NFUEL units for storage of renewable energy

Competitive Decentralized Ammonia Production

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Proton Ventures

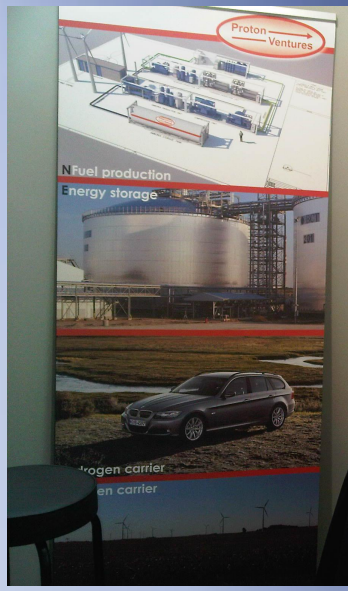
- Proton Ventures is based in Schiedam (Netherlands)

Proton Ventures

- Established in 2001
- We are a team of enthusiastic professionals who design and implement customized solutions for our customers.
  - EPC
  - Turnkey solutions
  - and provide investment
- Capable of conducting small to large projects of up to 50 million euros
- We have so far completed around 100 projects

Our NFuel concept

- NFuel concept is based on decentralized production of Ammonia from (decentralized) energy sources to ***store*** RENEWABLE ENERGY
  - surplus electricity
  - biomass,
  - stranded gas,
  - hydrogen as (by)-product



Our NFUEL concept

- Decentralised production offers
  - Small units, easy to handle for construction
    - No steel construction
    - Fast assembly time at site
    - No big construction effort
  - Multiple, identical units
    - The “Ford”- concept makes units cheap(er) in investment
  - Simple and transportable units, if needed
  - To be realized on small footprint
  - Low or less environmental impact issues

Lightning has tremendous energy content,

However,
it cannot be stored and made available when needed

Energy storage of fluctuating renewables by NFUEL

- Renewable sources are characterised by large fluctuations
  - **availability**
  - **day-night swing**
  - **maximum-minimum in few seconds**
- Creates grid inbalance
  - Leading to energy wastage
  - Curtailing issues,
  - Delayed grid infrastructure

To bridge the energy balance

If not balanced correctly

Surplus

Shortage

Production (Upstream)

Usage (Downstream)

Storage

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

To bridge the energy balance

If not balanced correctly

Surplus

Shortage

Production (Upstream)

Usage (Downstream)

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

Customers facing Complications

- Hurdles along the way
  - System misbalance
  - Problem to integrate larger amount of fluctuating power within the system
  - Potential for huge amounts of power wastage
  - Profitability renewables *(depreciation/payback discussions)*
  - Who pays the misbalance

Proton's Wind Energy Liquefaction – NFuel Unit

Focus 1:Agriculture: NH_3 as fertilizer

Surplus of electricity like stranded or curtailed wind
Eg: Curtailed **wind**

Use Surplus Electricity to Produce a Value Added product, such as Ammonia

Or Shortage of electricity

Proton's Wind Energy Liquefaction – NFuel Unit

Focus 2:Industry: Denox in power plants, CO_2 capture, feedstock for chemicals production

Surplus of electricity like stranded or curtailed wind
Eg: Curtailed solar

Use Surplus Electricity to Produce a Value Added product, such as Ammonia

Or Shortage of electricity

Proton's Wind Energy Liquefaction – NFuel Unit

Focus 3:Transportation fuel: Direct injection in the internal combustion engines, Fuel Cells

