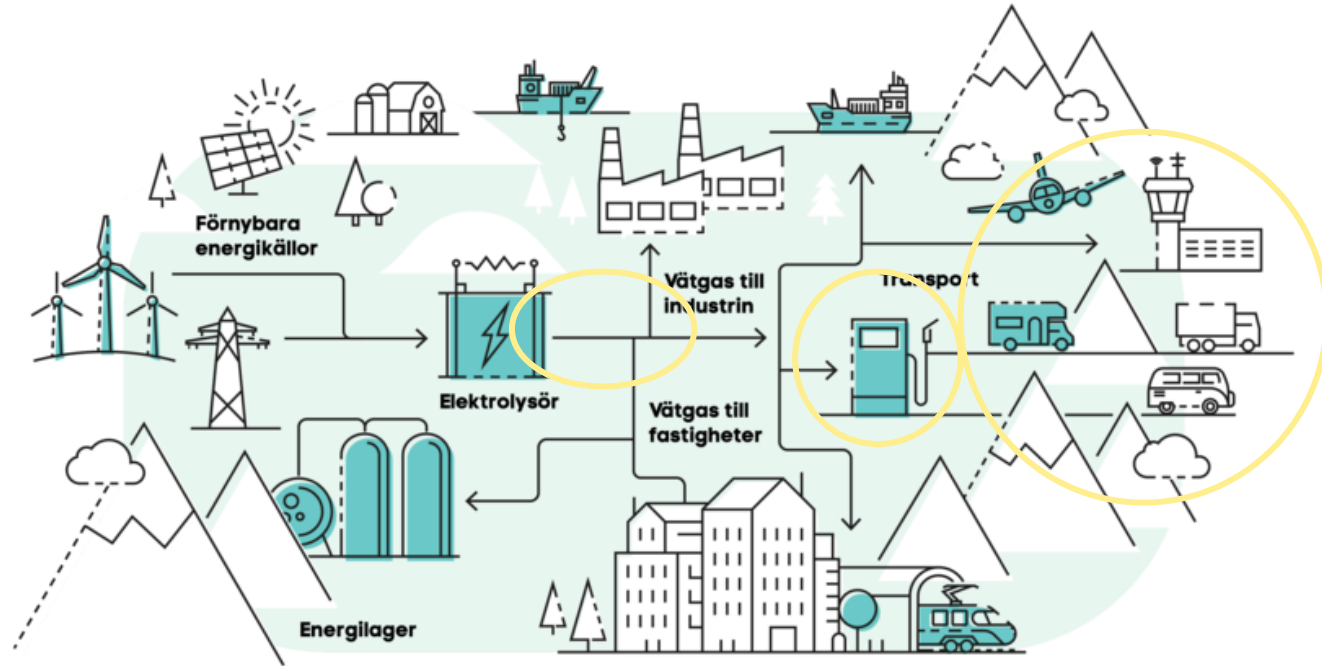


An introduction to hydrogen systems within electromobility

SEES Vårmöte – Vätgas & Bränsleceller 02/05-2023

Annika Carlson, RISE

Today's topic

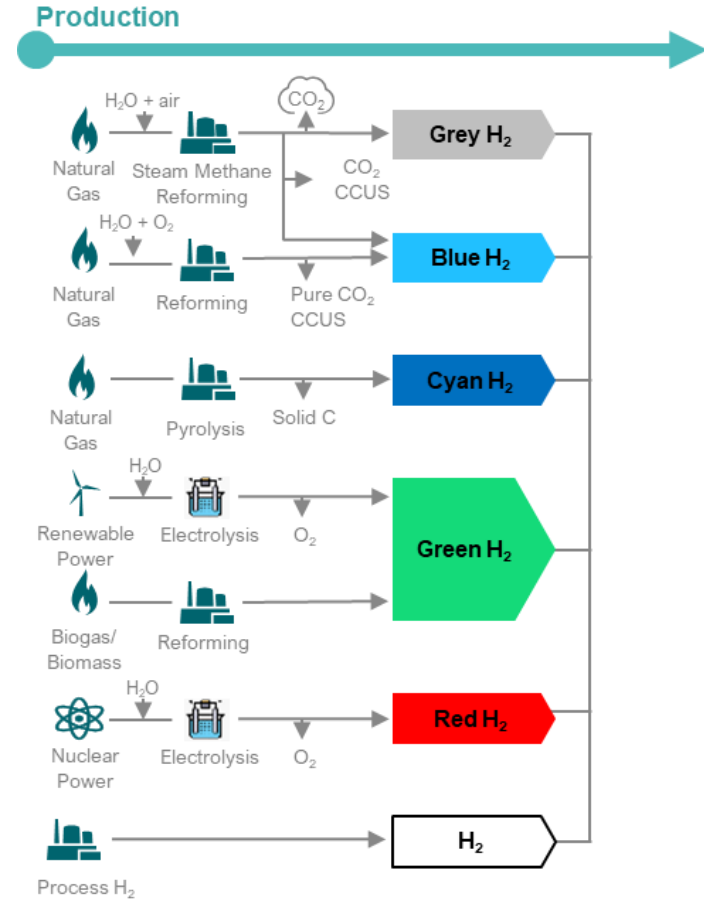


Agenda

- Introduction
- Shortly on hydrogen production
- Refuelling stations
- Fuel cell systems
 - Fuel cells to handle peak charging
 - On Vehicles

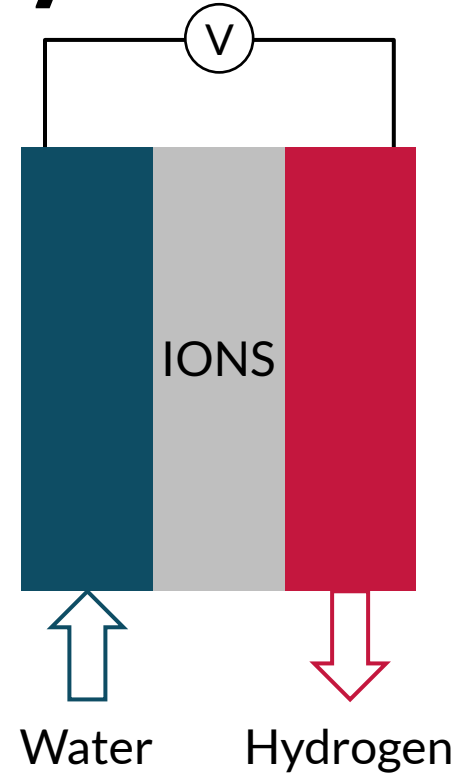
Olika sätt att producera vätegas:

- The hydrogen rainbow?
- Actually, there are varying definitions between countries
- I prefer to talk about what is said in the EU regarding grades as this is what will affect most.



