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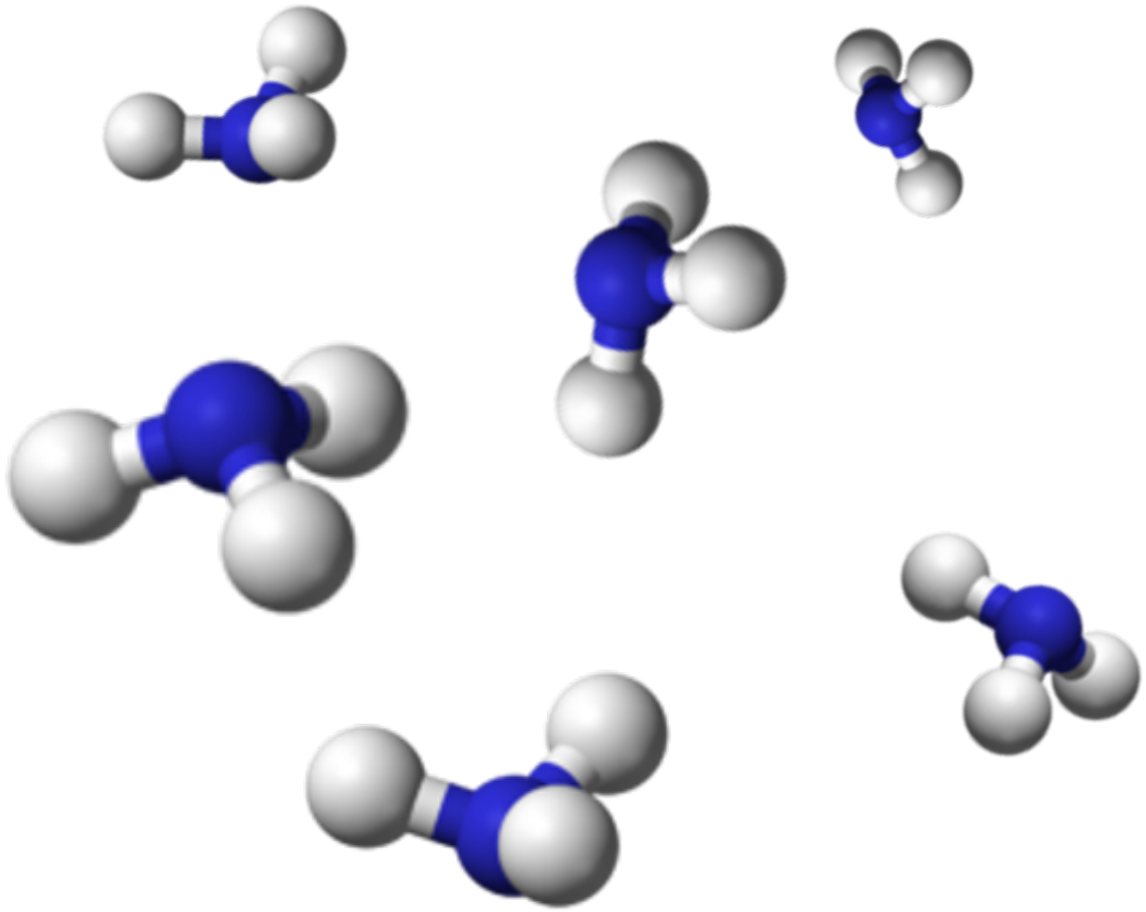
NH3 Energy 'EU' Update

Ammonia Energy Association
conference Orlando 13-11-2019

www.protonventures.com

What this is about

- New Shareholder
- Company Portfolio
  - NH_3 & Energy Storage & Handling
  - NH_3 Energy Storage
  - Current NFuel Projects Highlights
  - Modular approach
  - Hybrid systems
  - NOx and N_2O removal
  - Battolyser
- Hybrid Systems
- Cost vs energy efficiency
- Stakeholders
- Societal Matters
- Take Aways



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New Shareholder

- We have welcomed a new shareholder
- KOOLEN INDUSTRIES
- Interests in entire renewable energy chain
- Powerhouse for investments
- www.protonventures.com/news