Surplus of electricity like stranded or curtailed wind
Eg: **stranded gas**

Use Surplus Gas to Produce a Value Added product, such as Ammonia

Or Shortage of electricity

Proton's Wind Energy Liquefaction – NFuel Unit

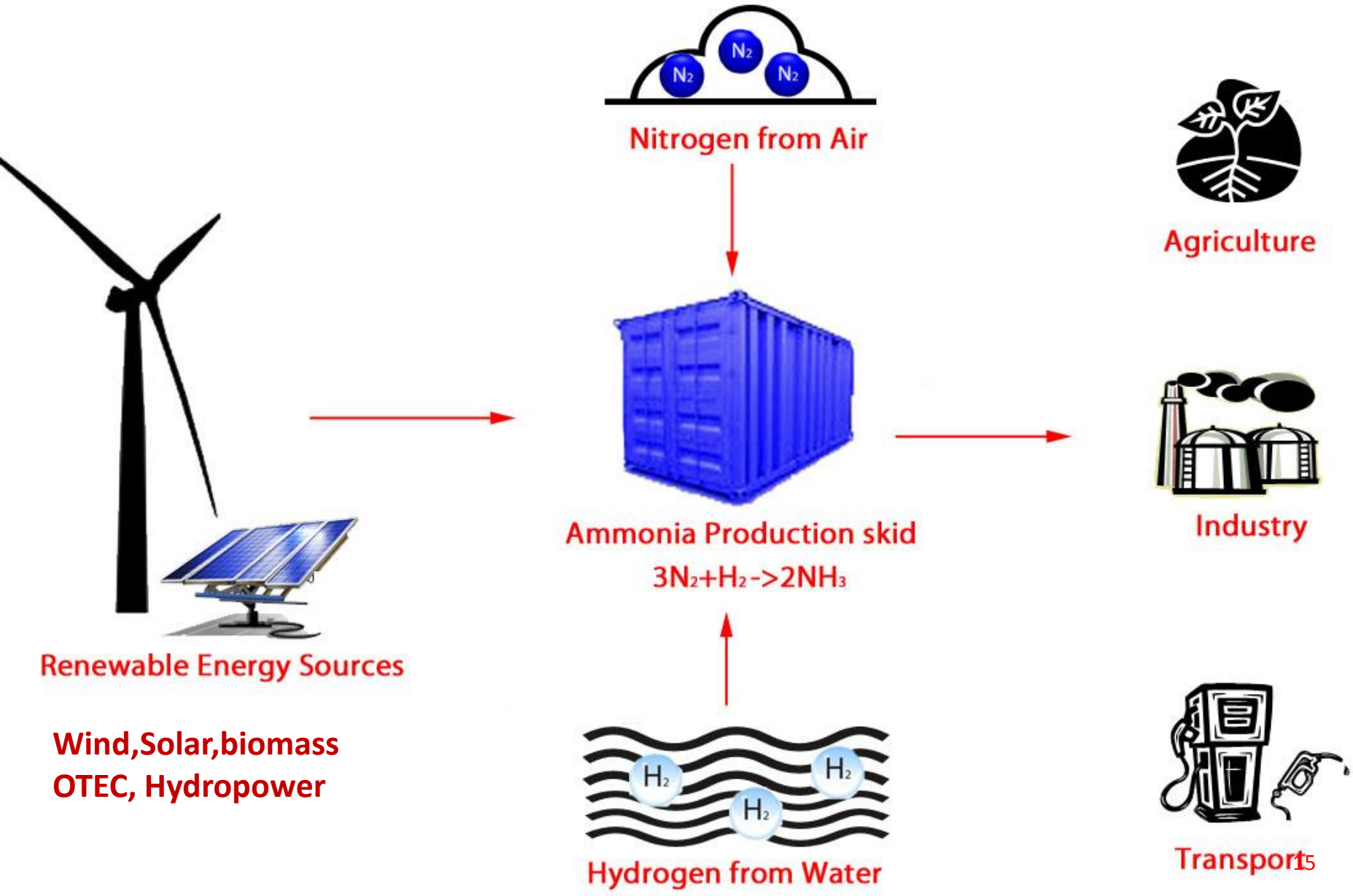
General : **Energy carrier:**
easier stored & distributed than power or H2

Surplus of electricity like stranded or curtailed wind
Eg: **by-product hydrogen**

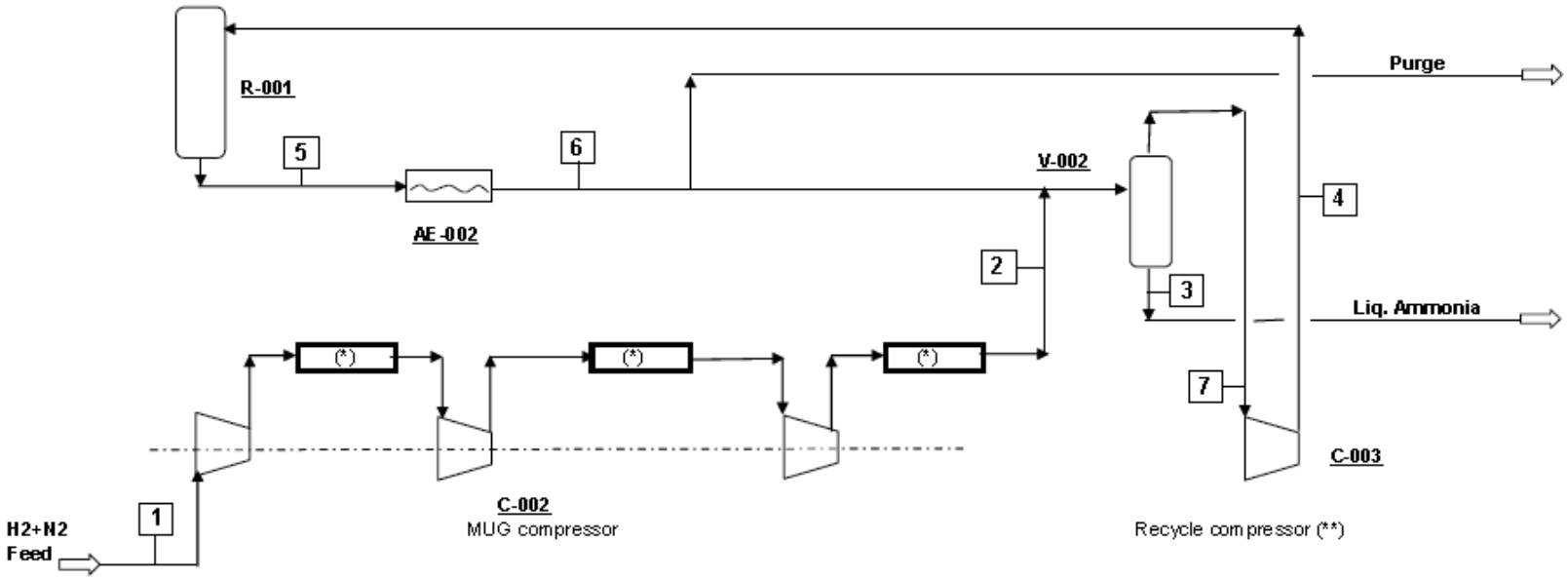
Use Surplus hydrogen to Produce a Value Added product, such as Ammonia