What is a water electrolyzer?

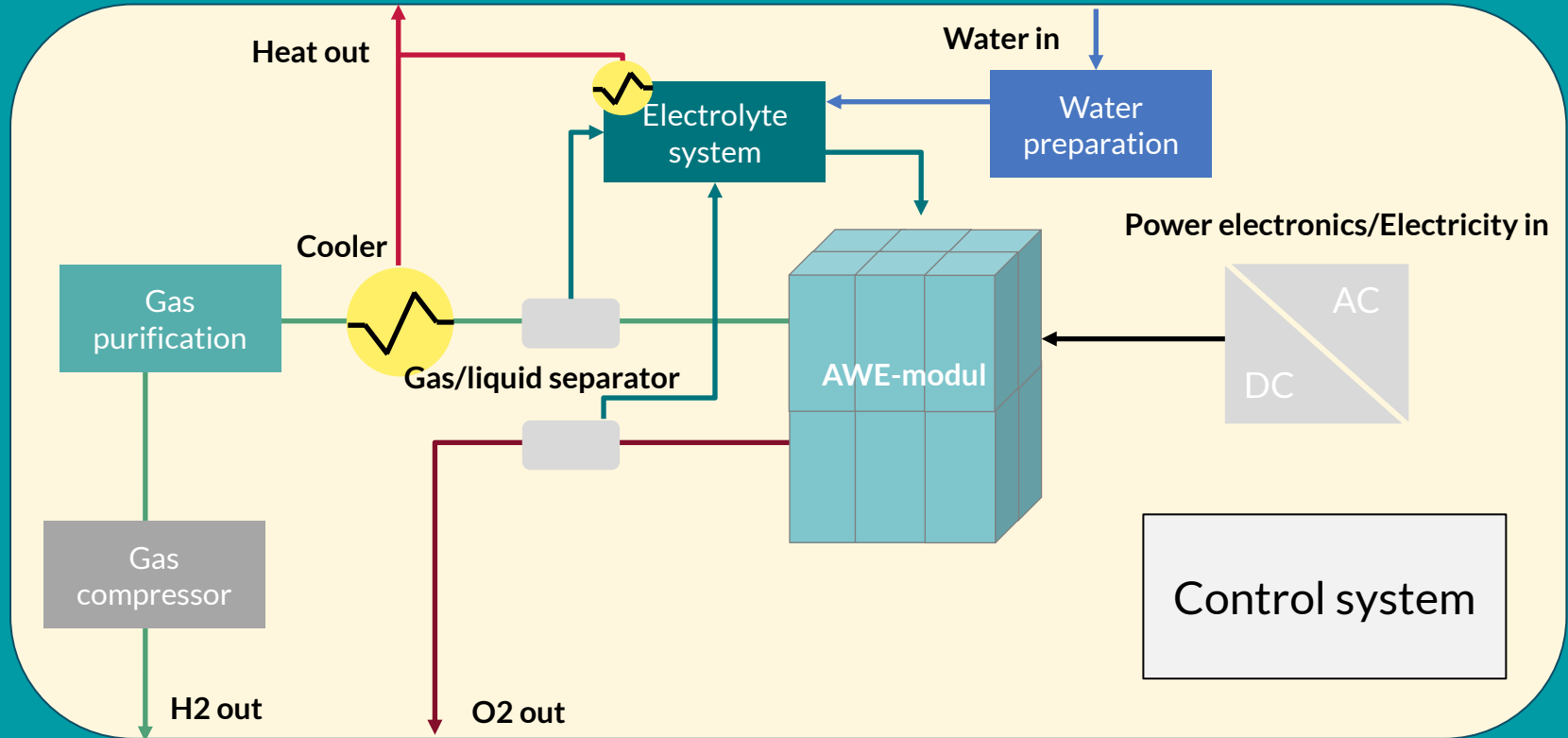
- Many many layers with electrochemical reactions
- In the system there are also:
 - Compressors
 - Heat exchangers
 - DC/DC and AC/DC components
 - Control systems
 - Gas purifications
 - Etc.



