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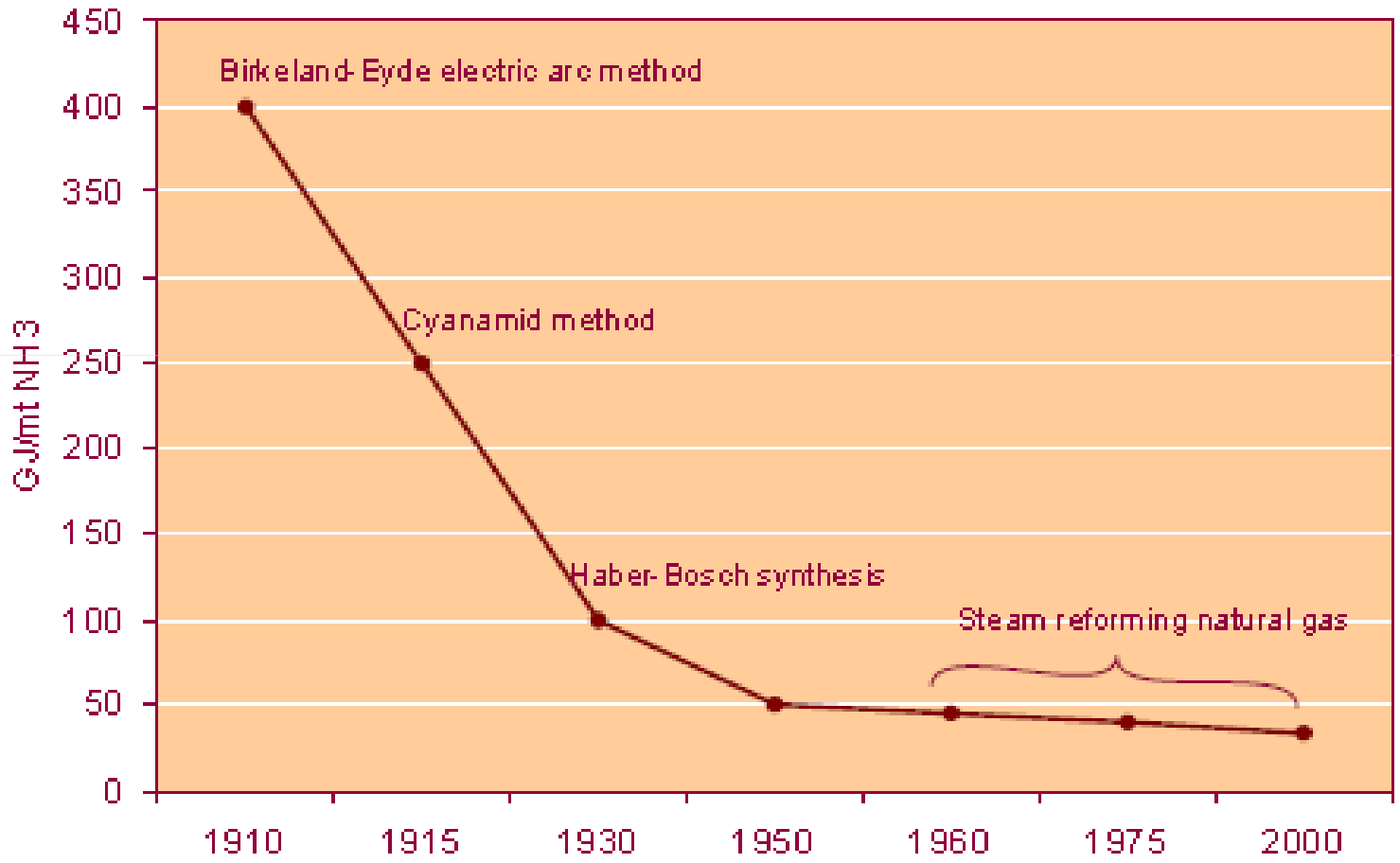
Question:
Is it mini-ammonia or MEGA-ammonia in future???

History of ammonia production efficiency



From MEGA-ammonia to mini-AMMONIA

Production of Fertilisers is based on price for ammonia:

Proven methods for N fixation (for fertilisers):

1903 Arc Method (Birkeland and Eyde);
$N_2+O_2 \rightarrow NO \rightarrow HNO_3$

1905 Cyanid Process

1910 Haber Bosch Process
- -Steam reforming
- -Loop only,based on H2-waste/electrolysers

Green Ammonia/ without CO_2 emissions

In development

2010 HP mini HB by Proton

20xx SSAP by NHthree

From MEGA-ammonia to mini-AMMONIA

First Ammonia reactor for 7200 t/a unit

About 7 meter high
Pressure about 300 Barg
Temperature: 450 C
Fe- Catalyst

From MEGA-ammonia to mini-AMMONIA

NH3:

A continuous drive towards cheaper NH3 price/ fertlisers:

Energy price and volume development:

1918:	100 GJ/t	7200	t/a	1 t/hr
1950:	50 GJ/t	250000	t/a	30 t/hr
1970:	34 GJ/t	500000	t/a	60 t/hr
1985:	31 GJ/t	650000	t/a	80 t/hr
2004:	27 GJ/t	1000000	t/a	125 t/hr