Or Shortage of electricity

NFUEL UNIT: Basic Concept



Simplified PFD NFUEL unit



(*) Cooler plus condensate separator on 3rd stage discharge
(**) Recycle stage with oil filter/separator on discharge if Syngas compressor lubrified
(***) Provide pulsation dampeners for both machines to reduce pulsation to abuot 1 %

[x] Stream number of Material Balance

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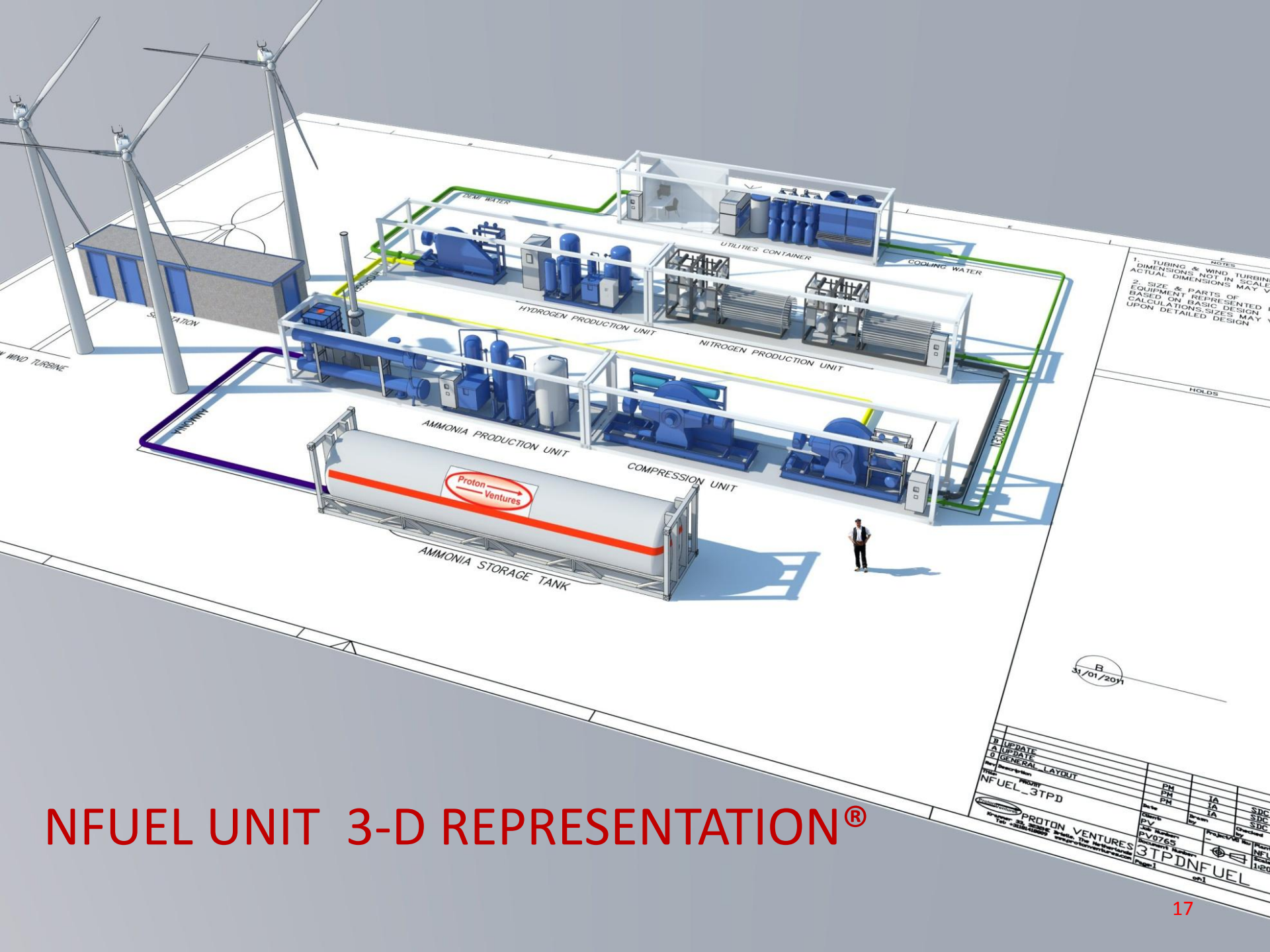
date 12-12-2010



NFUEL UNIT 3-D REPRESENTATION®

NFUEL UNIT: key features

- Fully automated process, design & control logic based on safe operation
- Zero Carbon process
- Safe and Proven technology
- Patented electrolysers
- Decentralised operations, hence no need for transport and logistics
- Long technical life
- Recognized international partners for supply of equipment
- Units are skid based, hence easily transportable. Hence, if needed can be relocated in the future if need be.