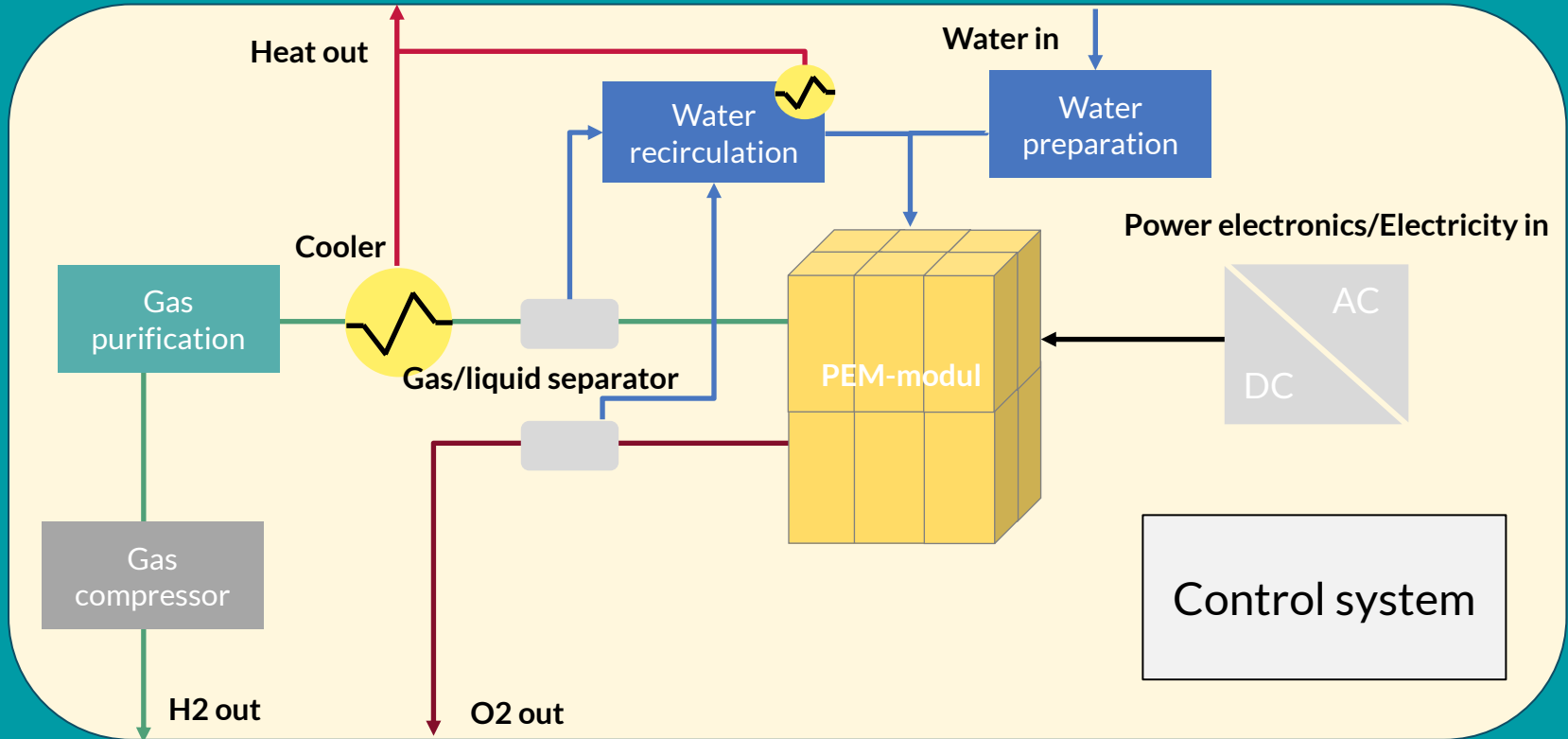
At refuelling stations two types are considered:

- Alkaline Water Electrolysis (AWE)
 - High TRL
 - Cheaper
- Proton Exchange Membrane Water Electrolysis (PEMWE)
 - High gas purity
 - More flexible

Example AWE:



Example PEMWE:



Engineering issues related to the Electrolysis units?

- To build the in the first place you need close collaboration between:
 - Chemical process engineers
 - Material engineers
 - Mechanical engineers
 - Electrical engineers
 - Programmers
 - Safety specialists
 -

Engineering issues related to the Electrolysis units?

- Much focus now is placed on:
 - Operational patterns and their affect on degradation
 - Cheaper materials
 - Automated production (Many layers need to work together)
 - Corrosion
 - Water purification
 - Hydrogen sensors and safety engineering

Refueling stations

HRS – Sverige

Active HRS today:

- Arlanda
- Sandviken
- Umeå
- Mariestad
- Göteborg

Planned going forward a selection:

Uddevalla, Göteborg (2),
Helsingborg, Malmö, Trelleborg,
Växjö, Karlshamn, Oskarshamn,
Linköping, Örebro, Stockholm (2),
Borlänge, Östersund, Sundsvall,
Luleå, Kiruna, Skellefteå

There are planes for around 70 stations



CGH2-stations:

- 350 bar
- 700 bar
- 1000-3600 kg

Refuelling station configurations

Supply

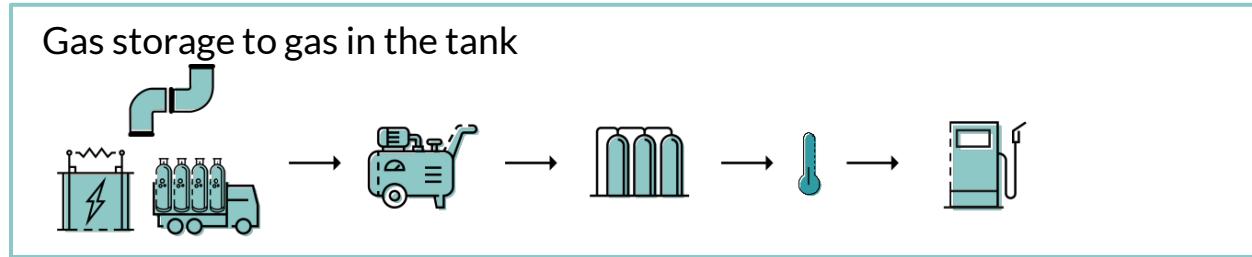
On-site
electrolysis

Pipeline

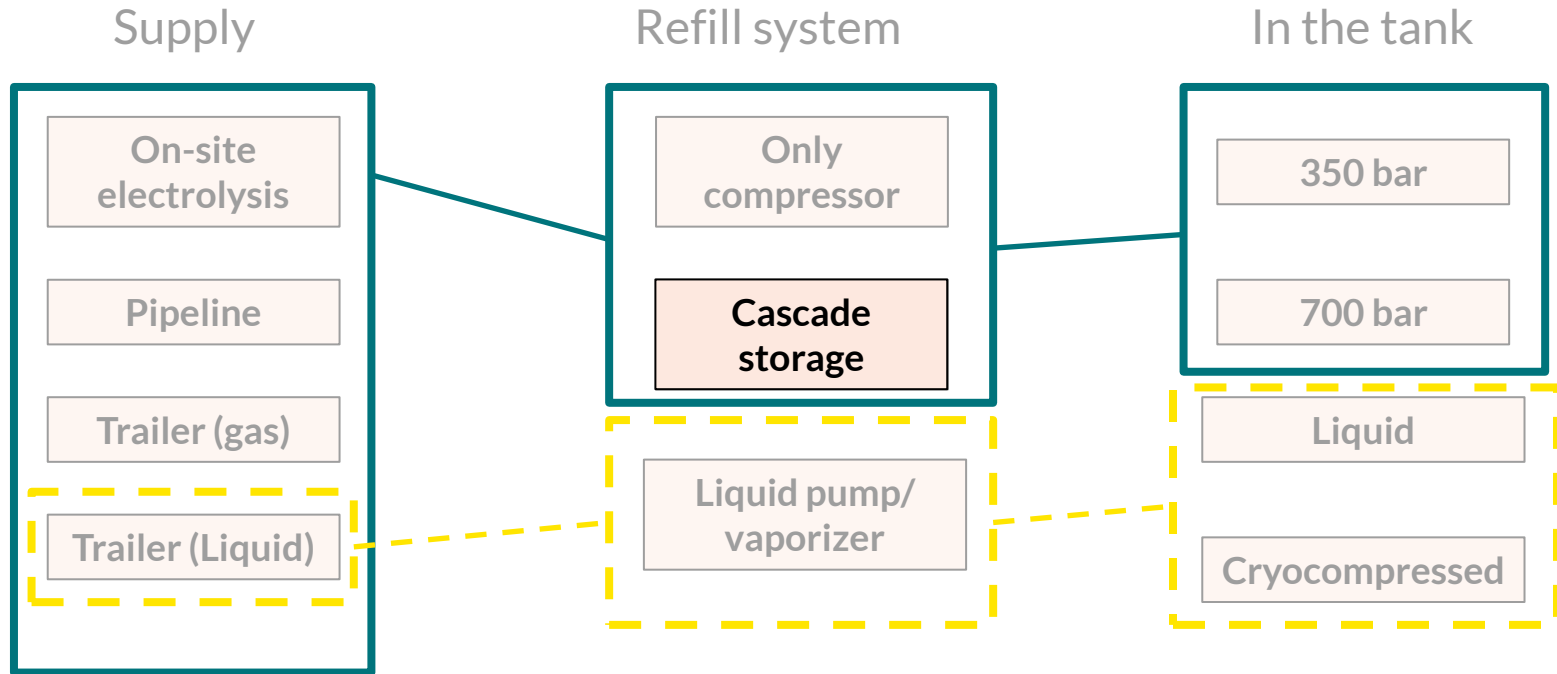
Trailer (gas)

Trailer (Liquid)

Schematically how can an HRS look?

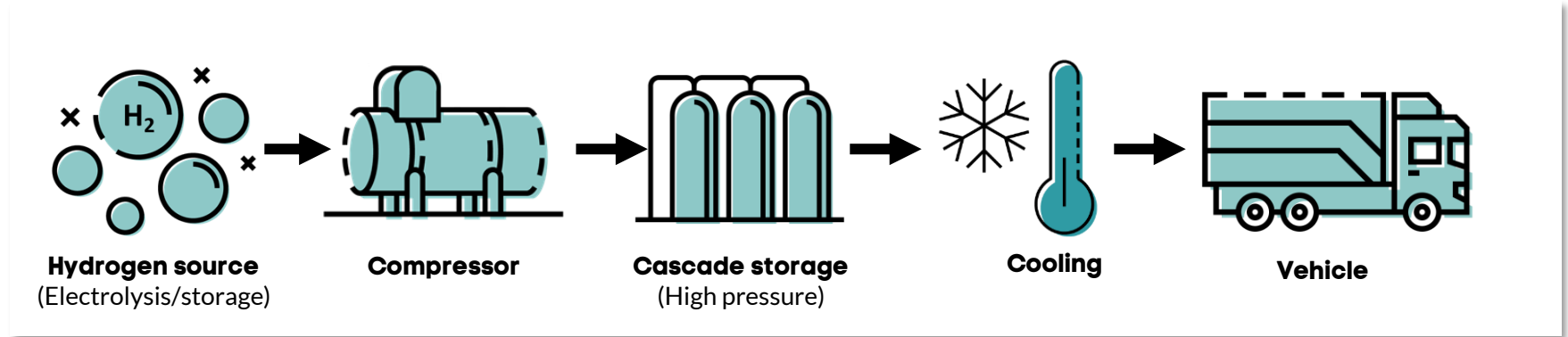


Refuelling station configurations



How a Cascade storage HRS Works?

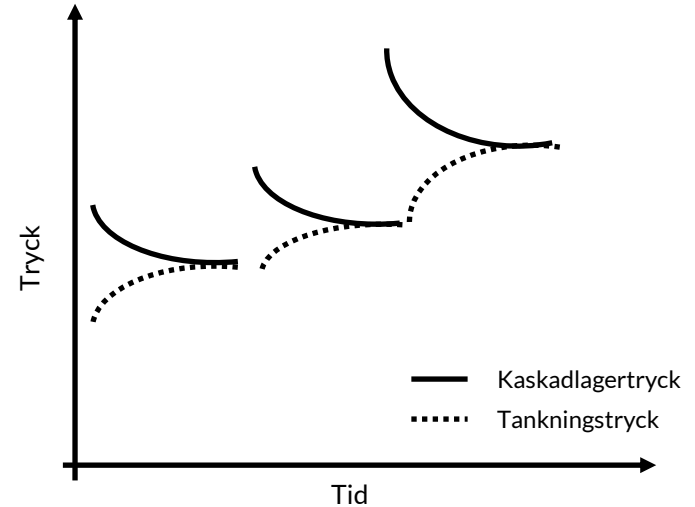
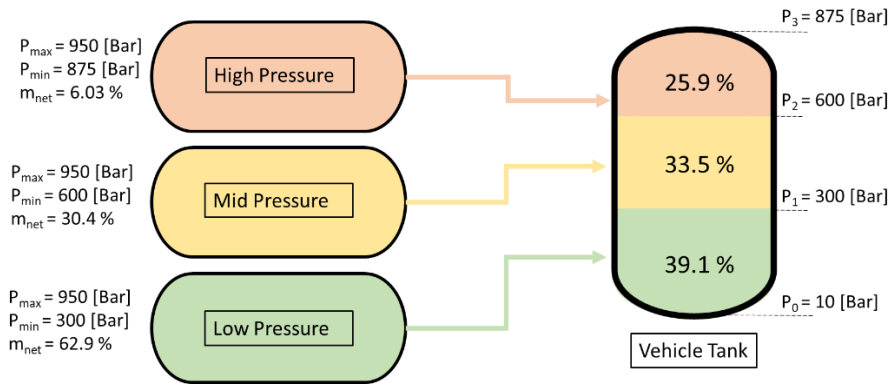
- Refilled from over pressure
- High pressure compressor (up to 950 bar)
- Several high pressure storage vessels that cooperate
- Cooling



Why cool the gas?