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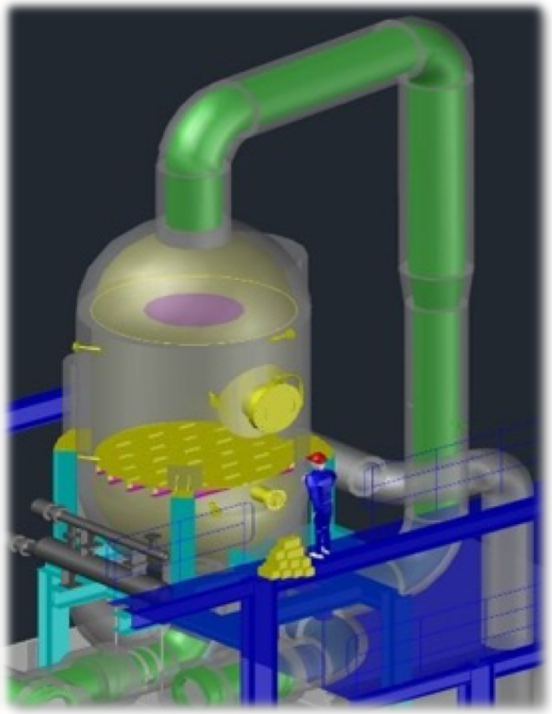
Company Profile

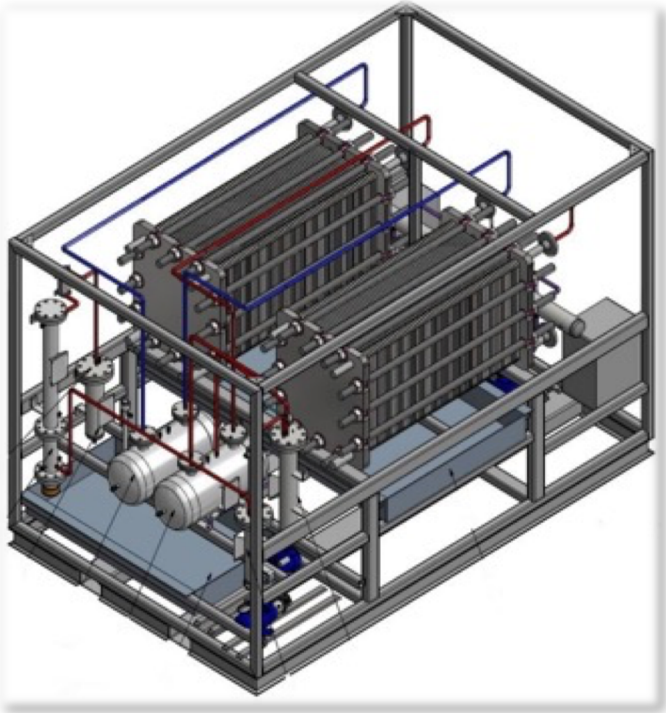
NH_3 & Energy storage

NH_3 Production (NFuel)

NO_x & N_2O removal



Battolyser



NH_3 & Energy Storage & Handling

- Refrigerated storage tanks
- Main & holding compressors
- Marine & railcar (un)loading facilities
- Utilities

Terminal projects

- 2 x 30,000 metric ton (Estonia, 2009)
- 1 x 10,000 metric ton (Bulgaria, 2013)
- 2 x 30,000 metric ton (Estonia, 2019 UC)
- 1 x 10,000 metric ton (Bulgaria, 2019 UC)

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Ammonia Energy Storage

- 10,000 metric ton of Ammonia
- This equals roughly :

