



***Waterpower
clean, flexible and feasible***

Project partners





Waterpower, a new concept to combat air emissions of ships at berth

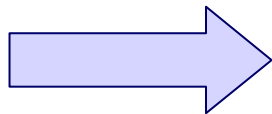
A ship at berth, running its generators, causes substantial emissions

A ship using 800 kWh electricity, a container-feeder ship or a small ferry, emits in 1 day*:

15 tons of CO₂

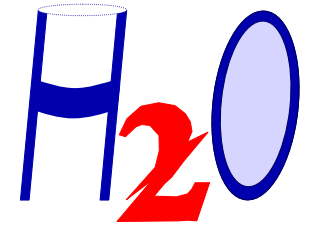
336 kg of NO_X

10 kg PM₁₀



shore-side electricity would be a great solution

* source DCMR calculations based on MGO 0.1% S



But..., that solution has a few drawbacks

Rotterdam has 440 berths

To install 1MW will cost EUR 2 – 4 mio per berth

Ship owners will not convert until they get shore-side power everywhere

Rotterdam wants many ships to use shore-side when it starts installing

A classic chicken-and-egg problem

How to find a solution that

- requires no fixed infra
- is flexible
- is very clean?



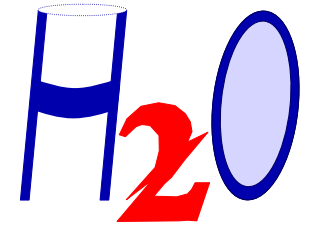


For such a project a lot of parties need to be involved



Inspectie Verkeer en Waterstaat

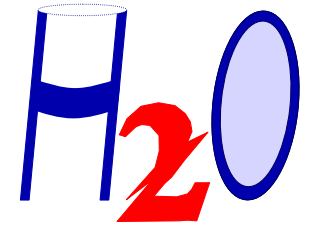




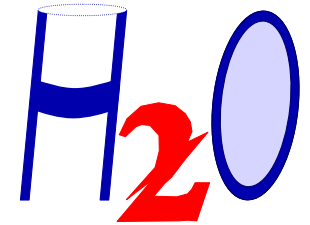
Let's make the session into a working session

Please think about good advice on three aspects

1. there is no clear problem-owner (or buyer of a solution). That makes setting up a consortium not very easy ;-)
2. how to break chicken-egg deadlocks like the shore-side power?
3. who pays for the cleaner air?
 - ship owners → competition with other ports
 - shippers → competition with other ports
 - Rotterdam → all of Netherlands has benefit of the port
 - Netherlands → Europort?



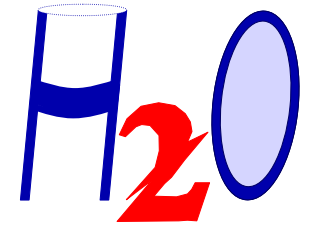
And now the Waterpower concept



What would be an ideal shore-side power system in Rotterdam?

The ideal system would:

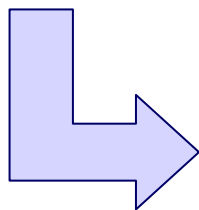
- cause no local pollution, emission or noise
- make optimal use of abatement techniques (including a CO₂ sequestration option)
- provide shore-side power at any location between Van Brienenoord and Hoek
- at very limited fixed infrastructure cost
- and competitive cost per kWh



