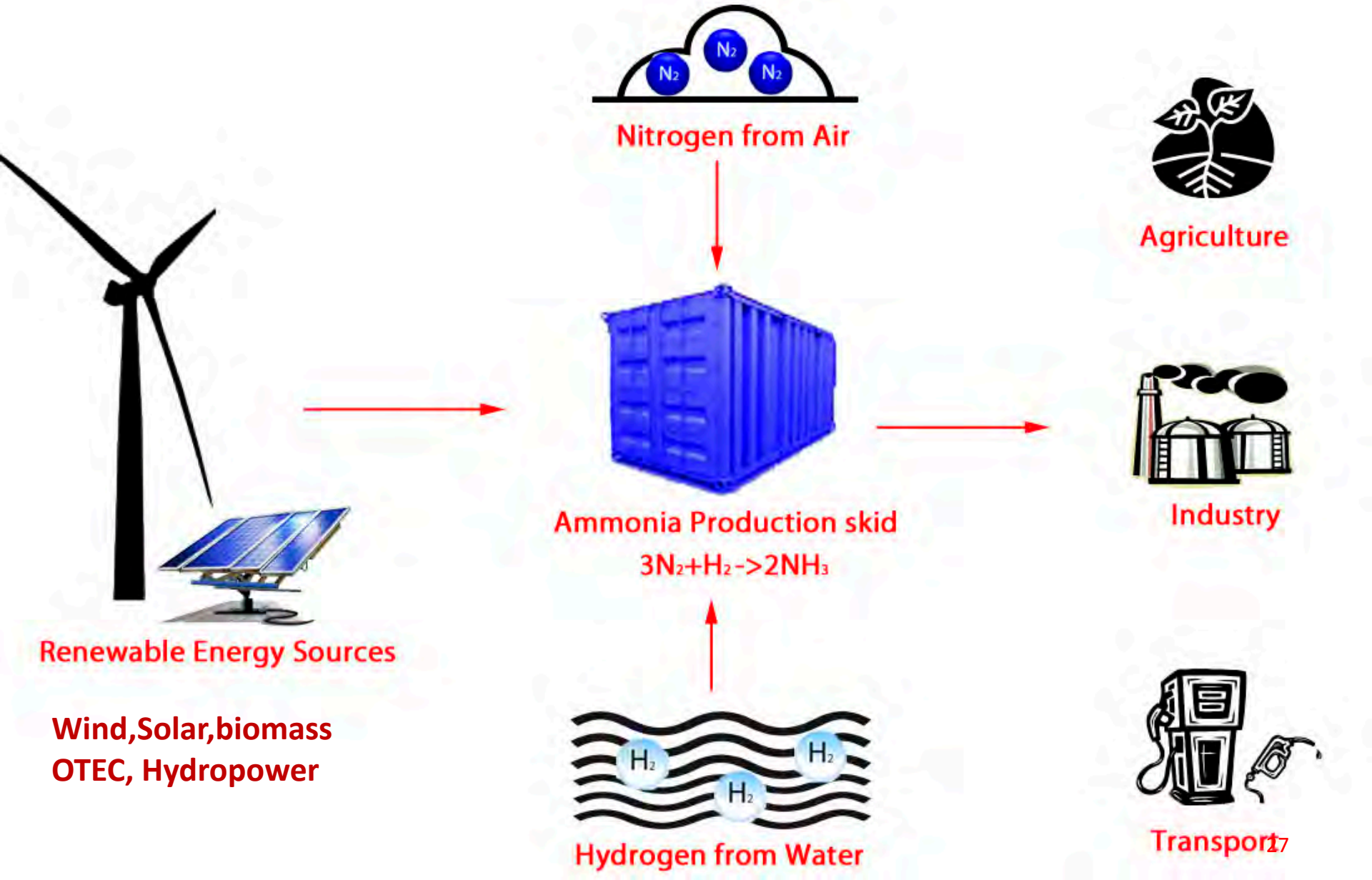


Wind 2 Ammonia



Gas 2 Ammonia

NFUEL UNIT: Concept



Highlights of mini-ammonia

- Fully automated process, design & control logic based on safe operation
- Power 2 ammonia or Gas 2 ammonia as per customer requirements
  - If hydrogen or nitrogen streams available as byproduct can be integrated in the system for ammonia production
  - Plug and play system
- Decentralised operations, hence no need for transport and logistics
- Units are skid based, hence easily transportable. Hence, if needed can be relocated if need be
- Skid based system offers an opportunity to replicate and keep cost per unit down

2 Projects – Ammonia System

- PAKRI in Estonia
- Maasvlaakte 2 in Netherlands
- Current focus on
  - Ammonia as an energy buffer
  - Power to Ammonia
  - Ammonia to Power
    - Stationary applications
    - Opportunity for heat capture
    - Constant load

PAKRI

- **PAKRI Science and Industrial Park (PAKRI) for renewable energy.**
  - Renewable energy related R&D, testing, education and incubators for new companies and start-ups.
  - www.pakri.ee
- For that the PAKRI has signed a development agreement with Tallinn Science Park Tehnopol and NN Arendus.