  225,000 GigaJoule (GJ) or 62.5 x 10^6 kWh

- This is why ammonia will play a key role
- Momentum is picking up

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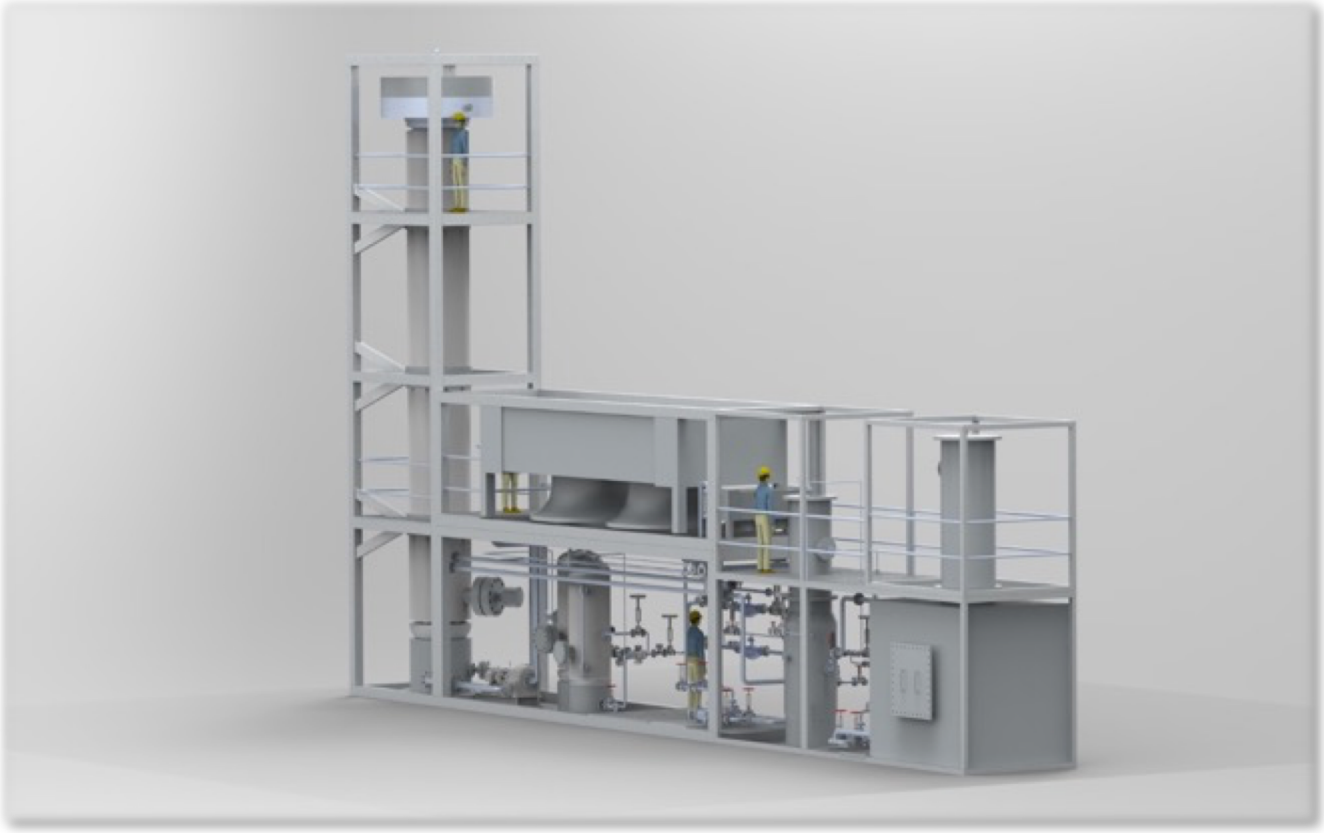
Current NFuel Projects Highlights

- Canada, Quebec:
  - Smallest size 3 MTPD for De-NOx use
  - Wind & hydro power based
- Canada, Saskatchewan
  - Medium to large size 10 – 60 MTPD
  - Shale oil flare gas based
- Canada, Manitoba
  - Large size x 2: 60 MTPD
  - Process waste H_2 gas
  - Ultimately hydro power based
- Morocco
  - Pilot plant for 4 MTPD
  - Solar PV based
  - Purpose: study upscale potential