The WATERPOWER concept might be quite ideal

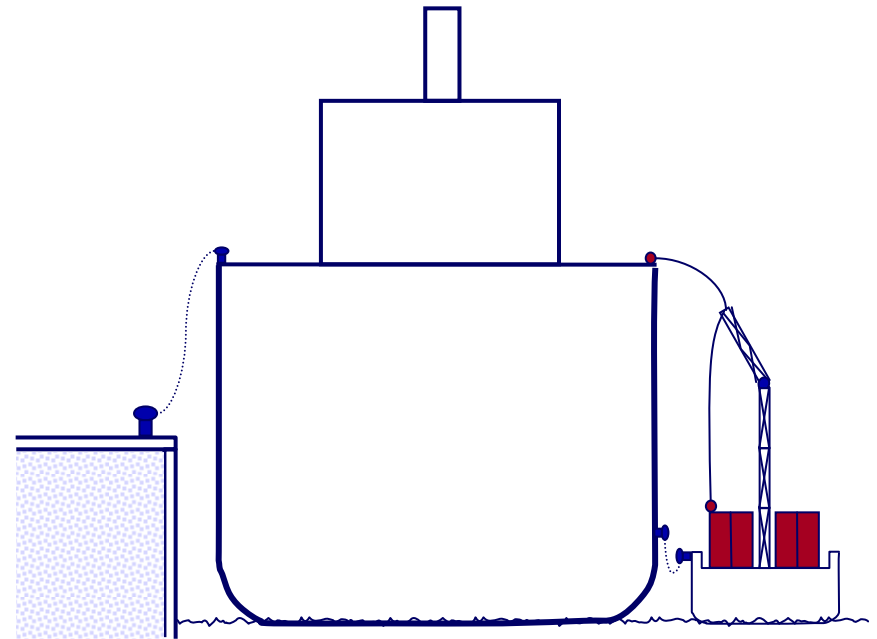
The main aspects of the system are:

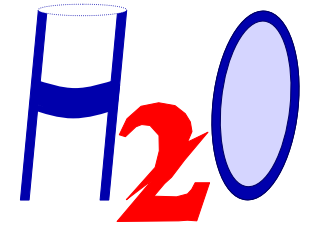
- power is provided by PEM hydrogen fuel cells
- the generator is on a barge together with power converting systems