NFUEL UNIT: key features

NFUEL characteristics:

- 1,6 MW continuous or about 14 kWh/kg ammonia , excl transport pump(s)
- 1 m3/hr potable water
- app 5000 ft2
- 110 NM3/hr air
- no operational manpower
- some maintenance (2-3%)
- fully automated
- intrinsic safe +

120 kg/hr NFUEL =app 3,3 Mton/day = app app 1000 t/annum

NFUEL UNIT: key features

NFUEL characteristics: Power2ammonia

2 * 125 Nm/hr electrolysers at 4,7 KWh/Nm3 H2

1 Dm-water unit (RO plus)
1 N2 generator (85 NM/3hr N2 pure)
1 syngas compressor
1 recycle compressor
1 ammonia reactor + loop ancillaries
1 storage tank app 15 Mton
1 control system (controlled from NL)

` 1 power contract
1 off take agreement for ammonia
1 land rental agreement
1 permit
1 license agreement
1 year time (production time)

120 kg/hr NFUEL =app 3,3 Mton/day = app app 1000 t/annum

NFUEL UNIT: key features

NFUEL characteristics: Gas2ammonia

1 mini-ATR for 250 NM3/hr H2

1 Dm-water unit (RO plus) bigger sized than for power
1 N2 generator (85 NM/3hr N2 pure)
1 syngas compressor
1 recycle compressor
1 ammonia reactor + loop ancillaries
1 storage tank app 15 Mton
1 control system (controlled from NL)

` 1 gas contract
1 off take agreement for ammonia
1 land rental agreement
1 permit
1 license agreement
1 year time (production time)

120 kg/hr NFUEL =app 3,3 Mton/day = app app 1000 t/annum

How does it compare with Gasoline

oil prices ($) per gallon	$/mmbtu Oil
3	26,00
3,2	27,73
3,4	29,46
3,6	31,20
3,8	32,93
4	34,66
4,2	36,40
4,4	38,13
4,6	39,86
4,8	41,59
5	43,33