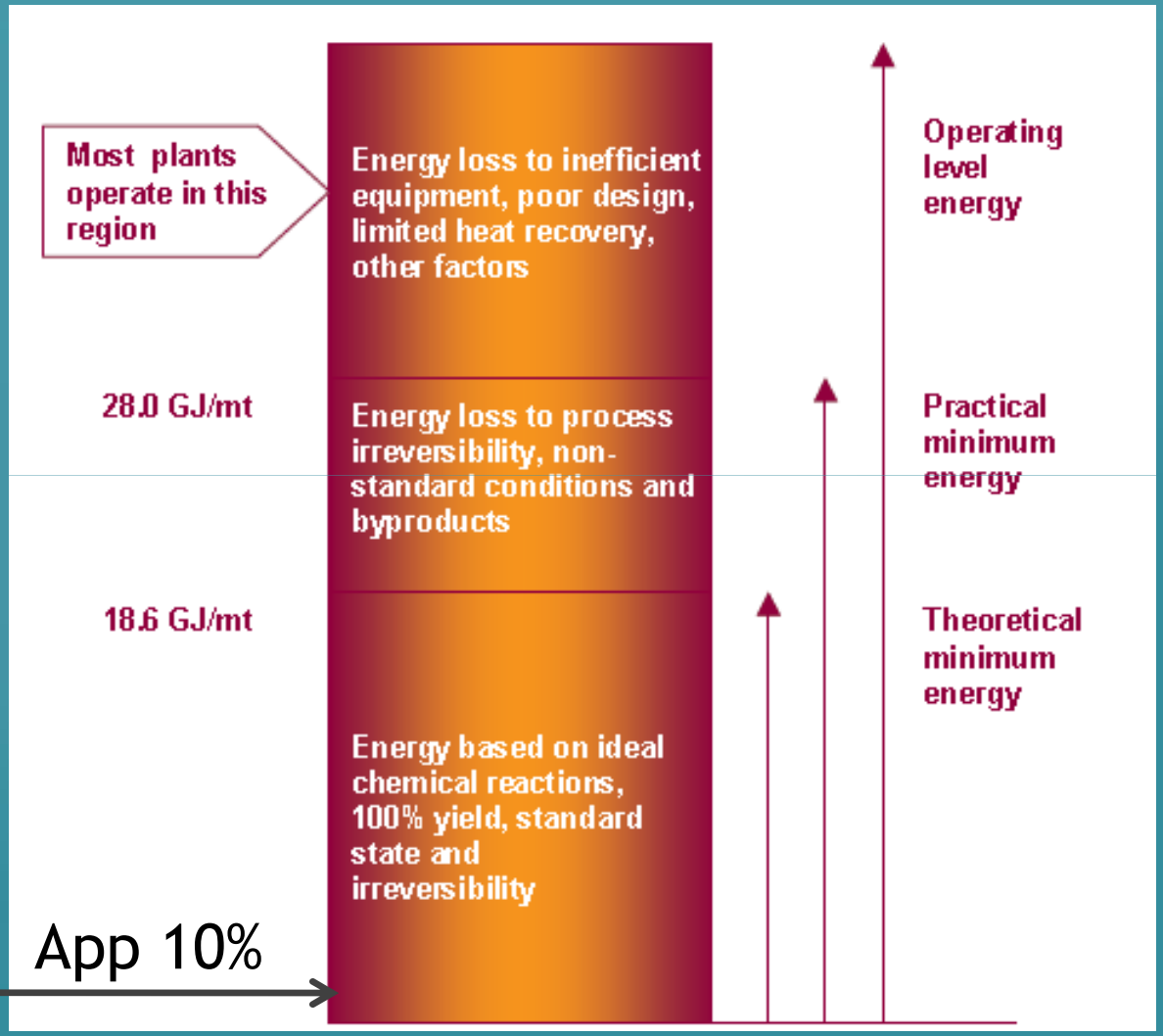
Nowadays: MEGA-AMMONIA plants are world scale units with high Energy Efficiency and single train units, but….

From MEGA-ammonia to mini-AMMONIA

still based on HABER BOSCH TECHNOLOGY

$$3\ H_2 + 1\ N_2 \rightarrow 2\ NH_3 + \text{“energy”}$$

From MEGA-ammonia to mini-AMMONIA



Synthese Loop 1.6 GJ/t → App 10%

Costs Breakdown MEGA Ammonia Plant:

Natural Gas costs:		
Feed Gas:	850	NM3 Gas
Fuel Gas:	110	NM3 Gas
Operational costs	30	$/t
Fixed costs	35	$/t
Depreciation + interest:	30	$/t

Average cost price: 200-400 USD/t
150-300 Euro/t
0,10-0,20 Euro/ltr

From MEGA-ammonia to mini-AMMONIA

2000 t/d NH3 unit(s)

Proton's last Ammoani terminal project for MEGA-Units

From MEGA-ammonia to mini-AMMONIA

Why Mini-ammonia/NFUEL?:

Decentralised production
- Smaller supply chain/logistical costs/margin loss

Based on sustainable sources (in fact all Sdolar based)
- Solar
- Wind
- Geothermal
- Biomass

Independant towards fossil fuels
- supply situation/ costs effects

No additional transports

From MEGA-ammonia to mini-AMMONIA

Potential Markets for NFUEL:

Small scale fertlisers production at remote locations
Aqua Ammonia production at power plants
Aqua Ammonia for waste incinerators
Green chemical (e.g. for HNO3- for MDI or TDI)

Ammonia for FUEL,
- as Fuel station for NH3-cars
- as storage for H2 cars
- as replacer of gasoline/diesel

How to realise an NFUEL UNIT today?:

For investors/decison makers:

- Proven technology
- No/Low environmental risk
- Safe
- Secure
- Reliable
- Simple to operate
  - Fully automated
  - Preferrably no manpower
- Maintenance free
- Possibilities for subsidies

Proton's NFUEL unit(s)

Total Package:

- Electrolyser(s)
- Nitrogen membranes
- Haber-Bosch Synthesis loop
- Control system Honeywell
- Storage and loading equipment
- Scrubber and related safety systems
- DM-water unit

- Process Guarantee
- Maintenance agreement(s)
- On-line Operational support

From MEGA-ammonia to mini-AMMONIA

References for mini-ammonia:

1 t/hr unit in Argentina, based on same concept

Rio Tercero at Petroquímica

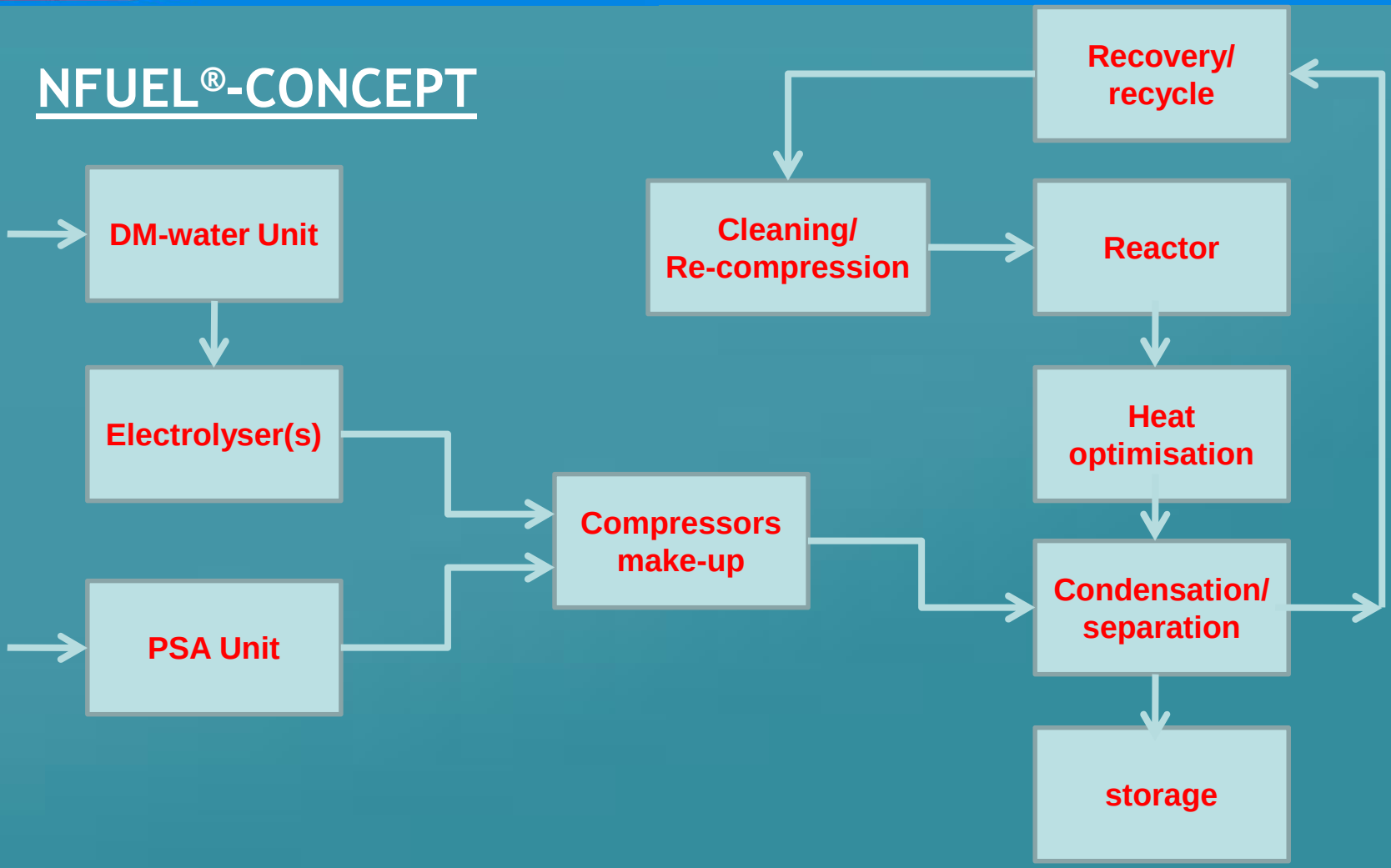
From MEGA-ammonia to mini-AMMONIA

Proton's Partners:

Casale Group (Switzerland)	Electrolysers
Ammonia Casale (Switzerland)	Ammonia reactor
Honeywell	Automation & control
Zeton (Netherlands/Canada)	Plant construction
Hatenboer Water	DM-water units
Nitrogen generator	Air Products
Proton Ventures BV	Overall Design

From MEGA-ammonia to mini-AMMONIA

NFUEL®-CONCEPT



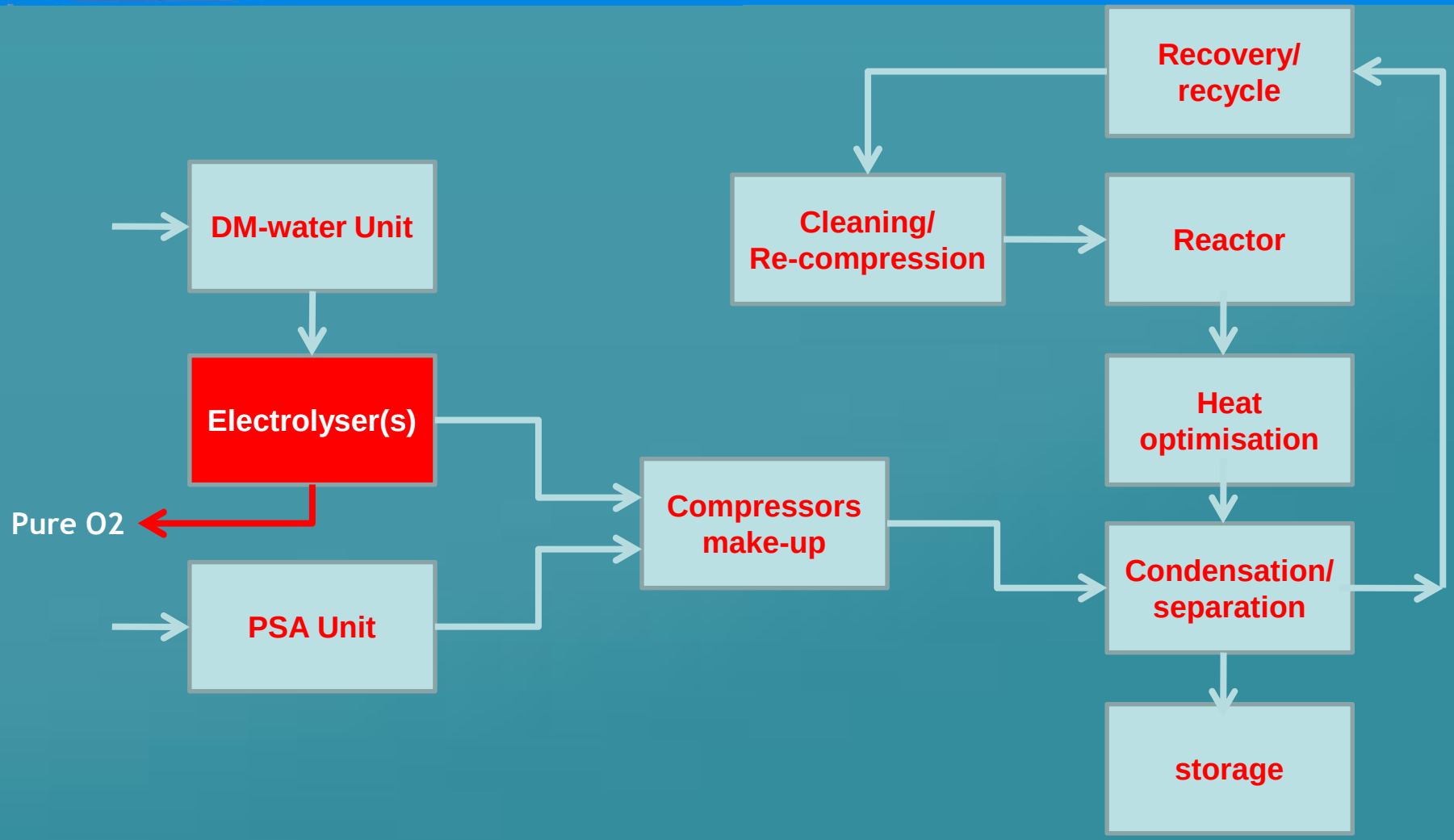
From MEGA-ammonia to mini-AMMONIA

Advantages /features:

- Not the standard HB configuration

- Investment more important than energy consumption
- Safety systems in place for non-industrial locations
- No cooling water required , avoiding water issues
- Fully automated
- Recovery of ammonia without refrigeration system
- 20 years catalyst life time guaranty due to set-up
- Easy to operate
- Not many turn-arounds required
- Integrated with different unit operations

From MEGA-ammonia to mini-AMMONIA



From MEGA-ammonia to mini-AMMONIA

Why Casale Electrolysers:

- Low energy consumption: ca. 4,0 kWh/Nm3
- High pressure H2 from cells; from 30 up to 100 barg
- Proven production record: 20 years on-stream
- Simple and low maintenance costs: once a year max
- Constructed in Italy
- Technology Patented, Alkaline based technology