- hydrogen is produced in the Rotterdam petrochemical sector



Resulting in:

- no local emission and very limited noise
- optimal abatement
- power anywhere

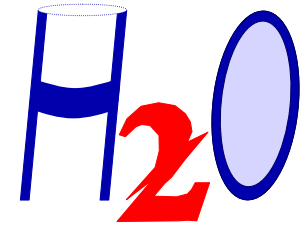




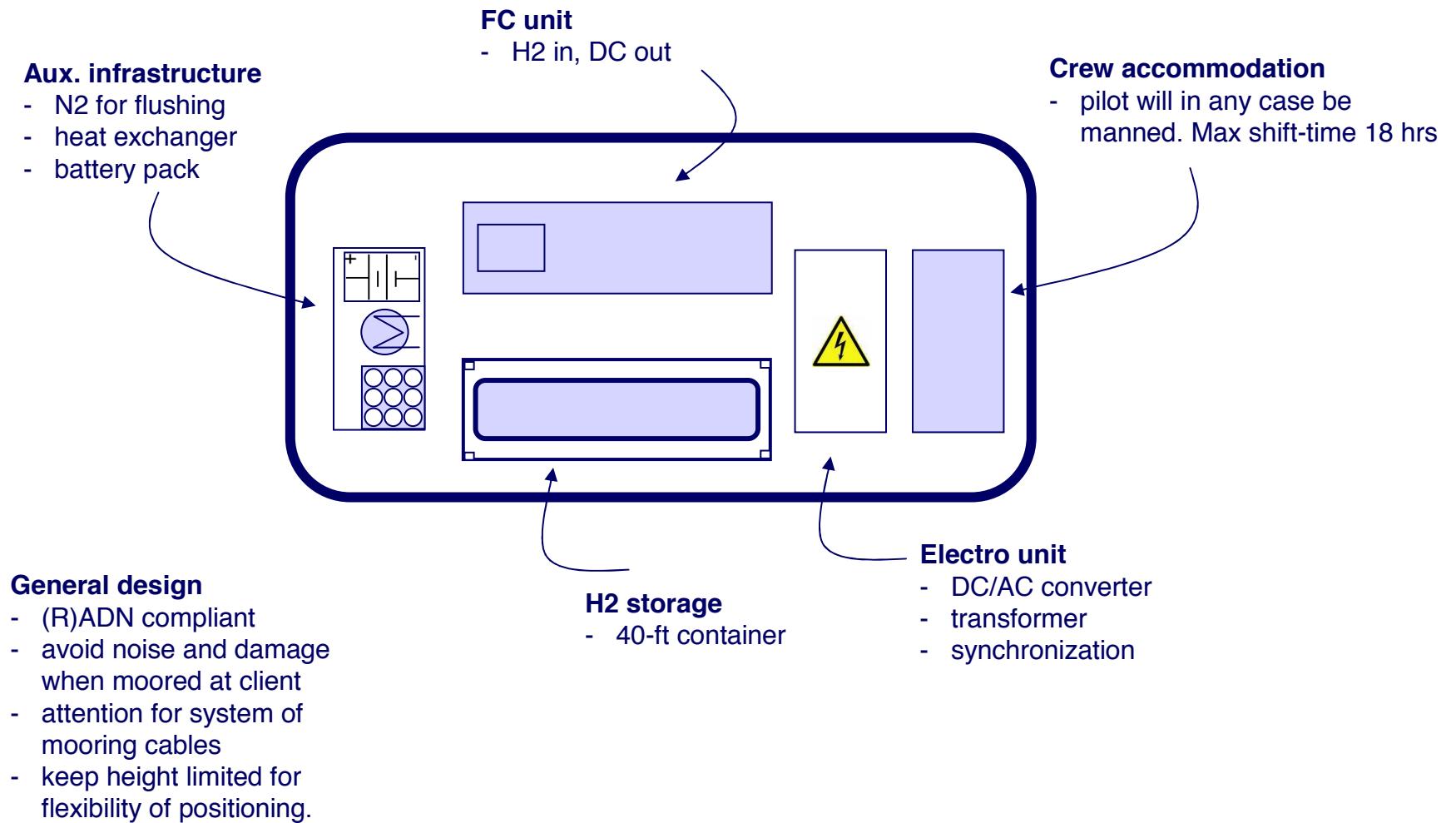
The system offers a number of advantages