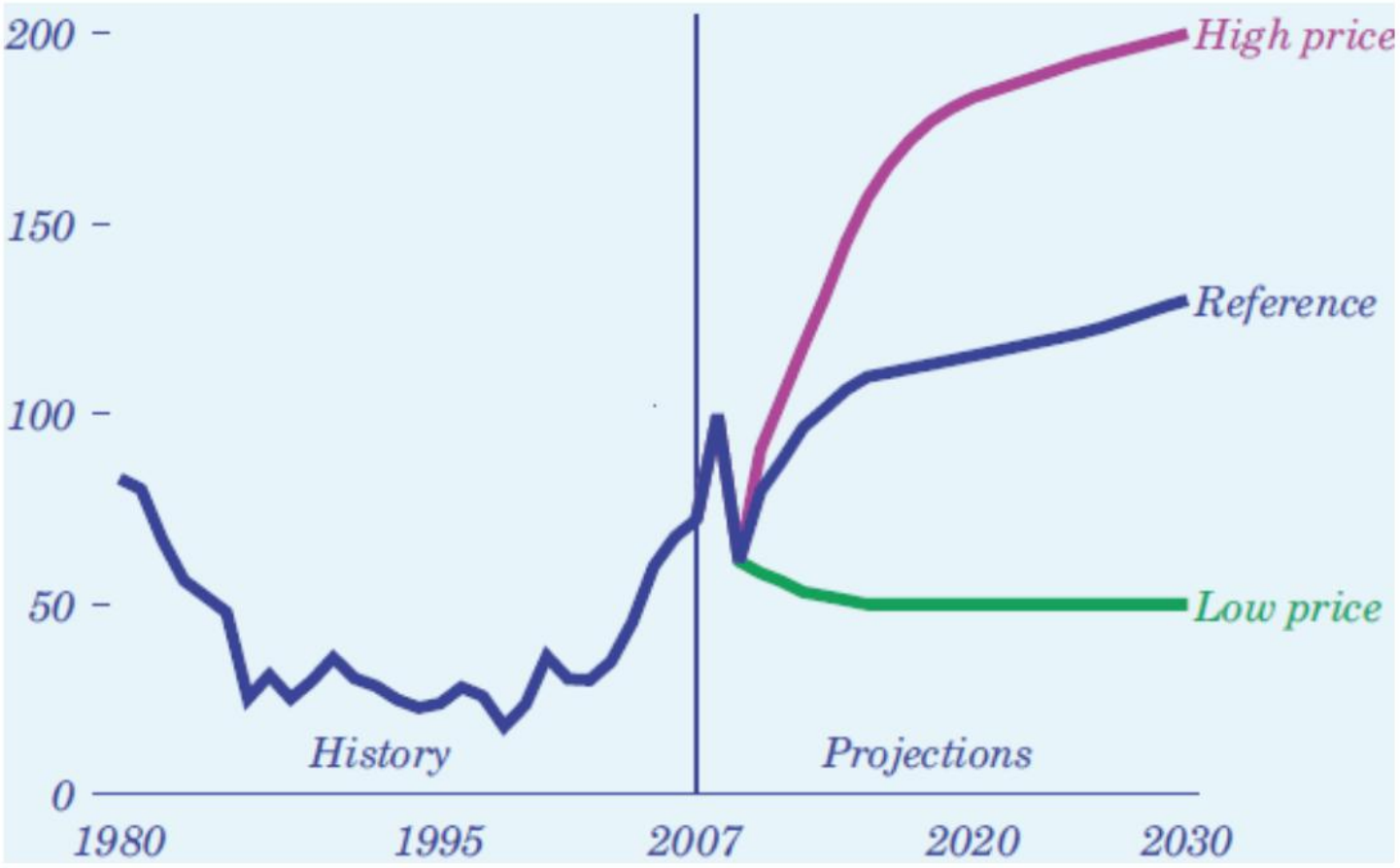
Current Gas Prices in Iowa

Ammonia prices $/Ton	$/Mmbtu Ammonia
500	28,46
550	31,30
600	34,15
650	36,99
700	39,84
750	42,68
800	45,53
850	48,38
900	51,22
950	54,07
1000	56,91