- Various sizes possible 10-450 Nm3/hr in one stack

- NOTE: NO VALUE OR INVESTMENTS TAKEN FOR O2

From MEGA-ammonia to mini-AMMONIA

Small electrolysers

10 Nm3/hr

15 Nm/hr

20 Nm/hr

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Medium sized electrolysers

From MEGA-ammonia to mini-AMMONIA

Larger electrolysers: 100-500 Nm3

Operational in Italy

100 Nm/hr

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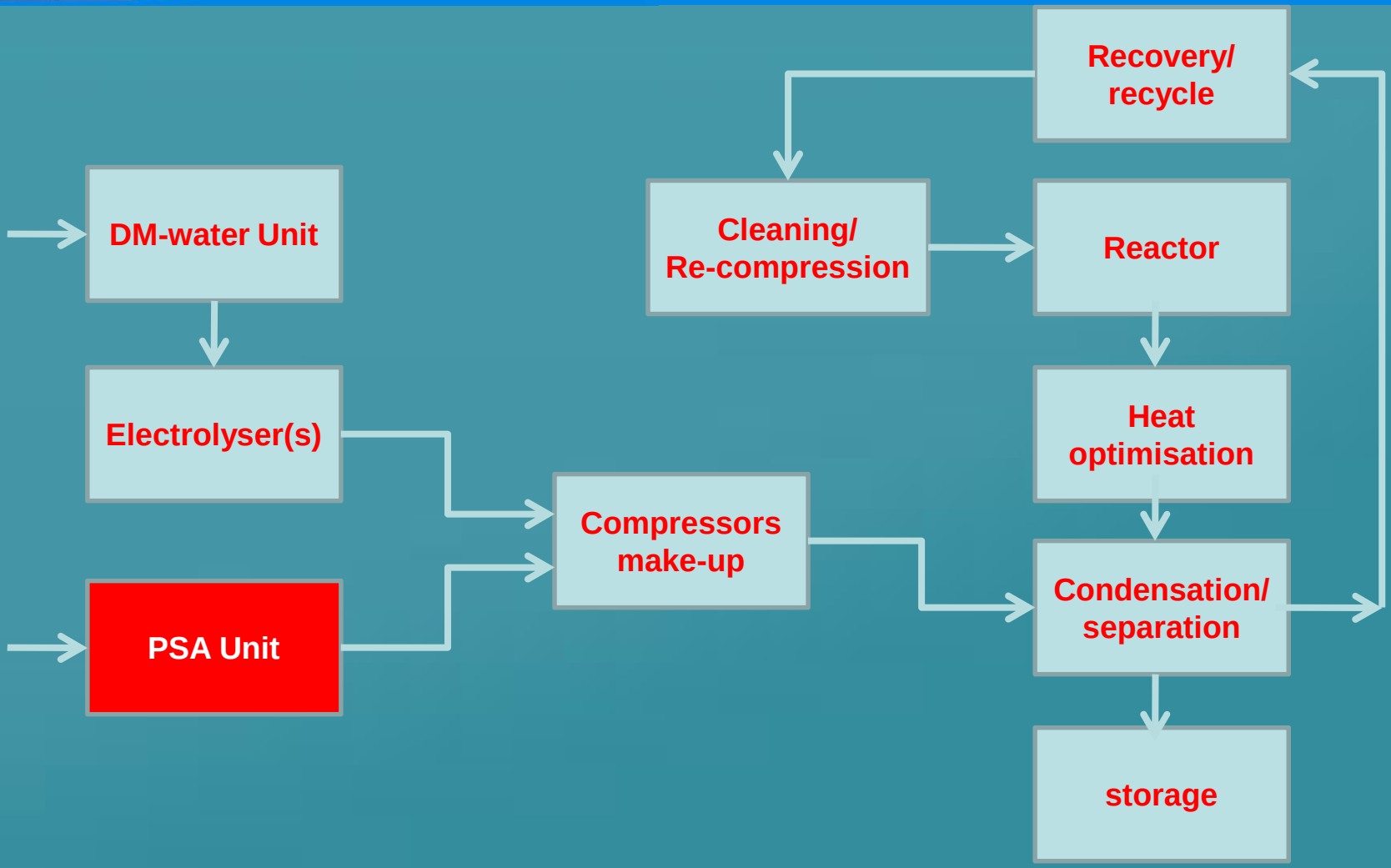


N2-supply

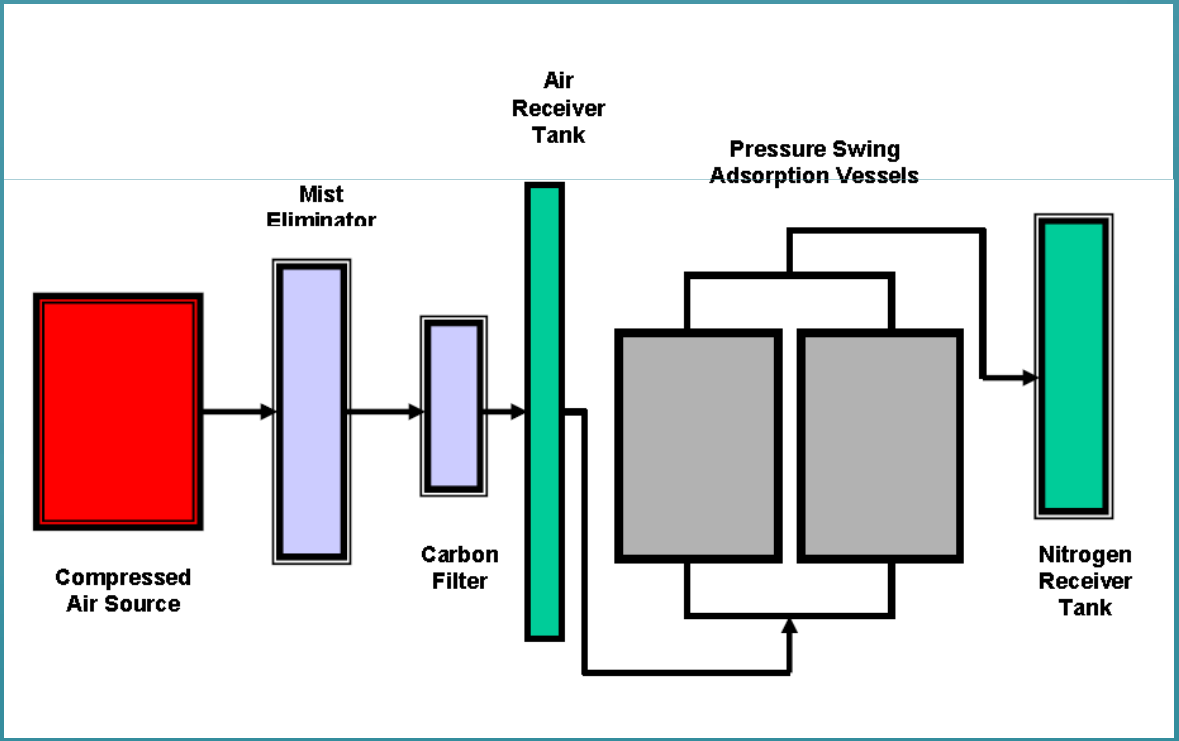
PSA is required over Cryogenic or Membrane technology:

- purity
- costs
- operability at “mini-scale levels”

Small units usually are PSA,

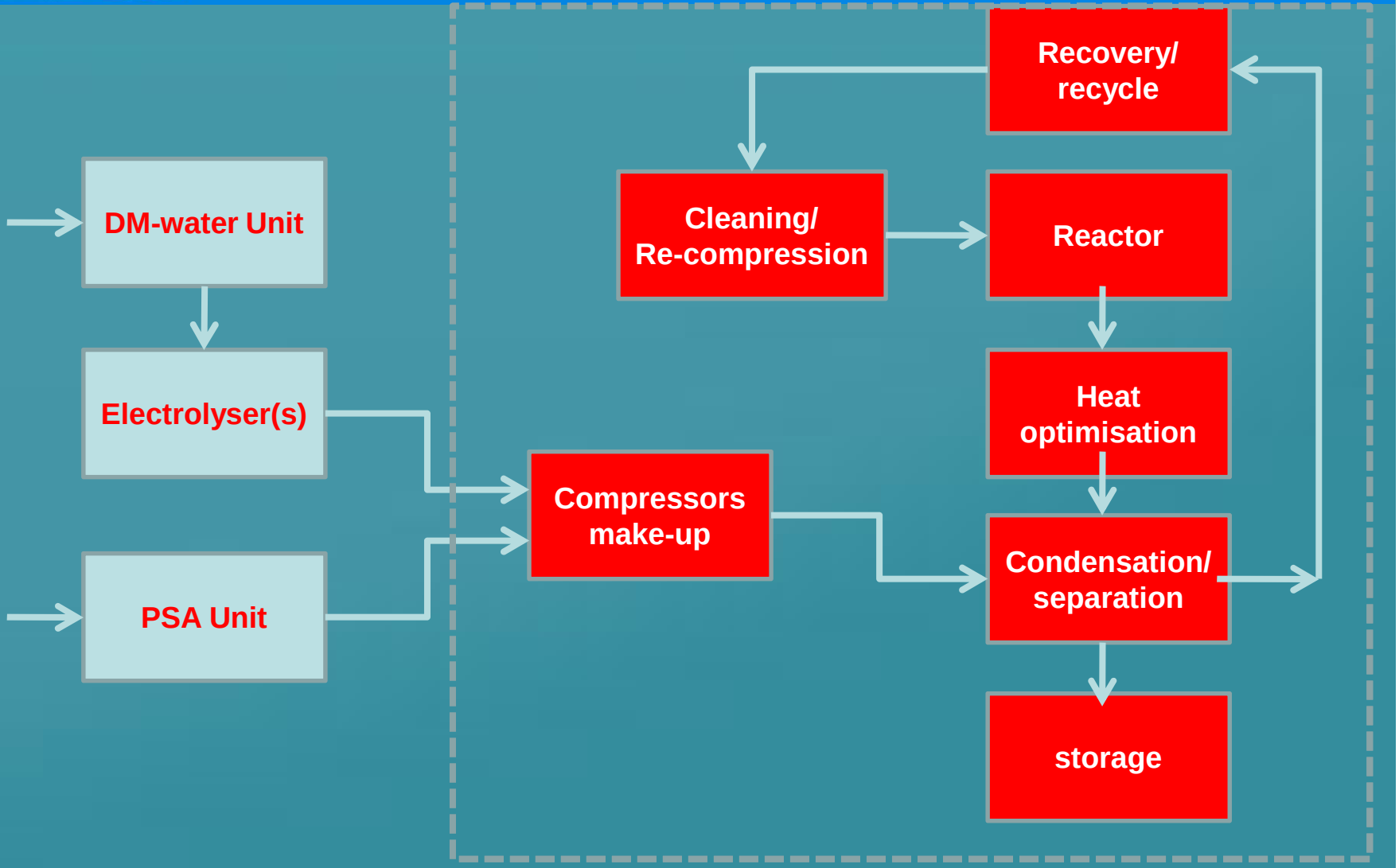
- N2: 95-99,99%
- Lowest costs per Nm3 N2 over 10 years time

Example for N2 generator/purifier
>99,9% pure
120-650 Nm3/hr N2 equals



Medium sized PSA unit for N2-production (picture UOP)

From MEGA-ammonia to mini-AMMONIA

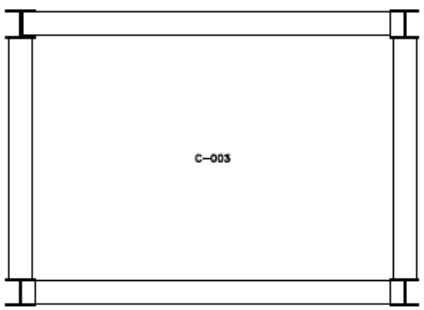


From MEGA-ammonia to mini-AMMONIA

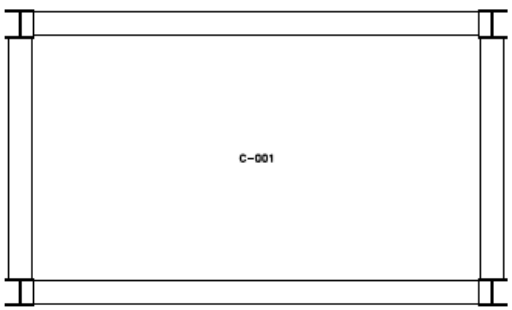
The NFUEL -unit:

- According Dutch Standards for Pressure Vessel Directive
- According PGS 13
- Sil 2 classification
- Scrubber versus stack for <100 kg/hr units
- Highest HP tubing spec for piping, commercially available
- No water for cooling,but optional (= cheaper, if available)
- Skid based:
  - 1 skid for 25 ton/annum
  - 4 skids for 1000-2000 ton/annum
  - 4 skids plus separate compressors for larger units