Why the choices as made:

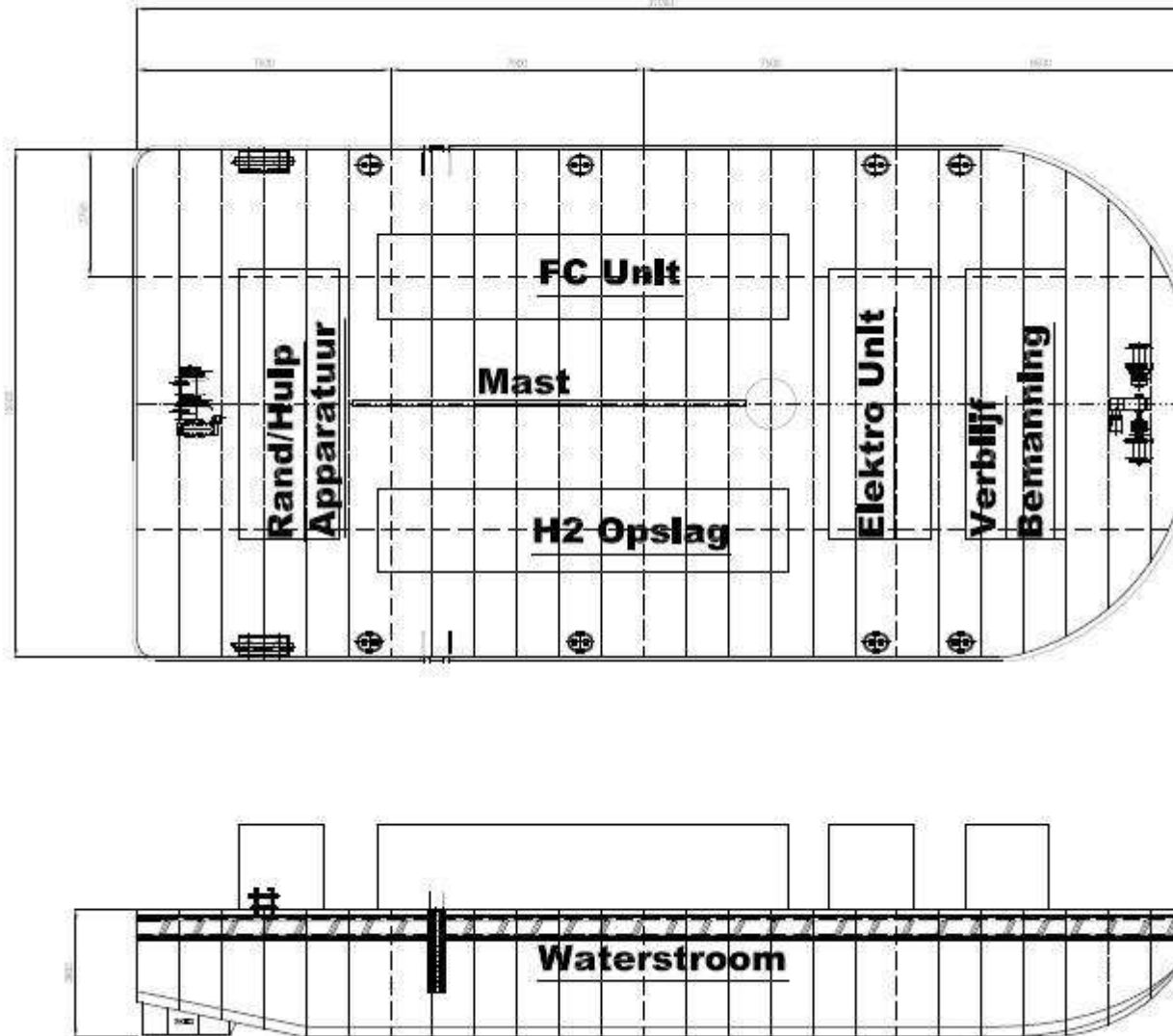
- PEM fuel cells
 - are rapid start/stop, like a generator
 - have reached “industrial” use and are scalable
 - the barge concept ensures
 - flexibility of location (for ship and near-shore use)
 - N=1 start (no chicken-egg issue)
 - hydrogen as fuel
 - is abundantly available in Rotterdam produced at sites with abatement options
 - an H2 grid is available in Rotterdam
 - might well be a choice for the future
- designed to be recyclable
 - good cost curve potential
 - high efficiency (45-65% electrical)