Decentralized ammonia production – NH3 price between 600-700$/Ton

Crude Oil Price Projection

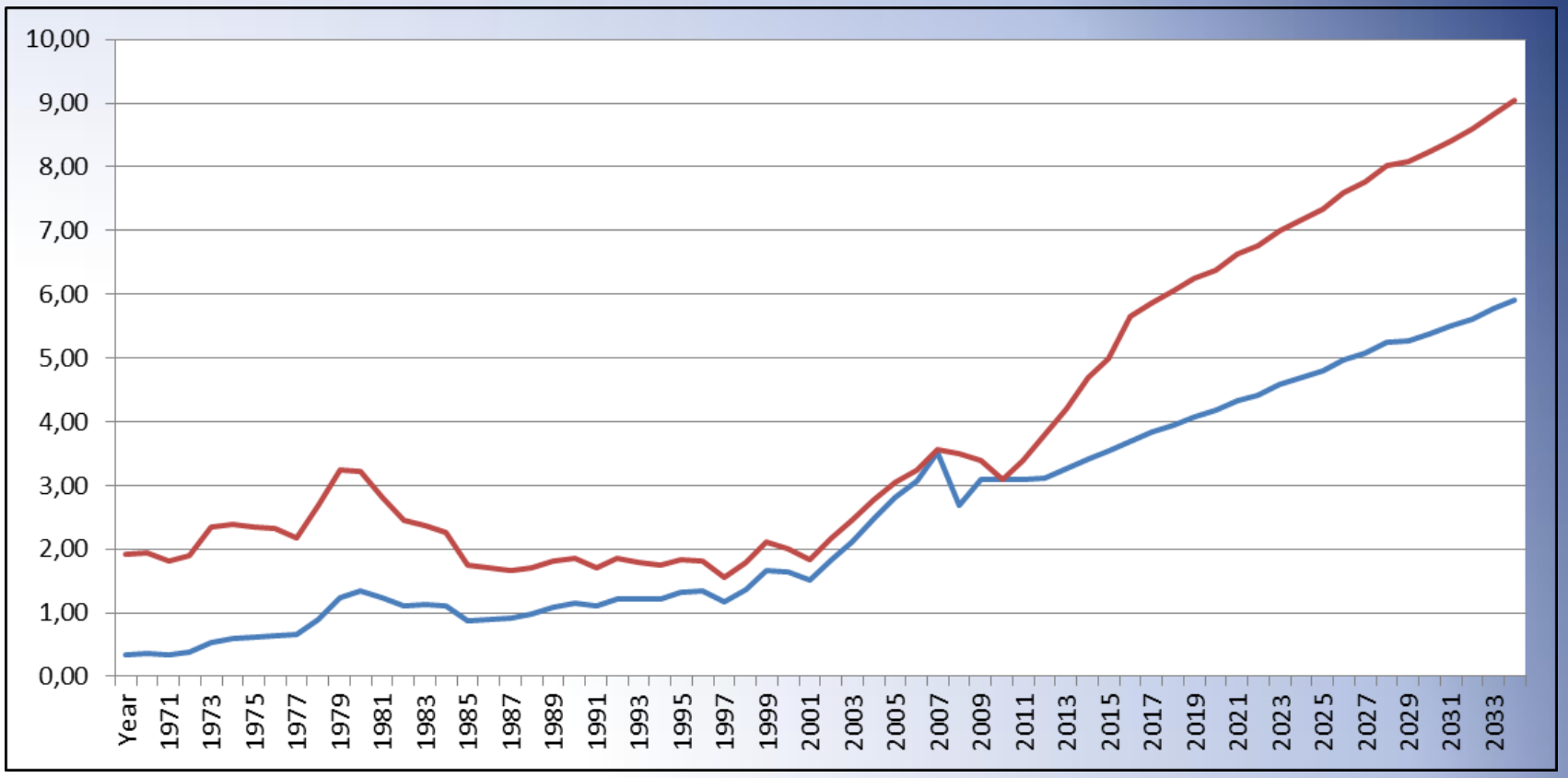
$/barrel



- ***World Oil Price Forwcast in three cases (adjusted as per 2007 $ prices)***
- ***Data source – DOE (2009)***

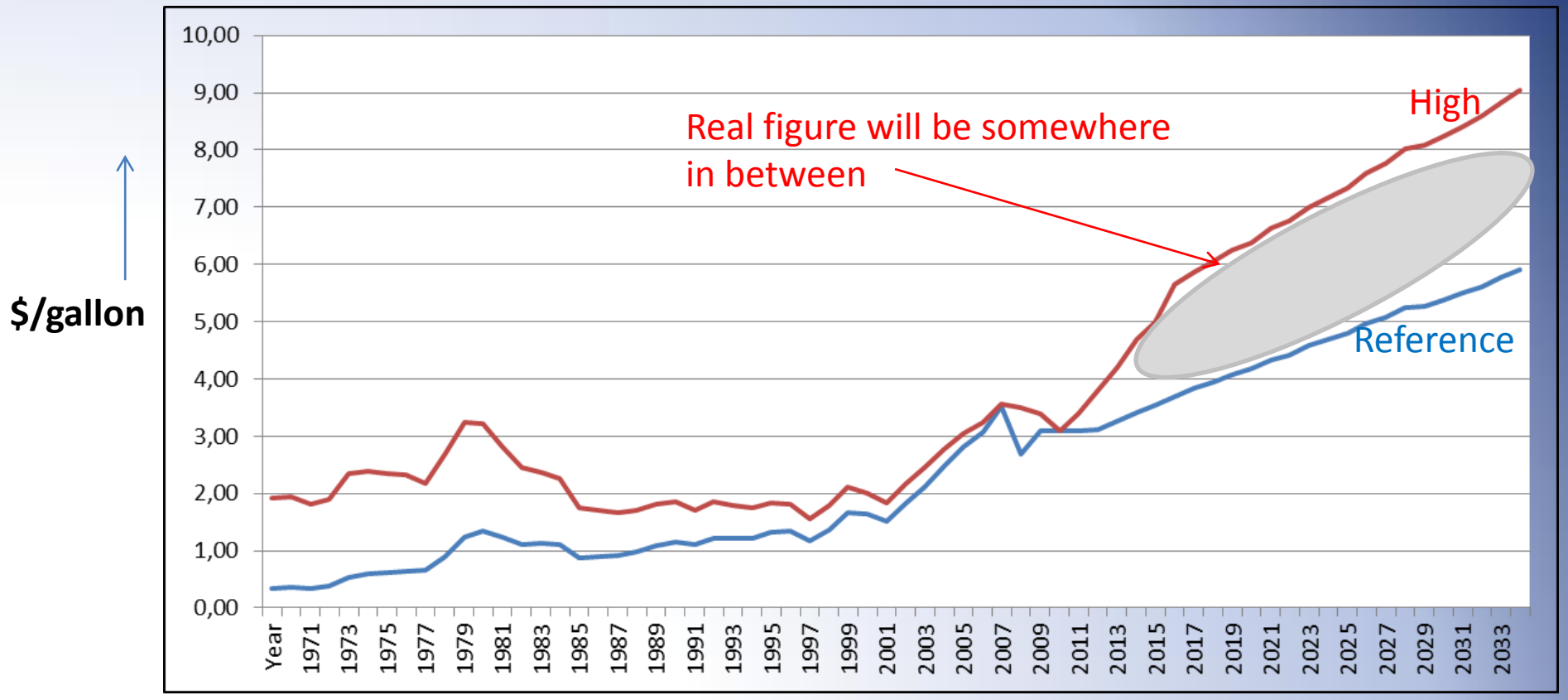
Oil Price Forecast

$/gallon



- ***Based on IEA Forecasts (2009 Annual Report)***
- ***Blue line is the Reference case scenario and Red line is the high price scenario***