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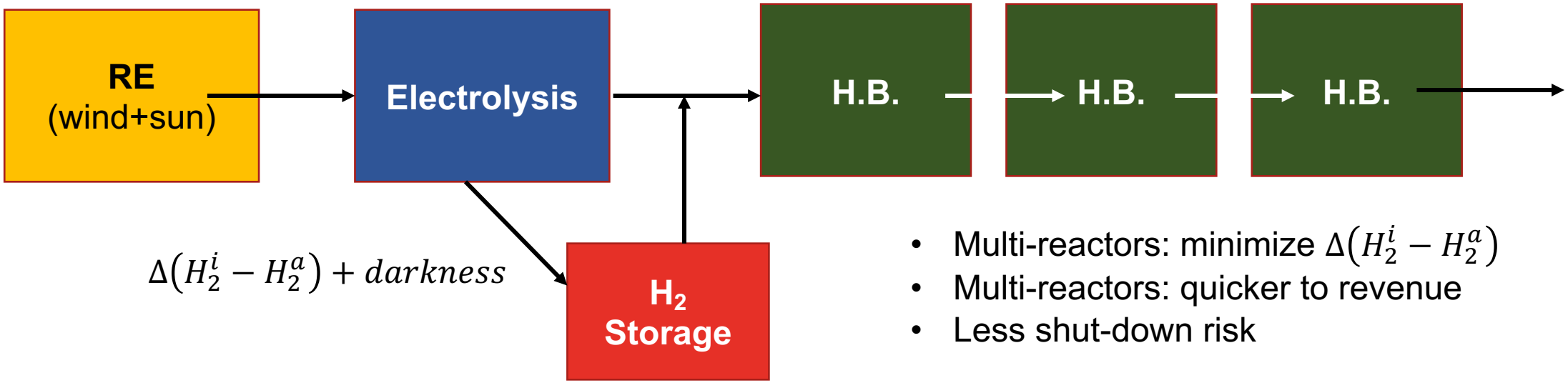
Modular approach: decentralized or also centralized

- Single train for decentralized approach (3 MTPD / 10 MTPD / 60 MTPD)
- Multiple trains (modular or larger) for capacities beyond say 100 MTPD
- Offers increased operational flexibility w.r.t. fluctuations in supply or demand



- Multi-reactors: minimize $\Delta(H_2^i - H_2^a)$
- Multi-reactors: quicker to revenue
- Less shut-down risk

H_2^i ideal efficiency Nm³/h
H_2^a actual efficiency Nm³/h

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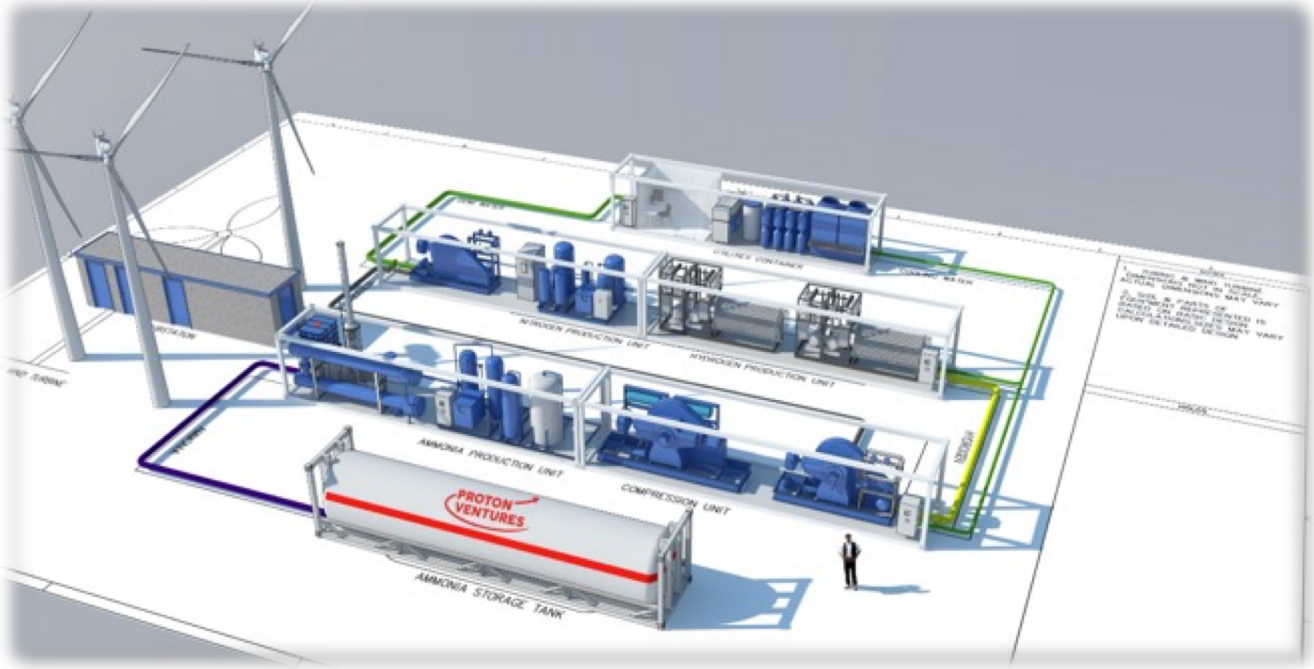
Hybrid Systems with(in) NFuel