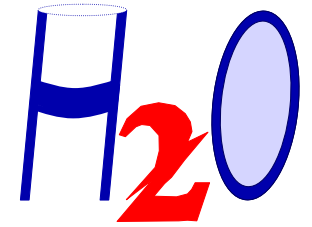


Design aspects 1st barge

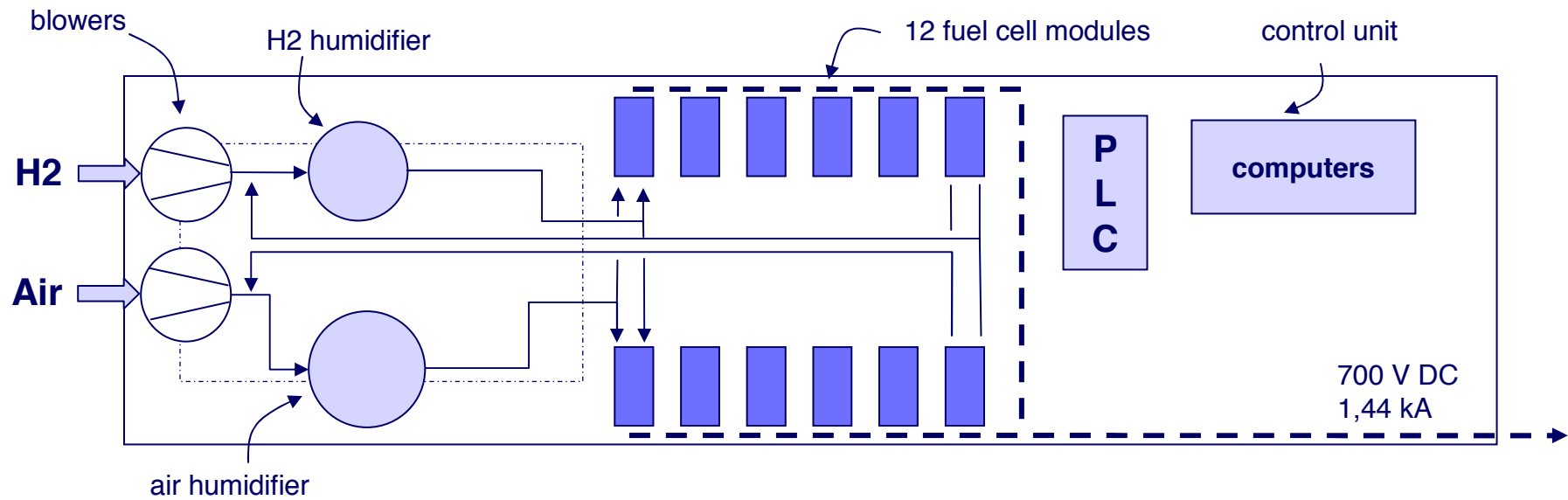


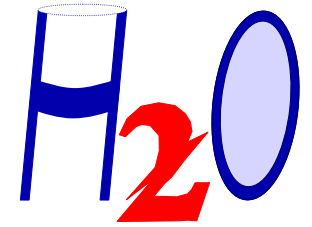
Placement of units onboard barge





Fuel cell unit





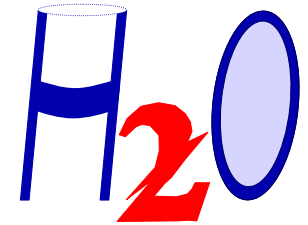
***Fuel cells and H₂-storage are becoming
“standard practice”***



PEM fuel cells have developed into standardized “industrial” components, meeting high reliability and up-time requirements

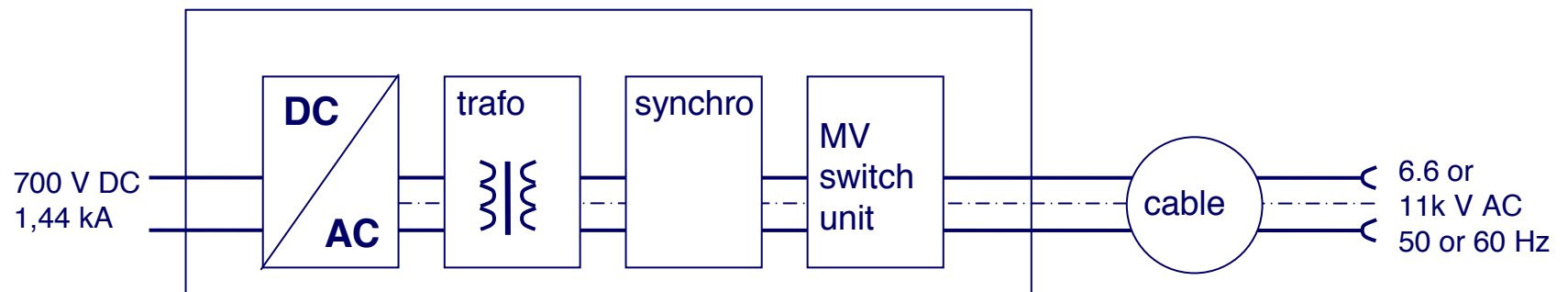
H₂ storage and transport in 40-ft units is “business as usual”. Units have 40 days storage “autonomy” and are approved for road and maritime transport