Oil Price Forecast



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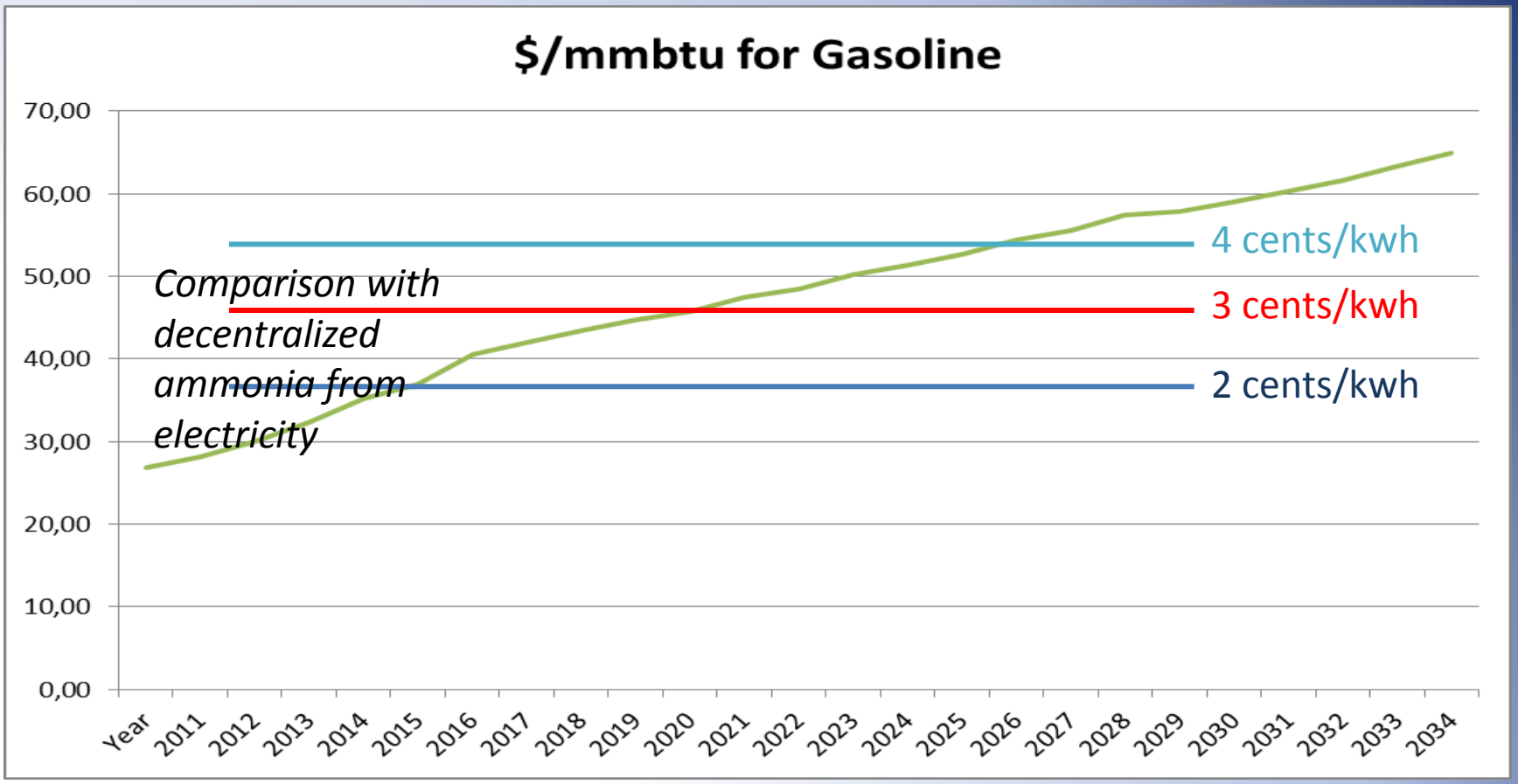
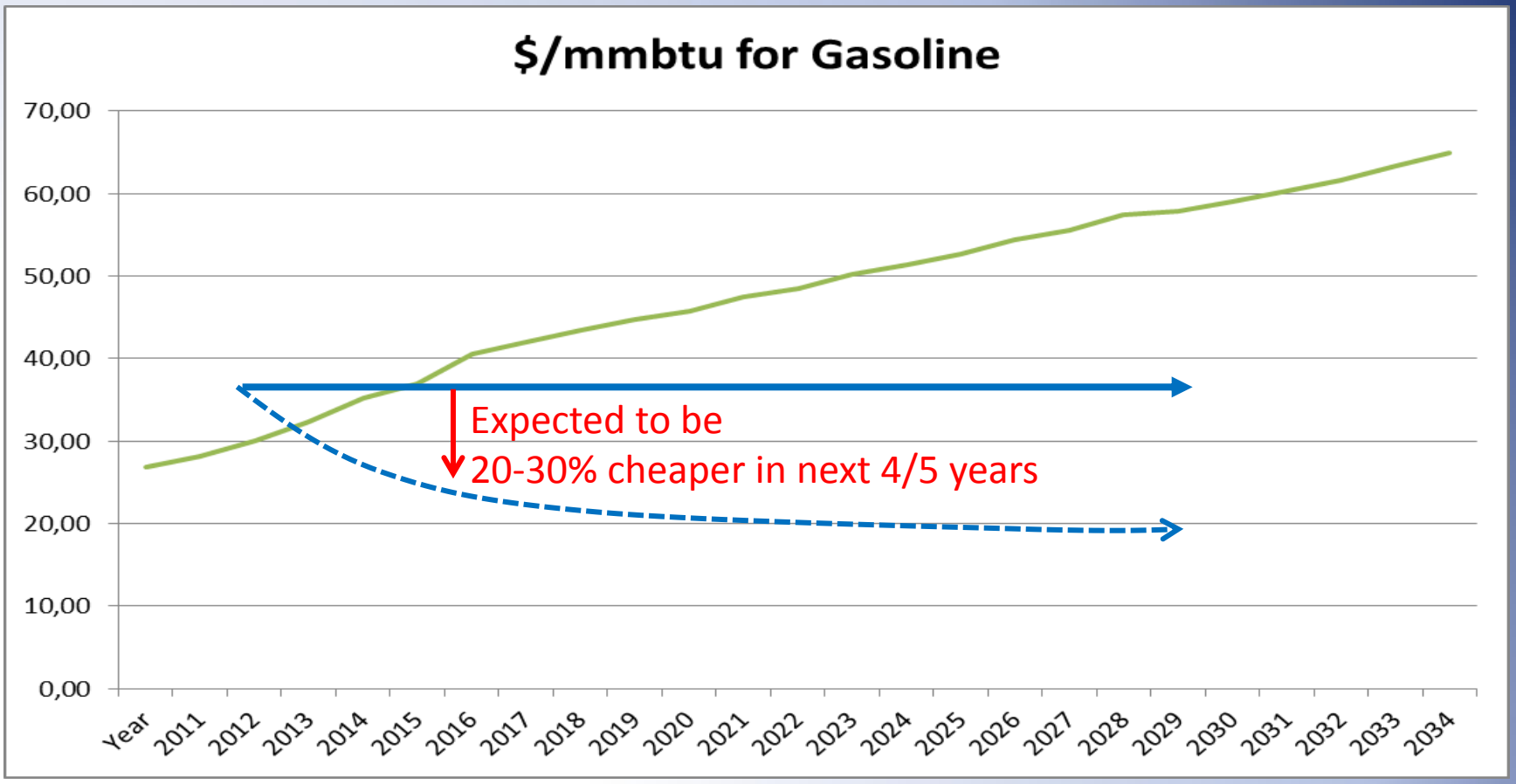
Price-point mbtu comparison