- Issue: Renewable intermittency

- Ammonia is **key**, but not the only solution
  - LOHC's
  - Sodium Borohydride ($NaBO_2$ / $NaBH_4$)
  - Metal powder hydride
  - Battolyser
  - Batteries
  - Combination of CSP and PV



- Components to optimize for intermittent duties:
  - Haber-Bosch based synthesis (recylce, etc.)
  - Electrolysis of water / SMR of bio- & waste gases
  - H_2 or power as intermediate buffers for hours/days

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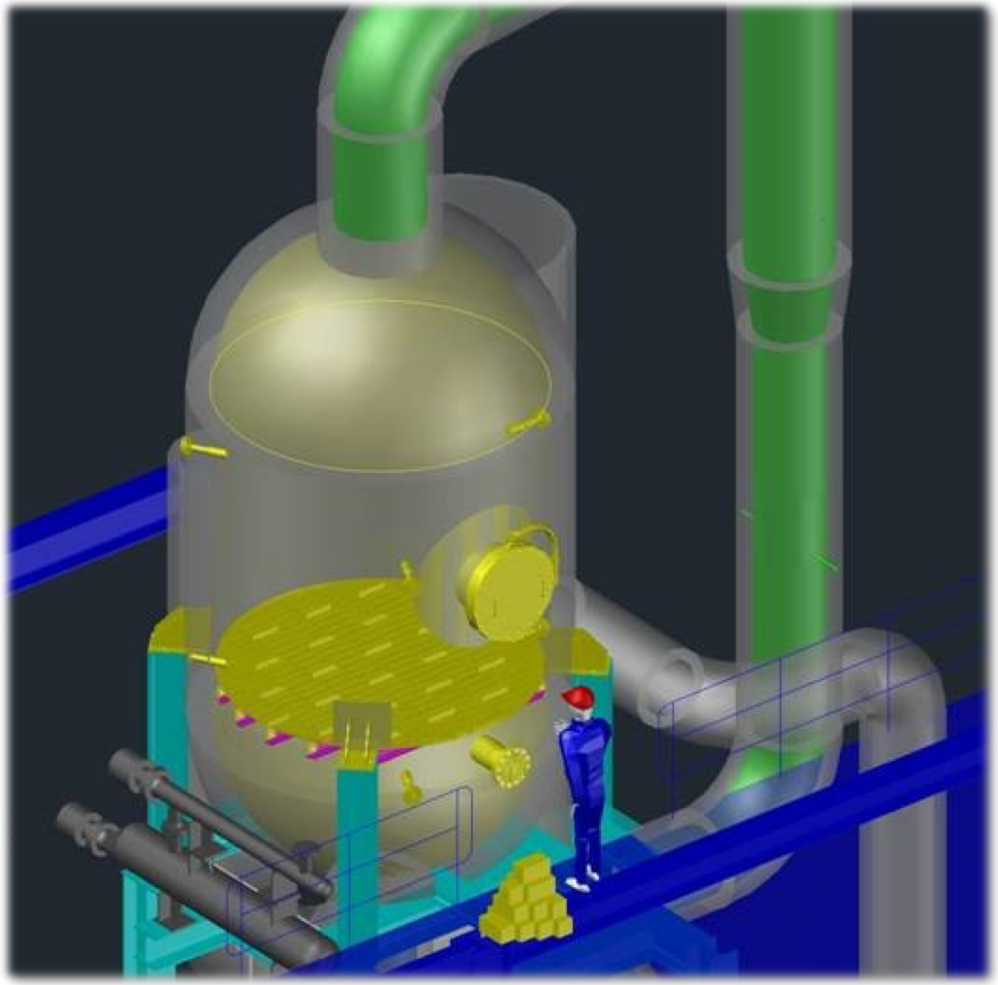
NO_X & N_2O Removal