- Hydrogen = Higher temp at expansion for most conditions
- Safety, ensure to keep the H₂-tank in temperature range
- Correlation between Temp and pressure means regulation makes the filling process smoother

How does a refueling station work? Cascade storage

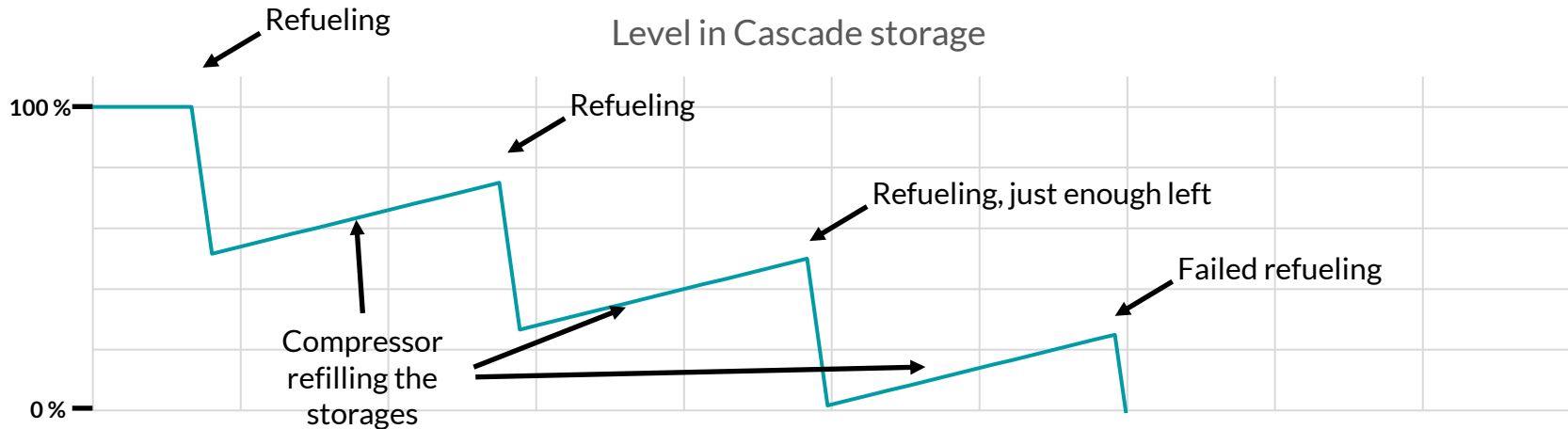


When several vehicles refuel in series

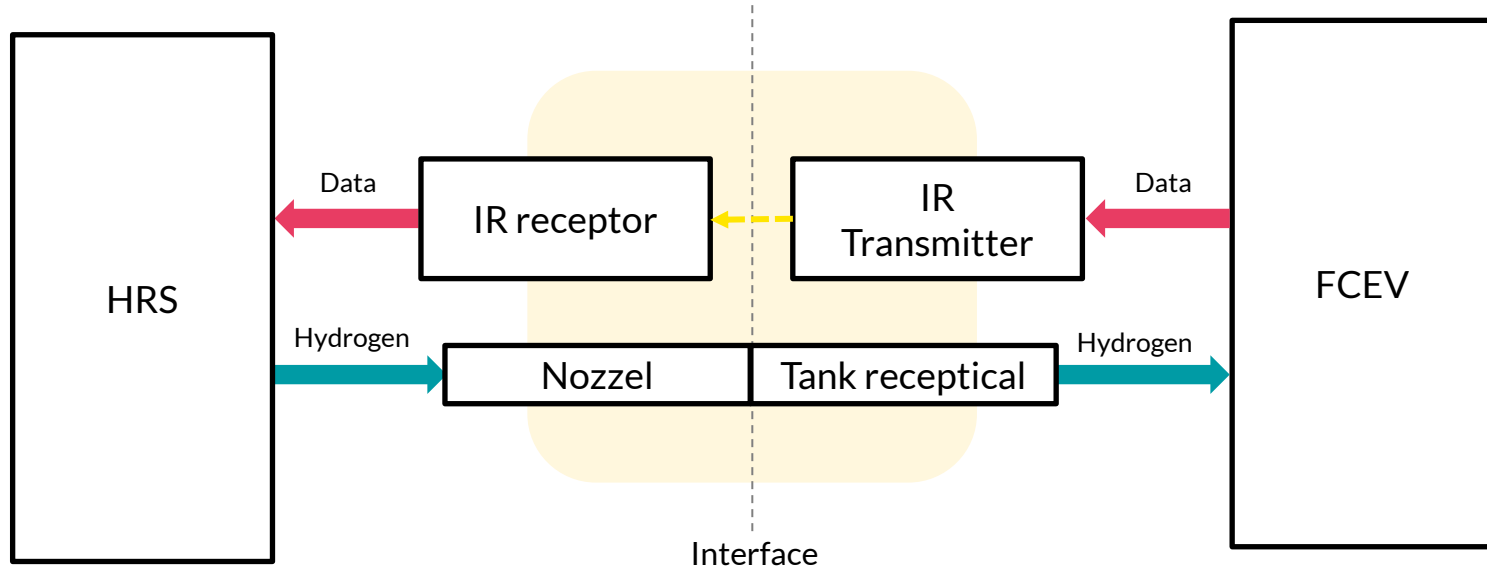
- If there are not enough hydrogen in the storage refuelling will take significantly longer time

Solutions:

- Larger cascade storage
- Larger compressor
- Scheduled/planned refueling



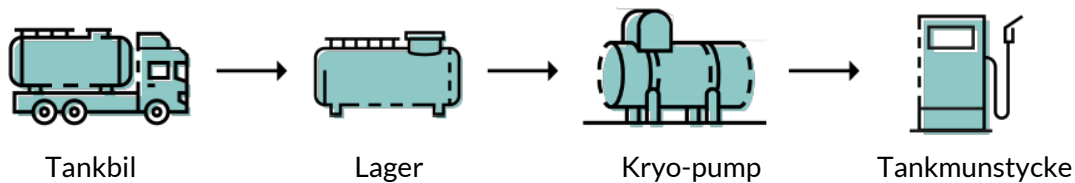
Communication with the vehicle at an HRS



Baserad på bild från: https://www.energy.gov/sites/prod/files/2014/09/f18/fcto_webinarslides_intro_sae_h2_fueling_standardization_091114.pdf

Liquid vs compressed over the coming 10-15 years?