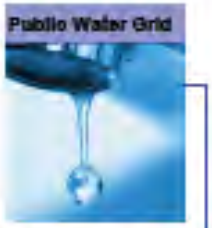
PAKRI Project

- Smart grid at PAKRI
  - Integrating various renewables, to produce ammonia. Ammonia can be further sold or converted into power.
- Upstream: Ammonia Production
  - With our partnership with NN, we would like to develop the technology that integrates the usage of renewables of renewables (wind, solar and geothermal) to power mini-ammonia units to produce ammonia.
- Downstream: Ammonia Usage
  - This ammonia can be converted back to electricity to satisfy PAKRI energy grid needs, and any extra ammonia can be supplied to other interested customers to be used for other applications.

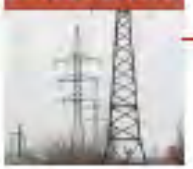
PAKRI Energy Grid (EG)

Rohelise energia tootmisüksikud / Green energy production units

Public Water Grid

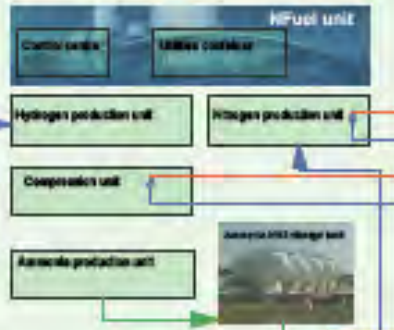


Public Energy Grid



Public Canalization

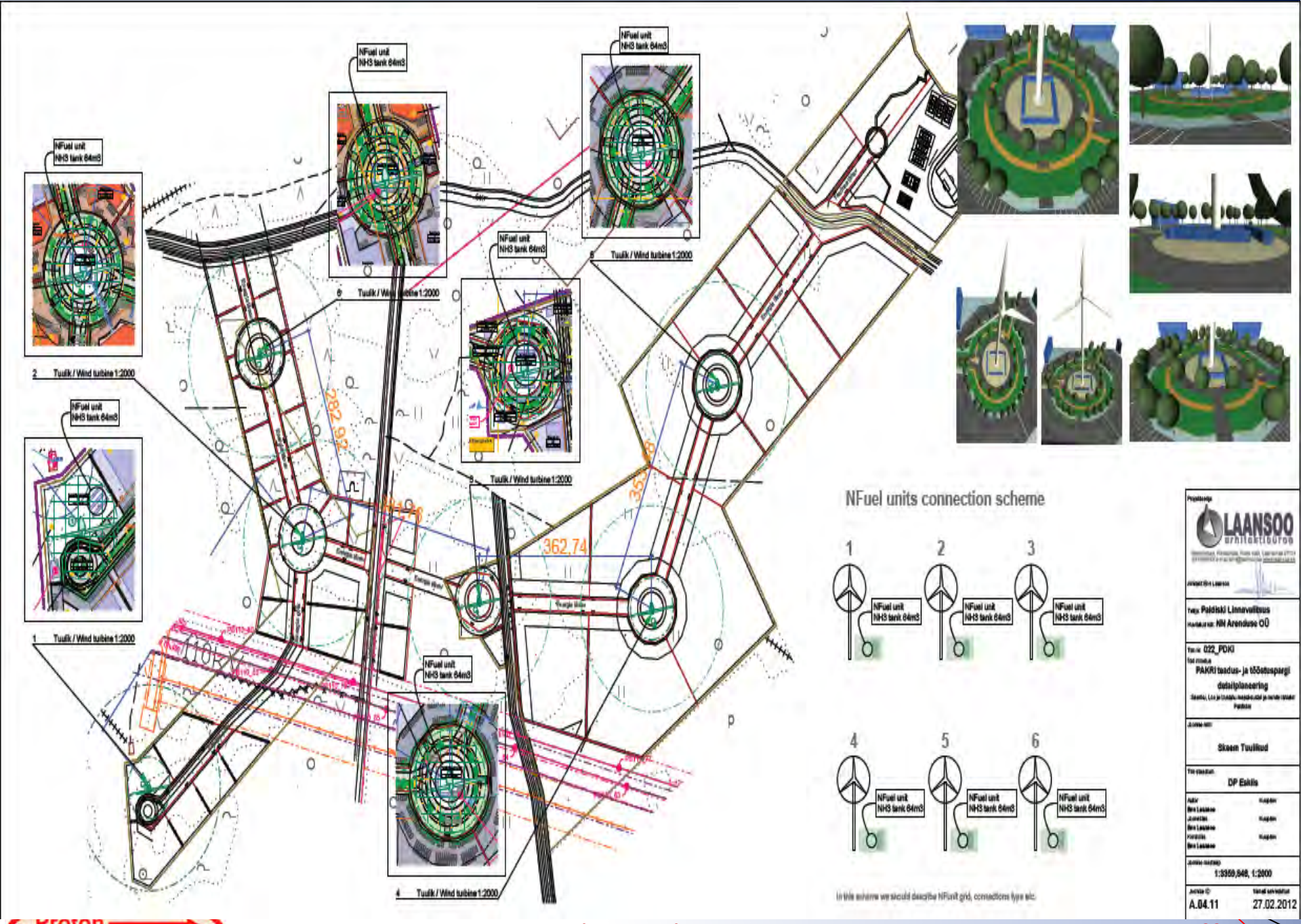
LNG Gas

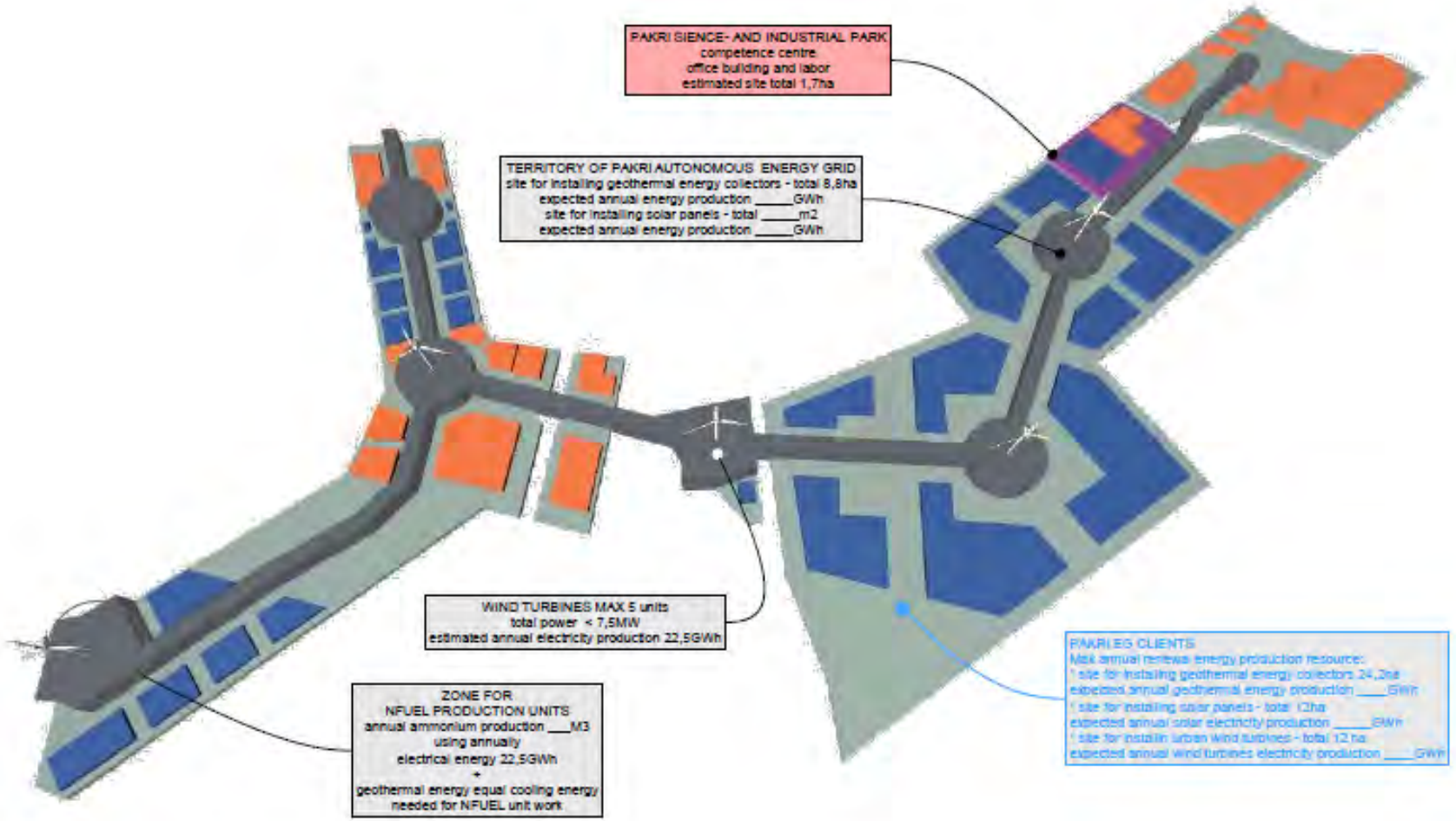


Backup and technological electricity

PAKRI EG client's are: PAKRI tööstus and industrial Park - housing brutto area ca 660 000m2 and PEAK - housing brutto area ca 160 000m2

Export


NFuel unit
NH3 tank 64m3
2 Tuulik / Wind turbine 1:2000
1 Tuulik / Wind turbine 1:2000
4 Tuulik / Wind turbine 1:2000
282.92
362.74
NFuel units connection scheme