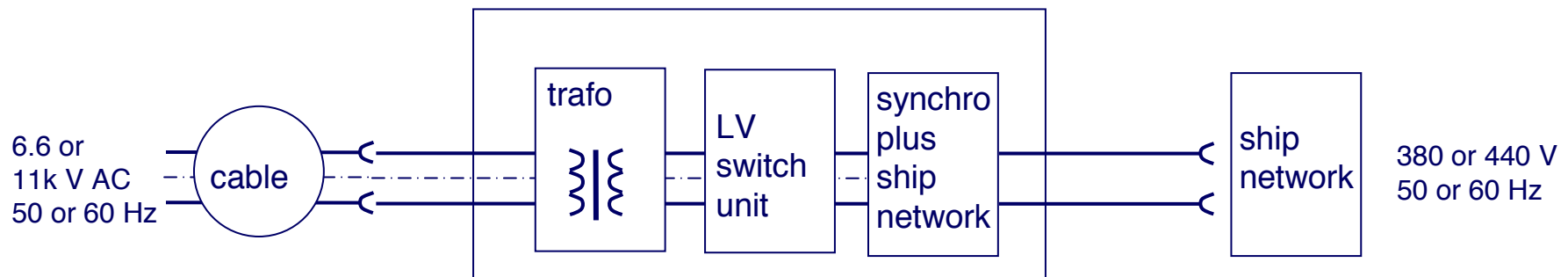


A ship needs infrastructure for any type of shore power, the barge unit meets ship's requirements

electro unit on board barge

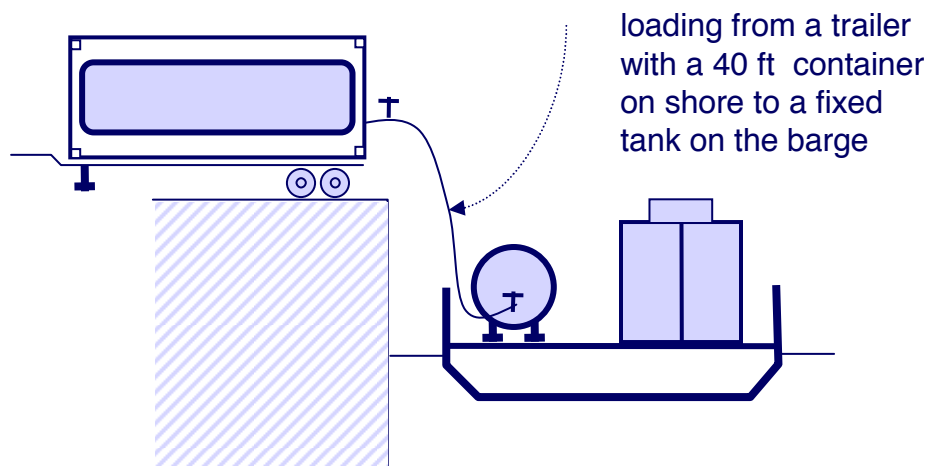
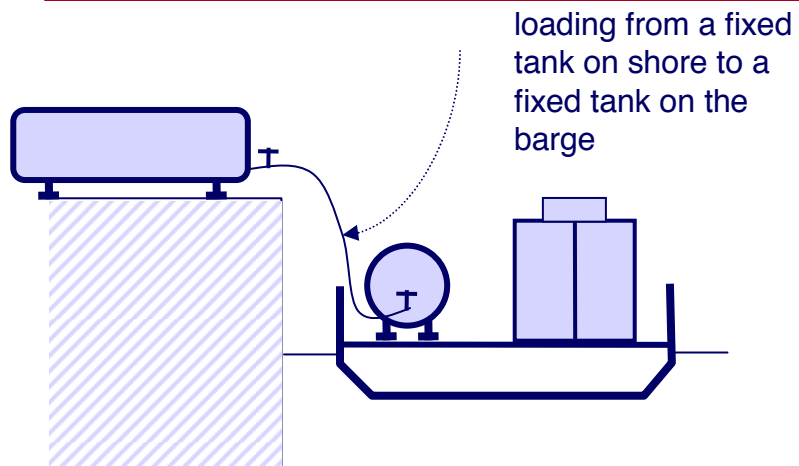