- Heavy-duty transport where liquid is considered most
- - 253 C, Is the temperature of LH2
- Daimler have shown 130h in the storage tank before significant losses
- Much will depend on the build-out of liquifaction plants and the tech development
- Reminder of the HRS supply chain:



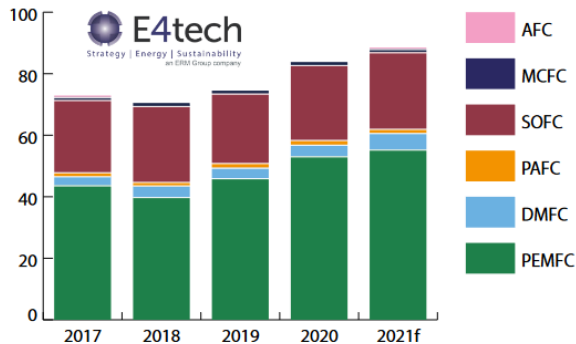
Engineering issues related to the HRS?

- Again many different engineering disciplines and development issues can be expected in all of them.
- The high pressure compressors are today a very needed focus area
- Storage is always being developed
- Higher flow systems for larger vehicles
- Pipes (we get alot of questions on material etc and compatibility)
- Hydrogen embrittlement
- Safety, is always central..

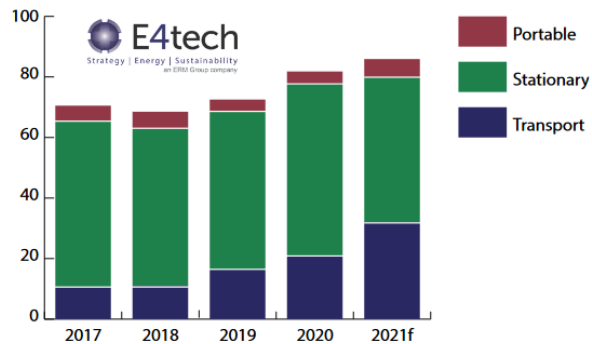
Fuel cell systems

Fuel cell review from 2021

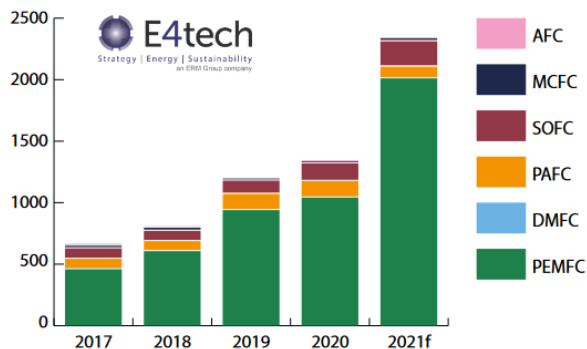
Shipments by fuel cell type 2017 - 2021 (1,000 units)



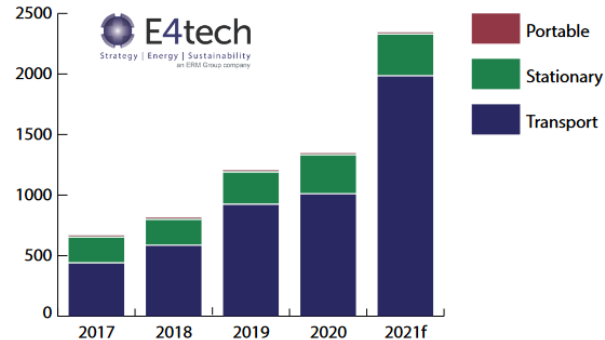
Shipments by application 2017 - 2021 (1,000 units)



Megawatts by fuel cell type 2017 - 2021

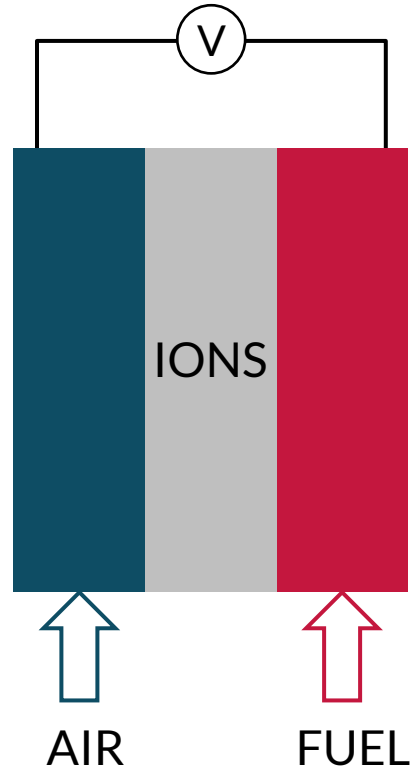


Megawatts by application 2017 - 2021

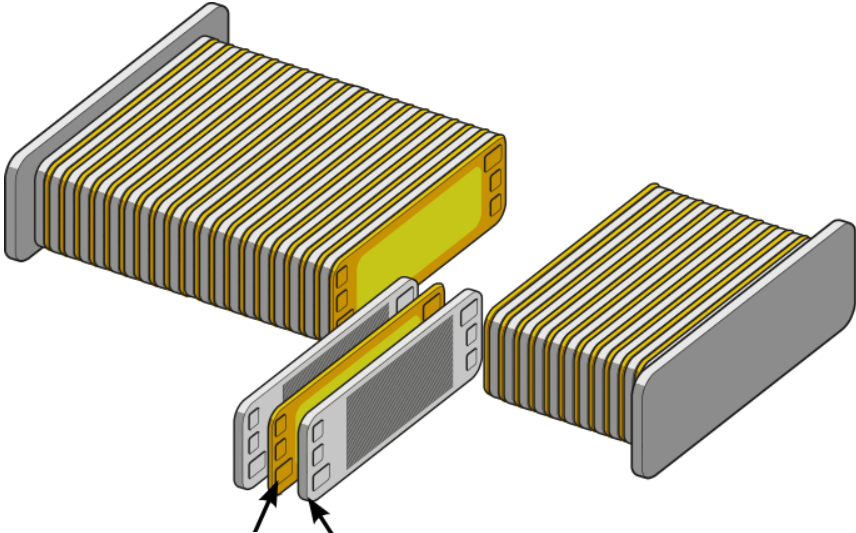


How do they work?