Key Features:

- Nitric Acid plants among others need to reduce NO_X & N_2O emissions
- Cost effective system to reduce GHG emissions
- NO_X & N_2O tertiary catalyst (TertiNOx™) developed by Halder Topsoe
- Main advantage:

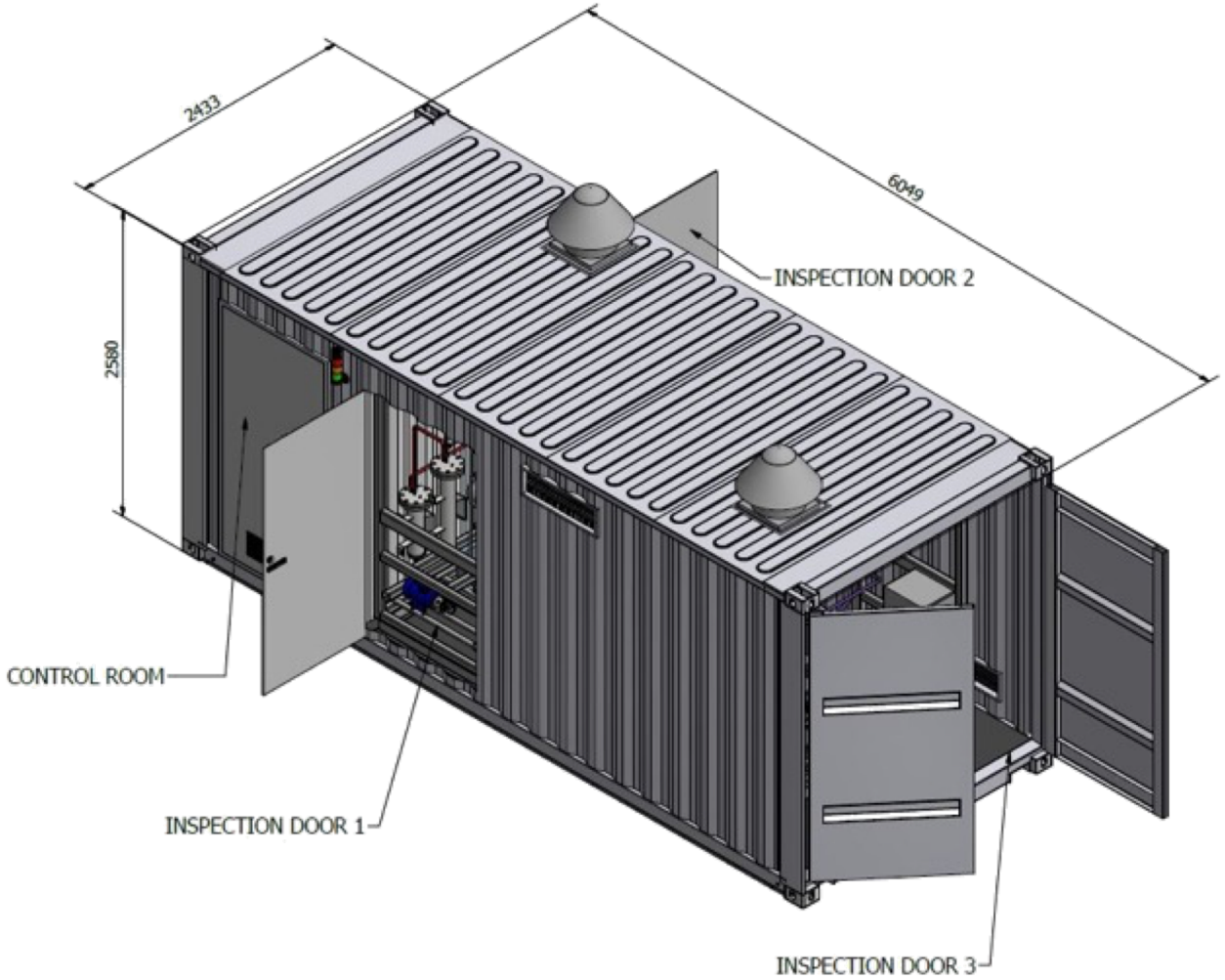
  Single system rather then two separate