- ***Price-point comparison of gasoline vs decentralized ammonia production***
- ***Here the green line represent the mean of reference and high case scenario of gasoline prices***

Price-point mbtu comparison



- ***Price-point comparison of gasoline vs decentralized ammonia production***

Avenues of capital cost reduction

- Building multiple units at the same time
  - Discounts on equipments from suppliers
- Technological improvements
  - Efficient and cheaper electrolysers
  - Reuse wasted heat (be careful with integrations!)
- Smart construction
  - Eliminate compressors, etc...
- Using by-product oxygen
- Continuous creativity to reduce prices
  - Improving the process and product

Opportunities

- 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 in talks with few partners to develop 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

Why decentralized

- Renewables available at stranded locations offers best opportunities today
  - Trade off with fossil fuels (gasoline costs much higher than average in New York/ heavily concentrated central)
  - Make use of local infrastructure for ammonia
  - Less transportation costs to bring ammonia to stranded area
  - New applications for ammonia in progress
    - Ammonia fuel cells
    - Ammonia power generators
    - Ammonia gas turbines
    - Ammonia Engines (stationary and mobile)

Why decentralized

- Large units have some negatives
  - More re-transportation
  - Storage and logistics problems rise
  - Need for long term, multi client agreements for financing
  - But larger units should be cheaper when more than 6 NFUEL units are required, step change

- 1000 ton/annum unit fits small communities
- 1000 ton/annum units can be easily increased by duplication

- Also important: Be independent! Full control once fuel applications start developing

- Also political reasons: what to do with stranded wind

Conclusions

- NFUEL units available today at 1000 t/annum units
  - power2ammonia and gas2ammonia
  - Proven technology
  - Financing possibilities with banks today
- Other sizes possible today as well, but not as skids
- Capital costs reductions underway

Conclusions

- For ammonia as a fuel
  - Decentralized ammonia production can be already competitive with gasoline at price-point mbtu at stranded locations
  - More area's will become competitive when gasoline price rise in time
  - Slow introduction is most logical process
  - Small capital investments seem the trend to go

Conclusions

- Ammonia as a fertilizer
  - Present ammonia farmer pricing competitive with NFUEL investment
    - Based on curtailed energy
    - Power balancing
    - To become independant
  - New add-on technology for farmers could make decentralised nitrates as well (patent pending)

Conclusions

- Ammonia as a chemical
  - Green chemicals from NFUEL will be new development
  - NFUEL units may have a positive effect on operating permits
  - Decentralised, high quality ammonia is available without transport and logistics problems
  - At site production of ammonia at power plants for DENOX

Thank you

For more details about our NFUEL- units

please email us at

info@protonventures.com