- The heart is a layered structure with electrochemical reactions.
- In box there are also
 - Flow regulators
 - Heat exchangers
 - Inverters
 - Etc.

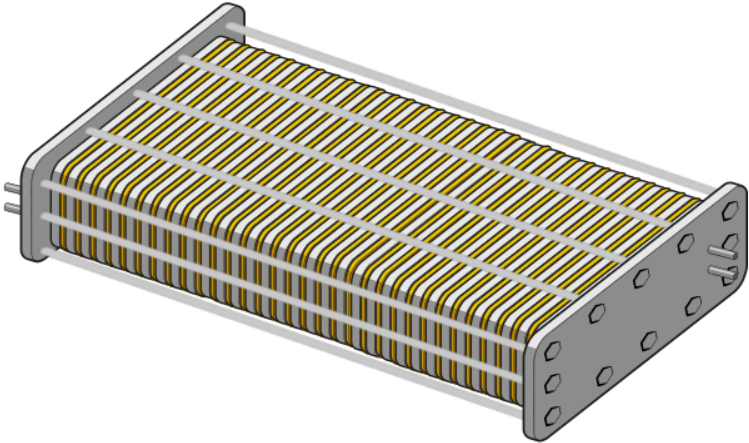


A fuel cell stack



Electrodes,
electrolyte,
Gas diffusion
layers

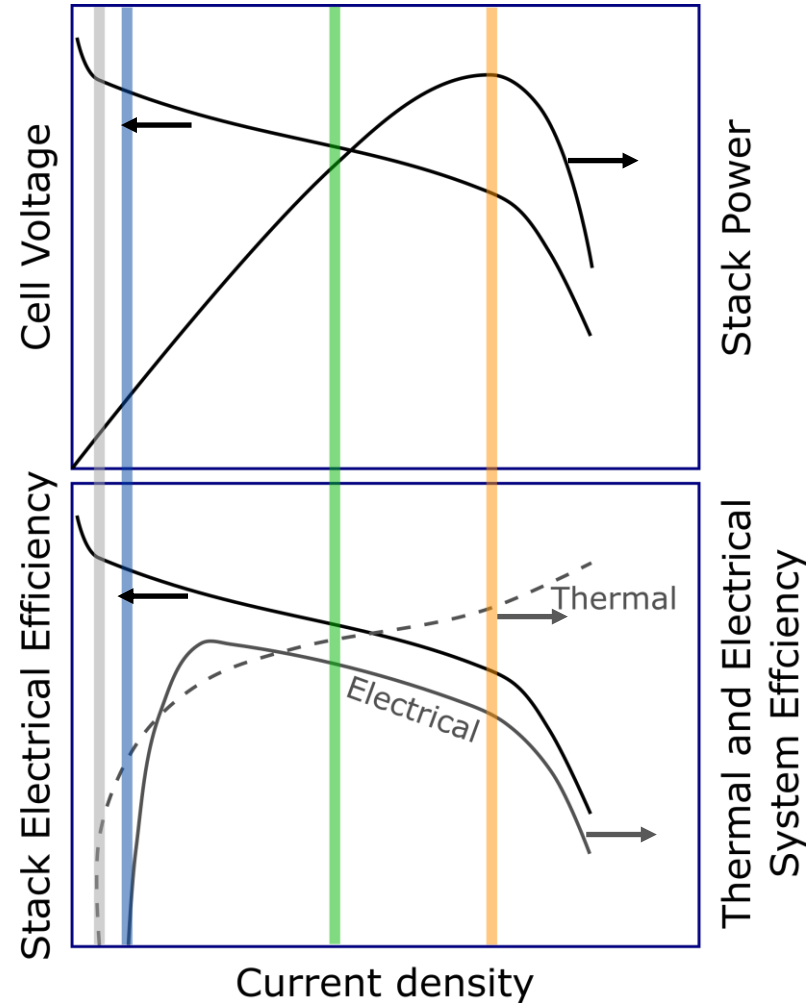
Bipolar
Plate



The operating range

From left to right:

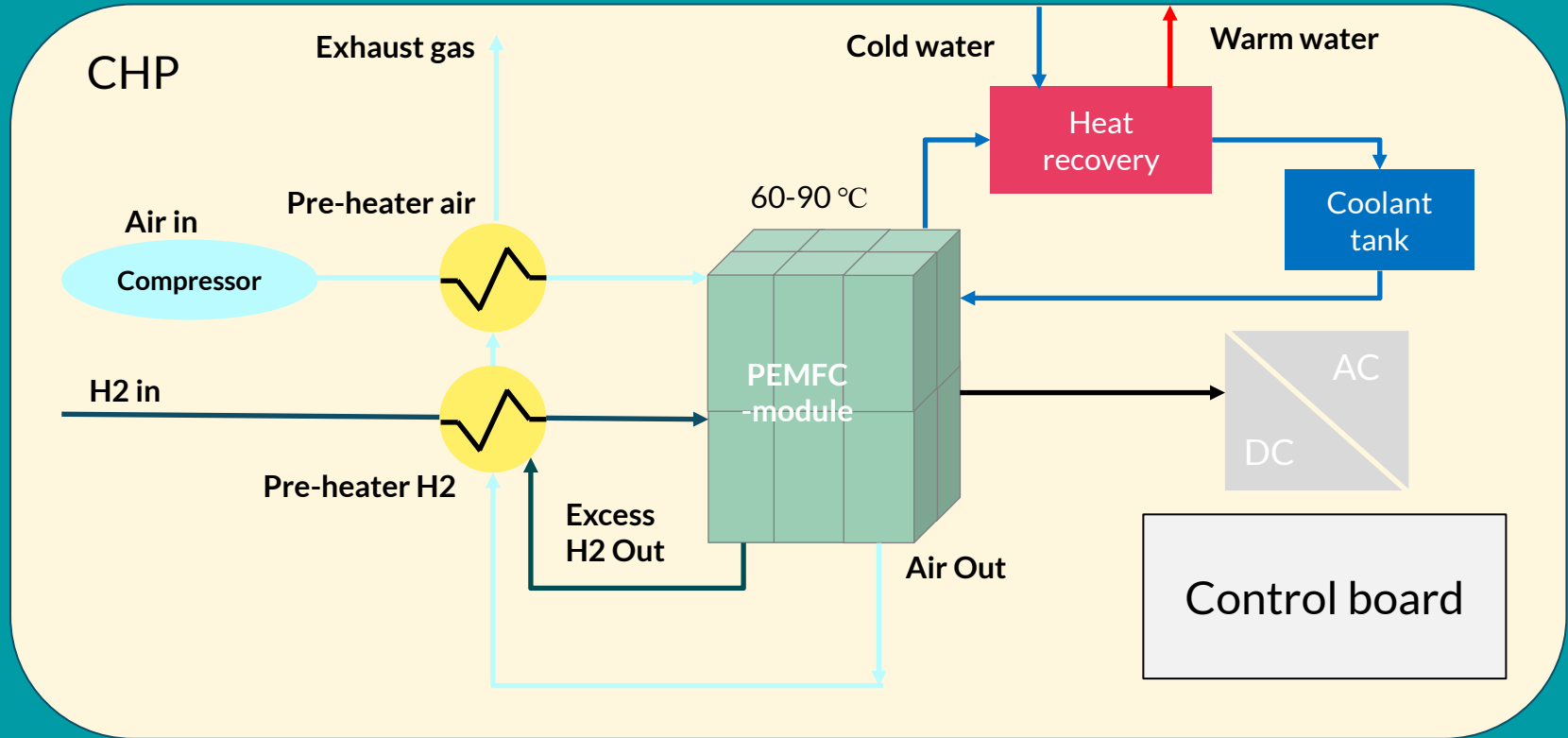
- Gray: Initial heat production
- Blue: Initial electrical output from system
- Green: Nominal operating point
- Orange: Maximum stack power



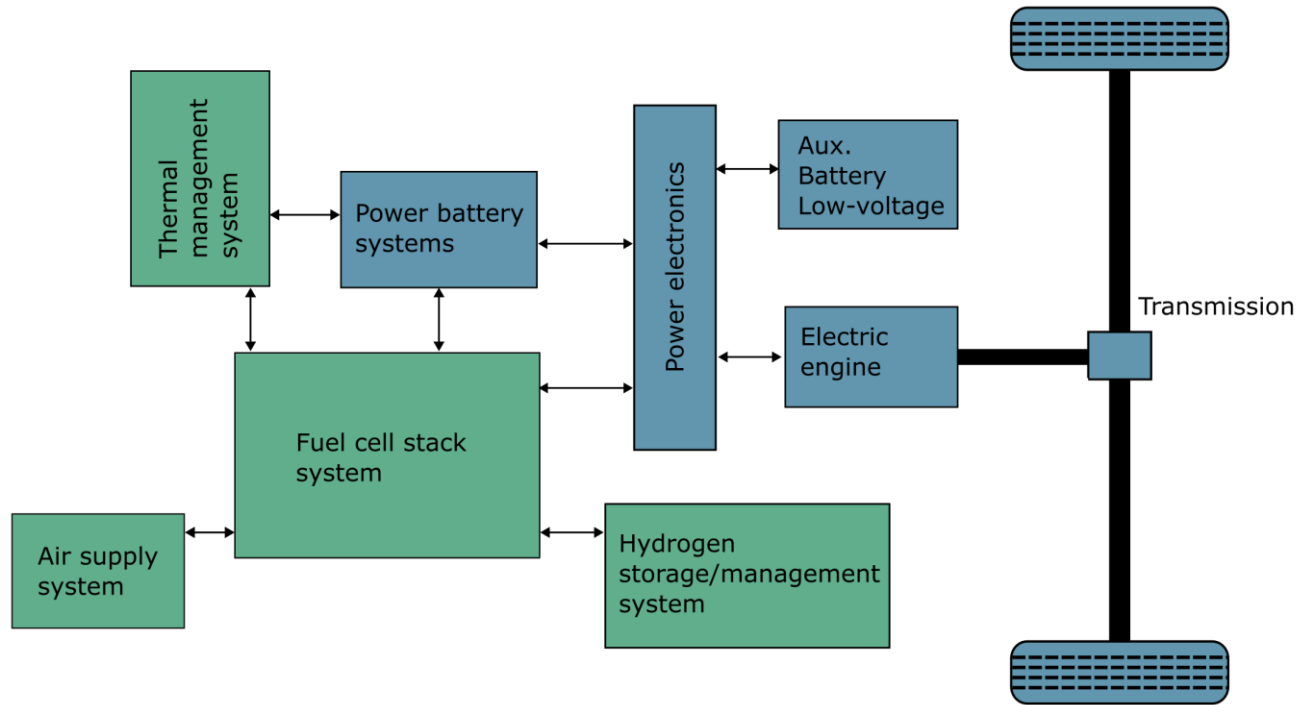
Fuel cells for charging battery electric vehicles

- Gensets
- It is a consideration for remote stations
- Purpose is to supply power when other sources aren't available

The PEMFC-system "stationary":



On-board the applications



Fuel cell and surrounding systems

Schematic image with explanation can be found at:

<https://www.greencarcongress.com/2016/04/20160419-toyota.html>

Engineering issues related to the fuel cell systems?

- Again many different engineering disciplines and development issues can be expected in all of them.
- Pressure vessels
- DC/DC components developed for the FCs
- Air compressors
- Thermal management
- FCs that operate above 100 degrees (for cooling and performance)
- Automated productionlines, additive manufacturing (today systems built by hand)
- Safety, is always central..

Summary

- It works!
- But;
 - Much tech development still needed
 - Several speciality components need to be cheaper
 - Complex systems and sometimes with space restraints
 - Some initial launch issues to be expected

“There is more stupidity than hydrogen in the universe, and it has a longer shelf life” – Frank Zappa

Tack för er uppmärksamhet!

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