Battolyser

Key Features:

- Integrated Ni-Fe battery and electrolyser
- Continuous H_2 supply under intermittent circumstances
- Short term power storage in the battery capacity
- Long term storage or direct conversion of power into H_2
- Maximize renewable power supply, usage & reduce curtailment



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Cost vs Energy Efficiency

- We will keep on using energy
- We will not change our behavior

- Todays thinking is primarily based on energy efficiency
- What if the energy source is infinite and no longer finite?
- Overall cost is 1st, energy efficiency 2nd
- ‘Engineering’ mindset change needed

- Financially: Demo’s / pilots do not target money making

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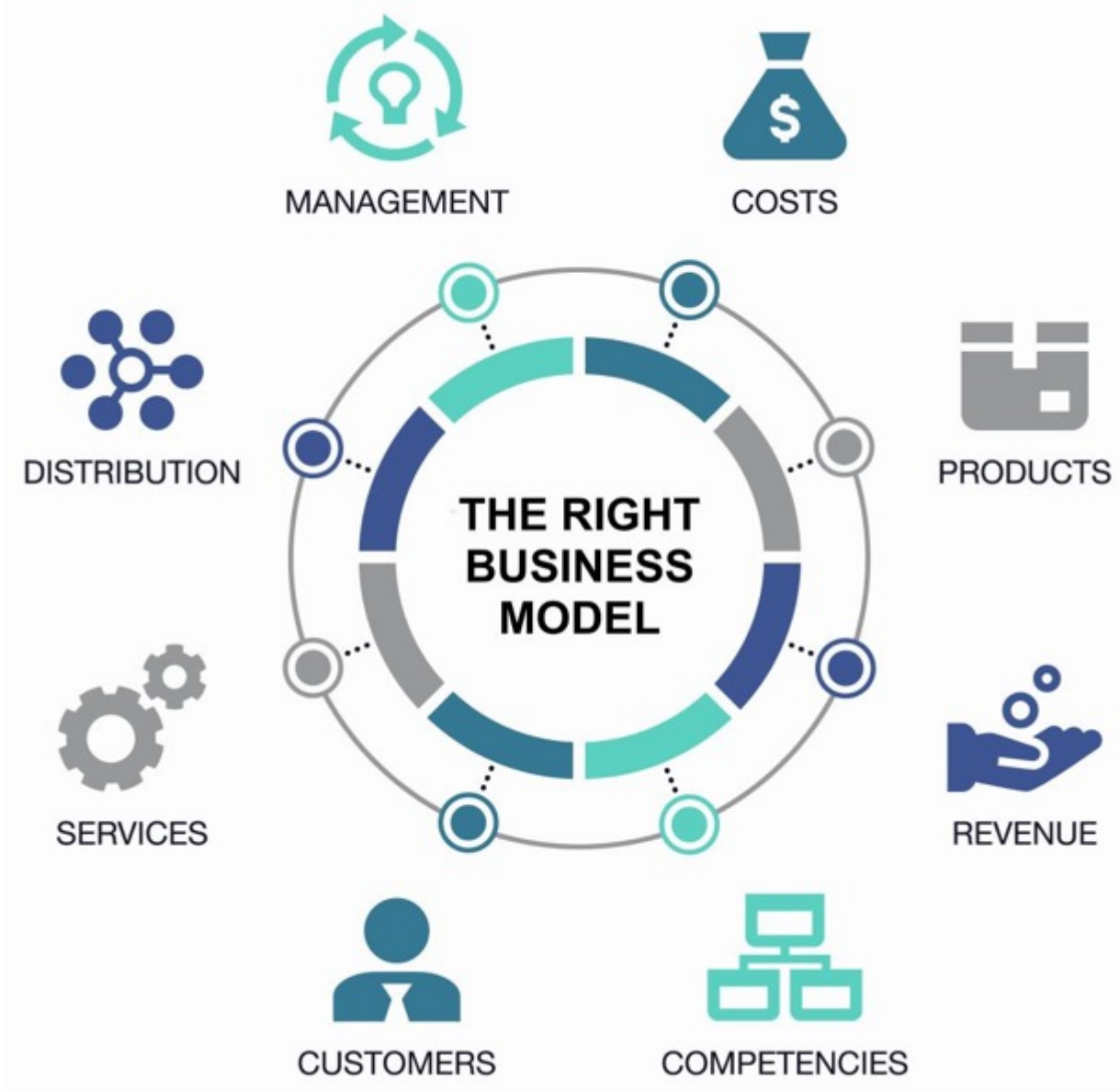
Stakeholders are People