1
2
3
4
5
6
NFuel unit
NH3 tank 64m3
LAANSOO
PÄKRI tiaadus- ja tööstuspargi
detailplaneering
Skeem Tuulikud
DP Eskiis
1:3369,848, 1:2000
A.04.11
27.02.2012



PAKRI Energiavõrk

Joonise ID: A.04.3

Viimati salvestatud: 6.01.2012

Töö nimetus
PAKRI TEADUS-, TÖÖSTUSPARGI DETAILPLANEERING, #Street

Töö nr: 022_PDKI

Tellija: NN Arendus OÜ

Arhitekt: Enn Laansoo

LAANSOO arhitektibüroo

Maasvlaakte 2

- *God created* the Earth, but the *Dutch* created the *Netherlands*.
  - A large part of the land is reclaimed from the sea

Maasvlakte2.com

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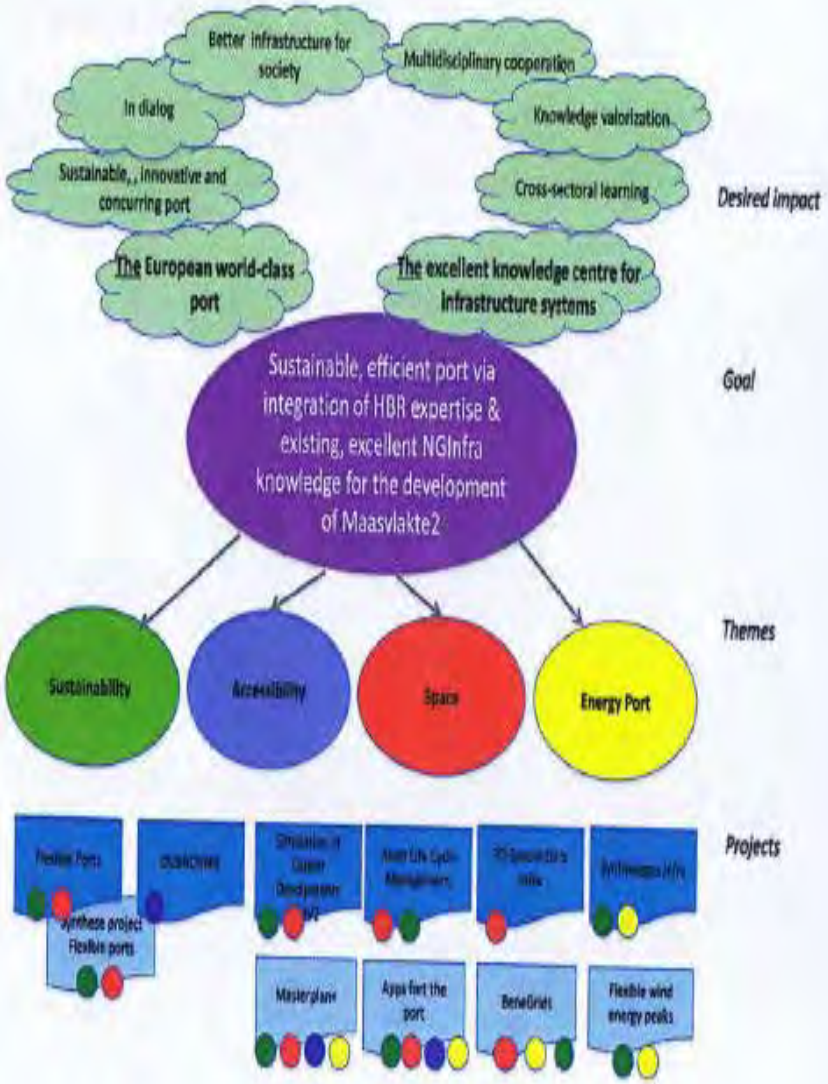
Maasvlaakte 2