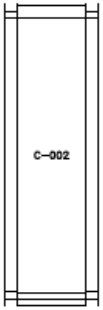
Top view 120 kg/hr installation



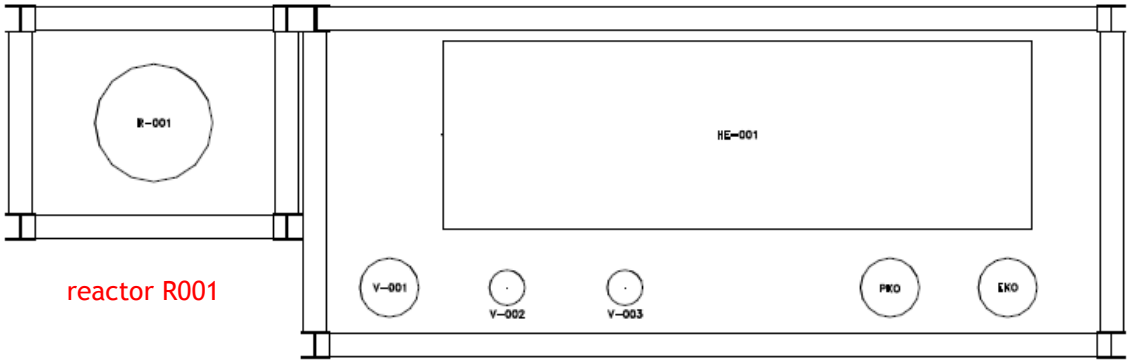
C003: recycle compressor skid



C001: main feed compressor



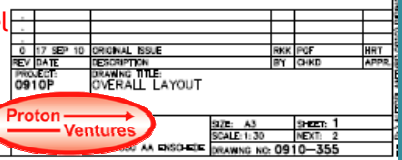
C002: nitrogen compressor



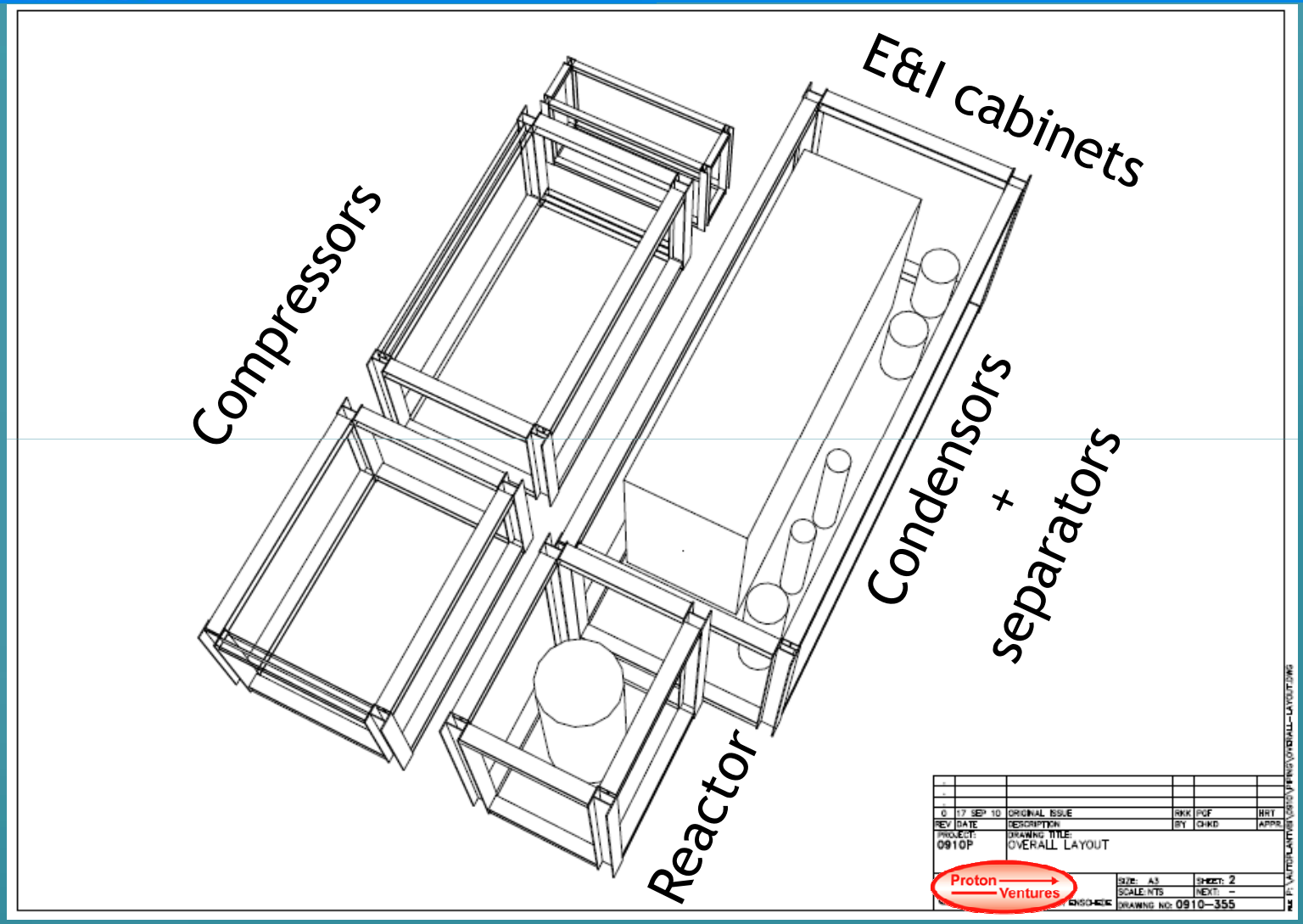
reactor R001

V001: High pressure separator
V002: Liquid ammonia flash
V003: Liquid ammonia flash

PKO: process knock out vessel
EKO: Emergency knock out vessel
HE001: Three fan air cooler



From MEGA-ammonia to mini-AMMONIA



From MEGA-ammonia to mini-AMMONIA

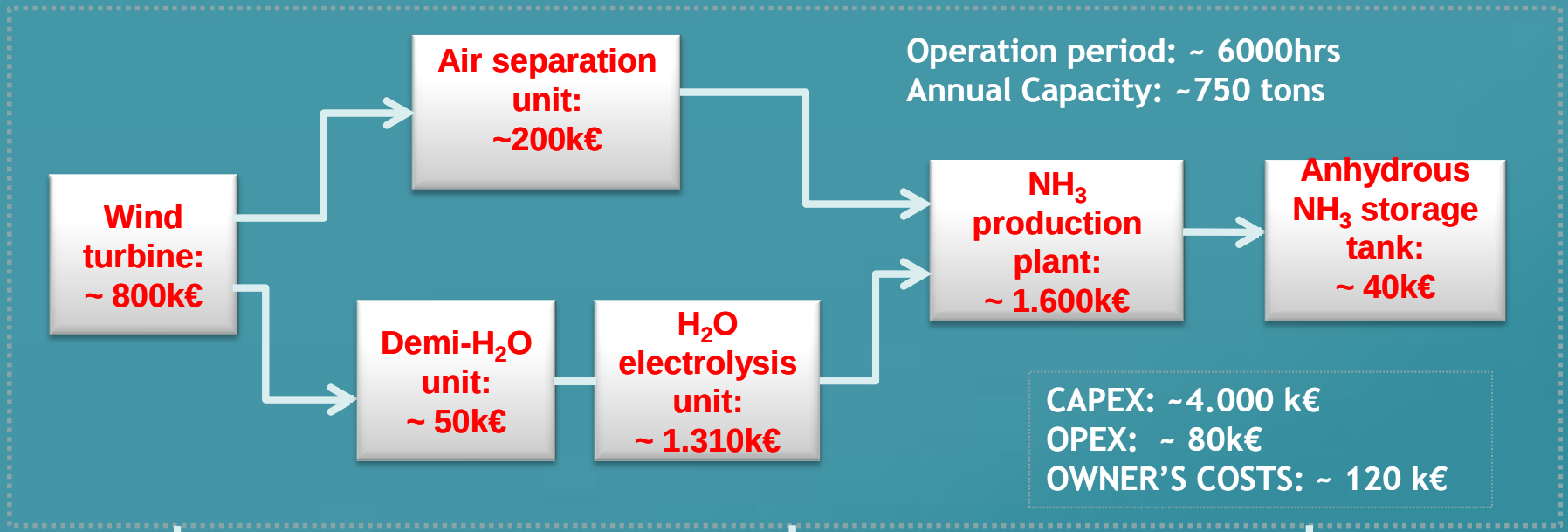
Costs comparison NFUEL versus MEGA:

50 kg/hr unit
120 kg/hr unit
1000 kg/hr unit

Total costs for : wind2ammonia® !!!!!
Depreciation 10 years
Interest: 4%
Service factor total unit: 0,5 / 0,75/ 0,98
Operational costs limited due to automation
2% maintenance

From MEGA-ammonia to mini-AMMONIA

125 kg/hr at 75% service factor



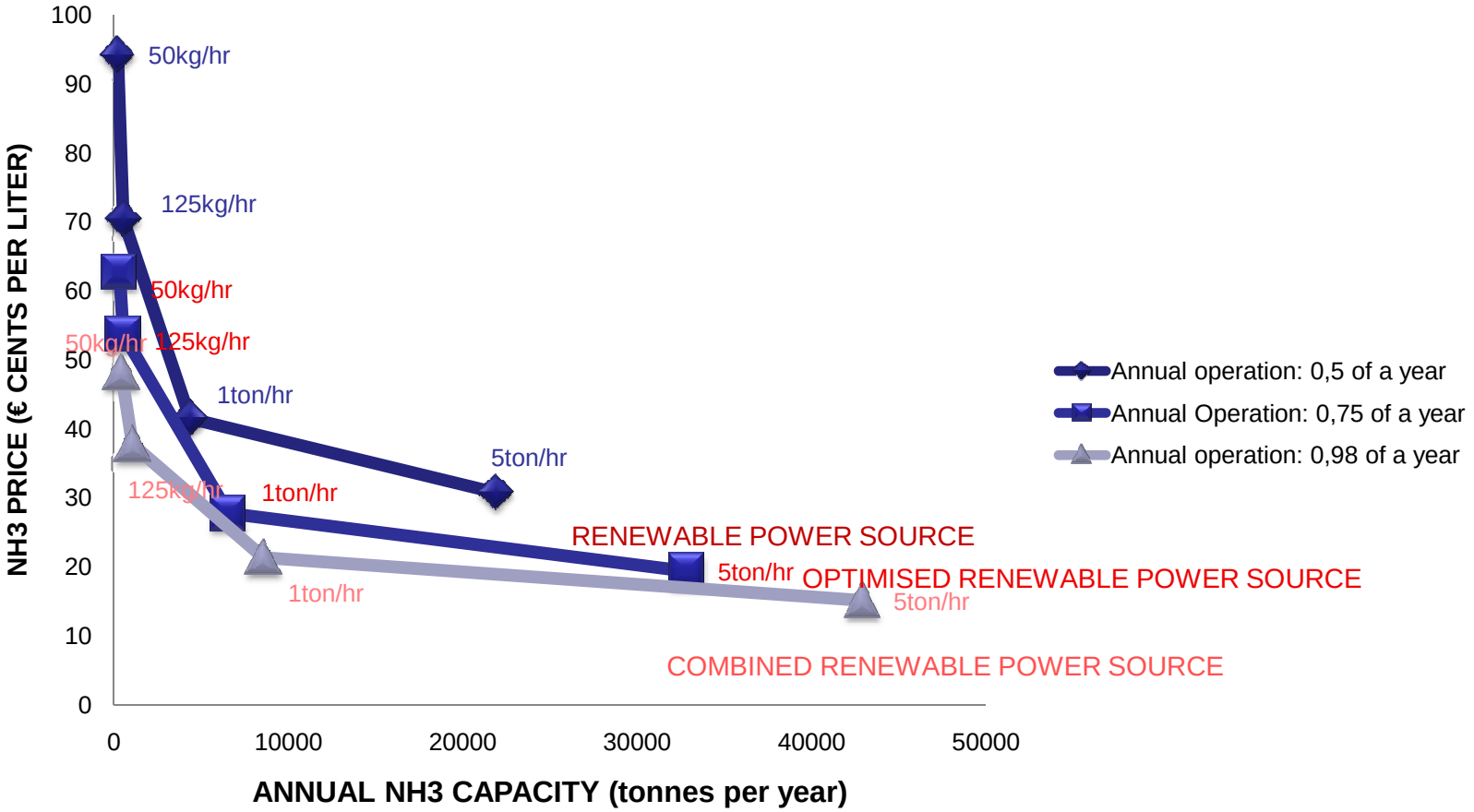
Fertiliser
~ 650 €/ton NH_3

Aq. NH_3
~ 160 €/ton NH_3

NH_3 Fuel
~ 0,4 €/lt NH_3

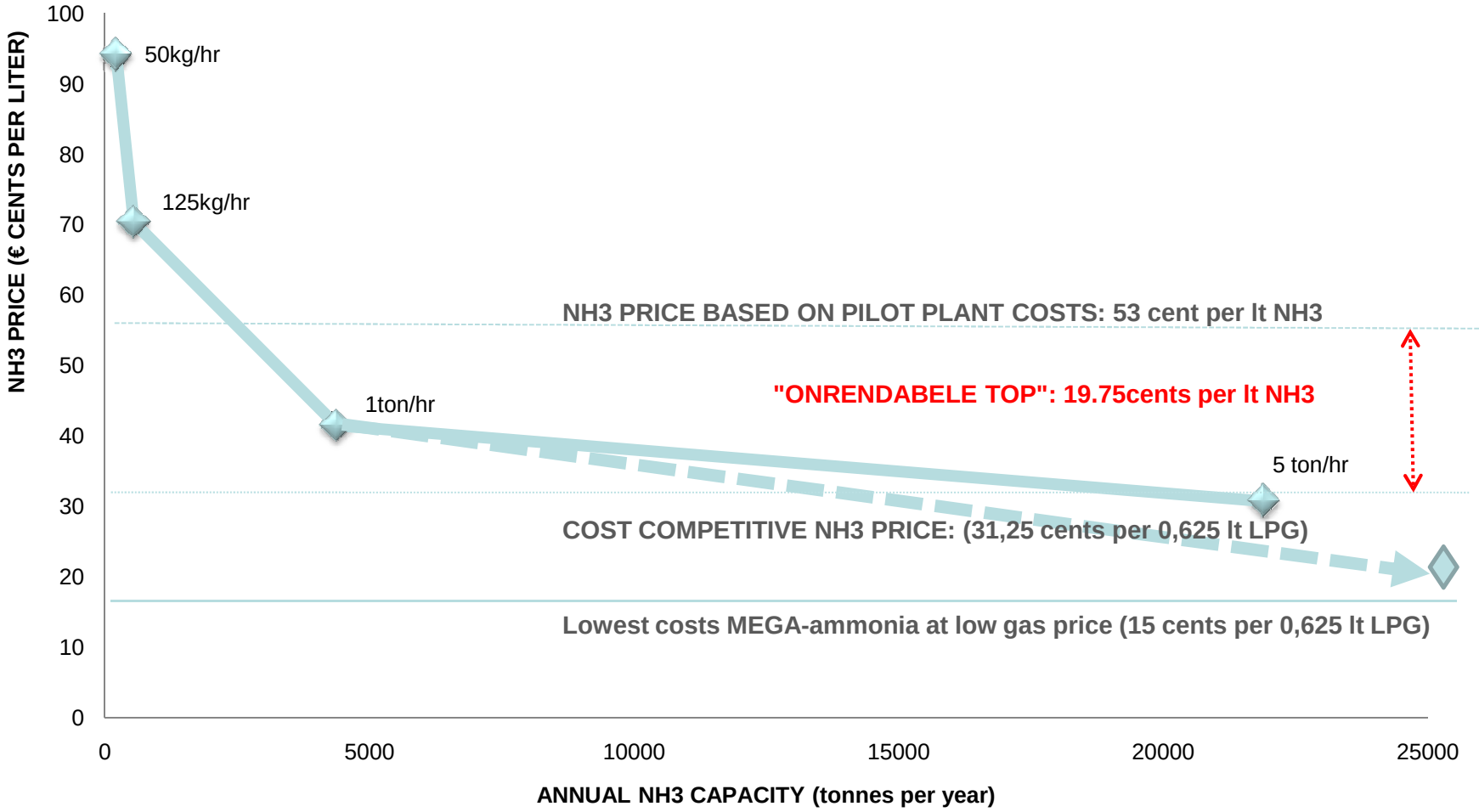
From MEGA-ammonia to mini-AMMONIA

NH3 PRICES FOR VARIOUS CAPACITIES & OPERATION PERIODS



From MEGA-ammonia to mini-AMMONIA

NH_3 PRICE FOR VARIOUS CAPACITIES @ 75% SF



NOTE: Prices calculated based on annual operation of 4380 hrs per year)

Ammonia production Costs Comparison MEGA-NFUEL

Comparison		4 euro/MMBTU	
		MEGA	NFUEL
CO2 emissions	kg CO2/kg NH3	1,25	0
Investment	euro/ton	31,00775	559,3496
Energy costs	euro/ton	120	0
Fix/var cap costs	euro/ton	70	220