- Public
- Law makers / Authorities / regulators
- Clients / End-users
- Technology / equipment providers
- Investors
- Academia



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Societal Matters

- Ammonia and the public opinion (psychology)

- Example: Dutch ‘Reactive Nitrogen’ issue
  - Tiny NL is a huge agricultural produce exporter
  - High intensity industry
  - Intensive infra and transport hub
  - Densely populated
  - High NO_x / Nitrate amounts in natural habitats

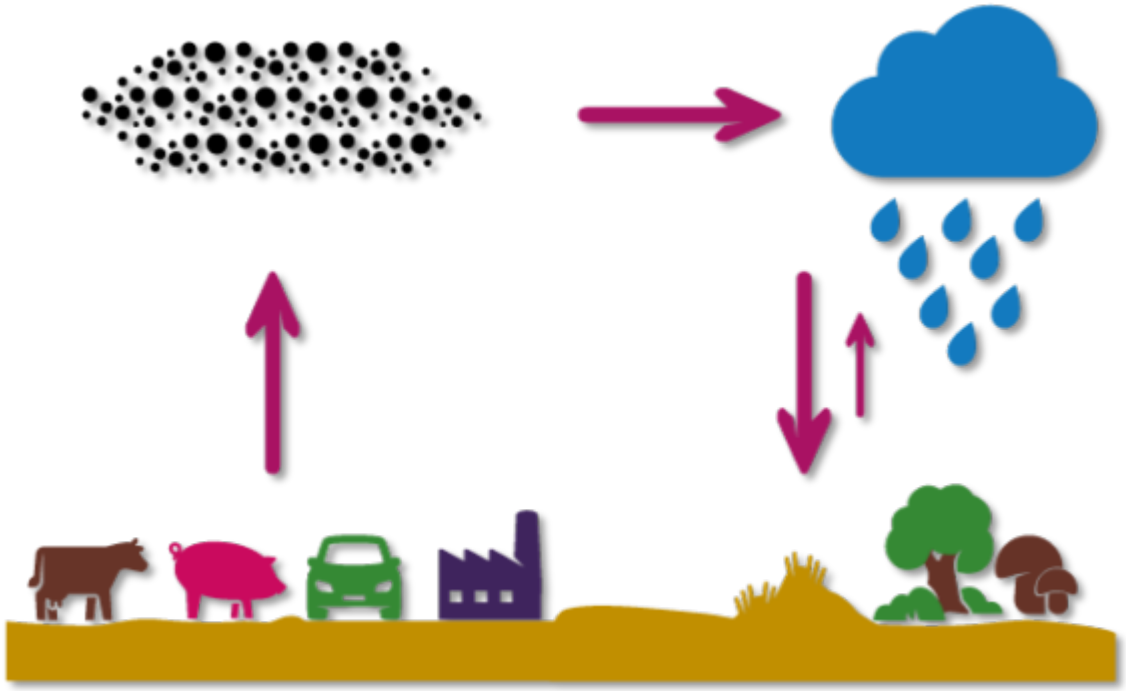

Illustration : CoBouw

- Timing could not be worse, as **green** ammonia is picking up

We need to help society and all stakeholders to embrace new solutions including for ammonia!

Some Take Aways

- Ammonia Energy is taking off!
- Small scale ammonia production modules work for both de- and centralized deployment
- Consider hybrid solutions
- Change of mindset (cost / energy efficiency)
- Look into soft skills to address stakeholder interests
- Psychological aspects of emotion vs. ratio
- Help society and stakeholders embrace AMMONIA

‘The energy transition will take some time;
No rush, but do hurry’

‘Ideas have no value, it’s about execution’

According to our new share holder: Kees Koolen

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