ship infrastructure for shore power



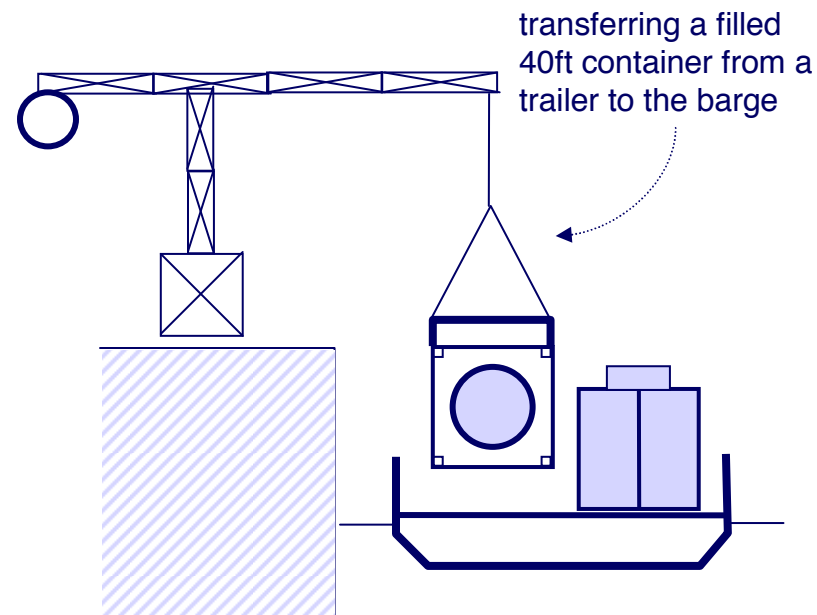


Also H2 loading was a bit of a discussion



Criteria

- safety
- manpower required
- logistical flexibility
- possible locations in the port
- regulations with regard to H2 storage





Economics

1st pilot barge

Capex EUR 7.4 mio, of which EUR 4.5 mio is sunk cost.

Opex EUR 700,000 per annum.

Series production

Capex EUR 3.7 mio

Normal operations

500 kW customers → EUR 0.44/kWh

800 kW customers → EUR 0.33/kWh

Comparison

Cost of conventional types of shore-side power
is EUR 0.17 to 0.82 /kWh

On-board generation price → EUR 0.10 to EUR 0.20 / kWh
depending on ship and generator sizes



Health benefits

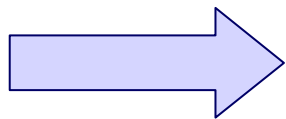
GGD Rotterdam has made estimates of health benefits linked to the reduction of exposure to NO₂ en particulate matter PM₁₀.

The amounts per inhabitant per annum are:

- NO₂ EUR 0.25 per 1 µg/m³ avoided exposure
- PM₁₀ EUR 85.-- per 1 µg/m³ avoided exposure

1 operational Waterpower barge reduces emissions (based on 2010 standard of MGO 0.1% S) with:

- 80 ton/annum NO₂
- 2,5 ton/annum PM₁₀



How large is the benefit?



Our model, a very conservative estimate

We assume

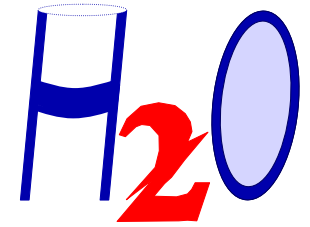
- the relevant Rijnmond area is 10 x 40 km's
- diesel emission reach 300 m height
- average wind speed is 10 knots
- ➔ this implies that 10/day all air is renewed

1 barge in operation lowers the exposure by 0,2 $\mu\text{g}/\text{m}^3$ NO₂ and 0,006 $1\mu\text{g}/\text{m}^3$ PM₁₀ for the 1.2 million inhabitants of Rijnmond, a health benefit of:

- EUR 55,000 for NO₂
 - EUR 580,000 for PM₁₀
- in total EUR 635,000

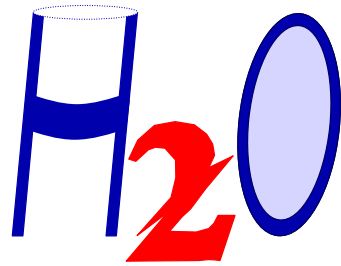
or **EUR 0.13/kWh**





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Waterpower secretariat

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