Total costs	euro/ton	**190**	**220**

Comparison		8 euro/MMBTU	
		MEGA	NFUEL
CO2 emissions	kg CO2/kg NH3	1,25	0
Investment	euro/ton	31,00775	559,3496
Energy costs	euro/ton	240	0
Fix/var cap costs	euro/ton	70	220
Total costs	euro/ton	**310**	**220**

From MEGA-ammonia to mini-AMMONIA

Conclusions:

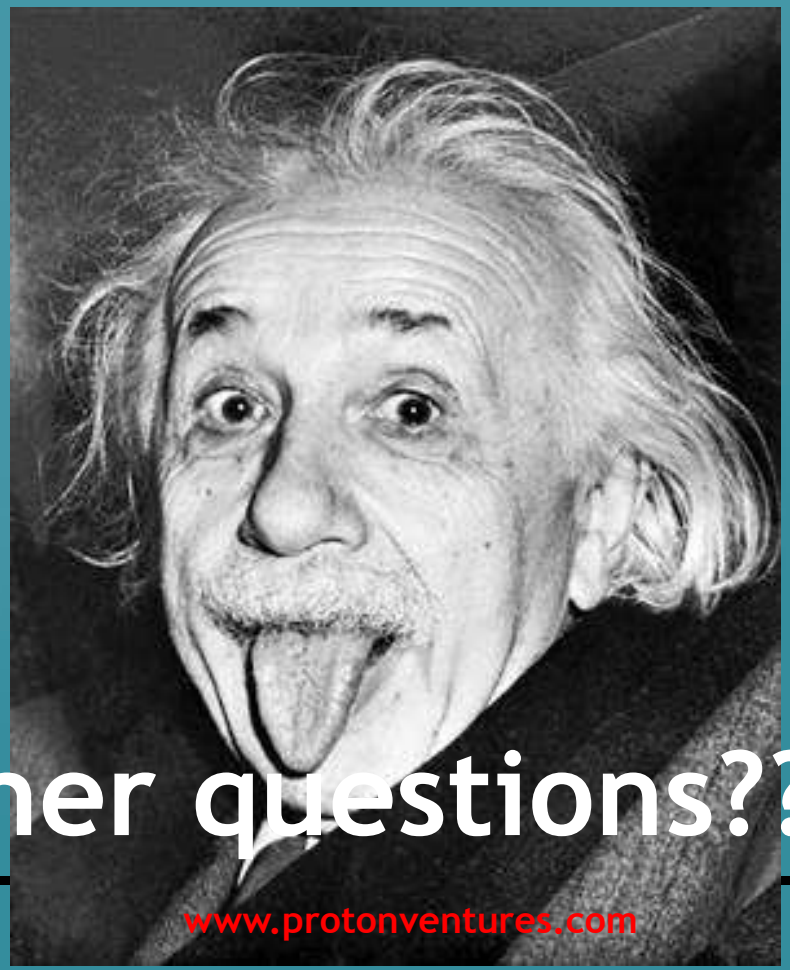
- Proton offers possibility to produce ammonia at mini-scale
- Price level is higher than commercially produced ammonia
- Real comparisons to MEGA-Ammonia are not honest due to:
  - -CO2 tax/costs for avoiding/SCC
  - -Logistics/land locked
  - -Price of power/gas
- Future optimisations/standardisation shall reduce price with learning curve

However,

Already today,NFUEL ammonia (1-5 ton/hr) seems to reach Market Price for Ammonia end-users at specific locations

Question:

Is it mini-ammonia or MEGA-ammonia in future???



Further questions????

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