- Maasvlakte 2 is a major civil engineering project in the Netherlands, constructing a new port and supporting infrastructure on reclaimed land adjoining the Maasvlakte.
- Approximately 2000 hectares will be reclaimed
- Infrastructure planners dream – a blank slate
- Focus on sustainability
  - Design
  - Operations
  - Cositing



	Project	Projectleader
1	Simulation of cluster development of Maasvlakte 2	Rob Stikkelman
2	Flexibility in port development and management	Michiel Nijdam
3	Development and greening of a syngas infrastructure	Rob Stikkelman
4	3D Spatial Data	Sisi Zlatanova
5	Dubrovnik	Larissa van der Lugt
6	Asset Life Cycle Management	Telli van der Lei
7	Masterplan+	Lori Tavasszy
8	Apps development in Port of Rotterdam	Wout Hofman
9	Industrial capture of surplus wind energy	Rob Stikkelman
10	Benegrids	Pieter Bots

Next Generation Port Infra, powered by Maasvlakte 2 is a four year alliance between Projectorganisation Maasvlakte 2 (PMV2) and researchprogramme Next Generation Infrastructures (NGInfra). The goal of the alliance is valorisation of NGInfra's excellent knowledge on infrastructural systems together with expertise of the Port of Rotterdam, focussed on a sustainable and efficient port. It is mainly focussed on infrastructural systems which will be part of the development, realisation and establishment of 'Maasvlakte 2' and an optimal exploitation of the port area. PMV2 and NGInfra are working together in projects to gain and expand knowledge. The financial scope of this alliance is 2 million Euros.

9 INDUSTRIAL CAPTURE OF SURPLUS WIND ENERGY

- **Flexibility**
- **Business case model**
- **Smart industrial grid**

The production of wind energy varies. Surplus amounts may occur and will remain unused until extra demand is created. In this project we explore the opportunities within the Rotterdam harbor industrial cluster to create additional flexible demand.

Examples are the production of green chemicals and the charging of automated guided vehicles. We have an eye for technology, economics, sustainability and stake holders.

Our final goal is to describe show cases for improving the environmental footprint of the Port of Rotterdam by using wind energy.

Port of Rotterdam

NEXT GENERATION INFRASTRUCTURES

Next Generation Port Infra, powered by Maasvlakte 2

PROJECTTEAM E-on Benelux NV: Sander Fijn van Draat, Daniel Lauwen, Menno Ros TenneT TSO BV: Hans van Hooijdonk Proton Ventures BV: Hans Vrijenhoef, Anish Patil PoR: Nicole van Klaveren-Pleumeekers, Wilco Van der Lans TU Delft: Rob Stikkelman, Kas Hemmes

PROJECT LEADER Rob Stikkelman, r.m.stikkelman@tudelft.nl

Project and deliverables

- Project Summary: Storing variable wind energie in the form of ammonia,
  - Greening of industrial processes
  - Making a value added product such as hydrogen or ammonia (hydrogen vector)
  - Prevent potential wastage of energy
- Project Partners:
  - TU Delft, HbR, Proton Ventures BV, E.oN, TenneT TSO B.V.
- Develop an integrated concept
  - Technology
    - Options, Chemicals and Cost/benefits, Smartgrid
  - Actors
    - Multi-actor analysis
  - And Institutional
    - Institutional analysis

Wrap-up

- We offer mini-ammonia units for stranded locations
  - To begin with the ammonia can be used as a fertilizer, as this is the established market
  - Over time as ammonia engines develop, farmers can use ammonia as a fuel
  - We are developing ammonia engines and generator sets to complete total supply chain.
- Advantages of decentralized fuel production fits the bill of a transportation fuel
  - Multiple points of production scattered around, but at strategic location, which will act as fuel stations for the future
  - Reduced costs and time for handling and transportation of fuel

Thank you

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