ADEL – ADvanced ELectrolysers 256 755

Topic SP1-JTI-FCH.2009.2.3:
New generation of high temperature electrolyser

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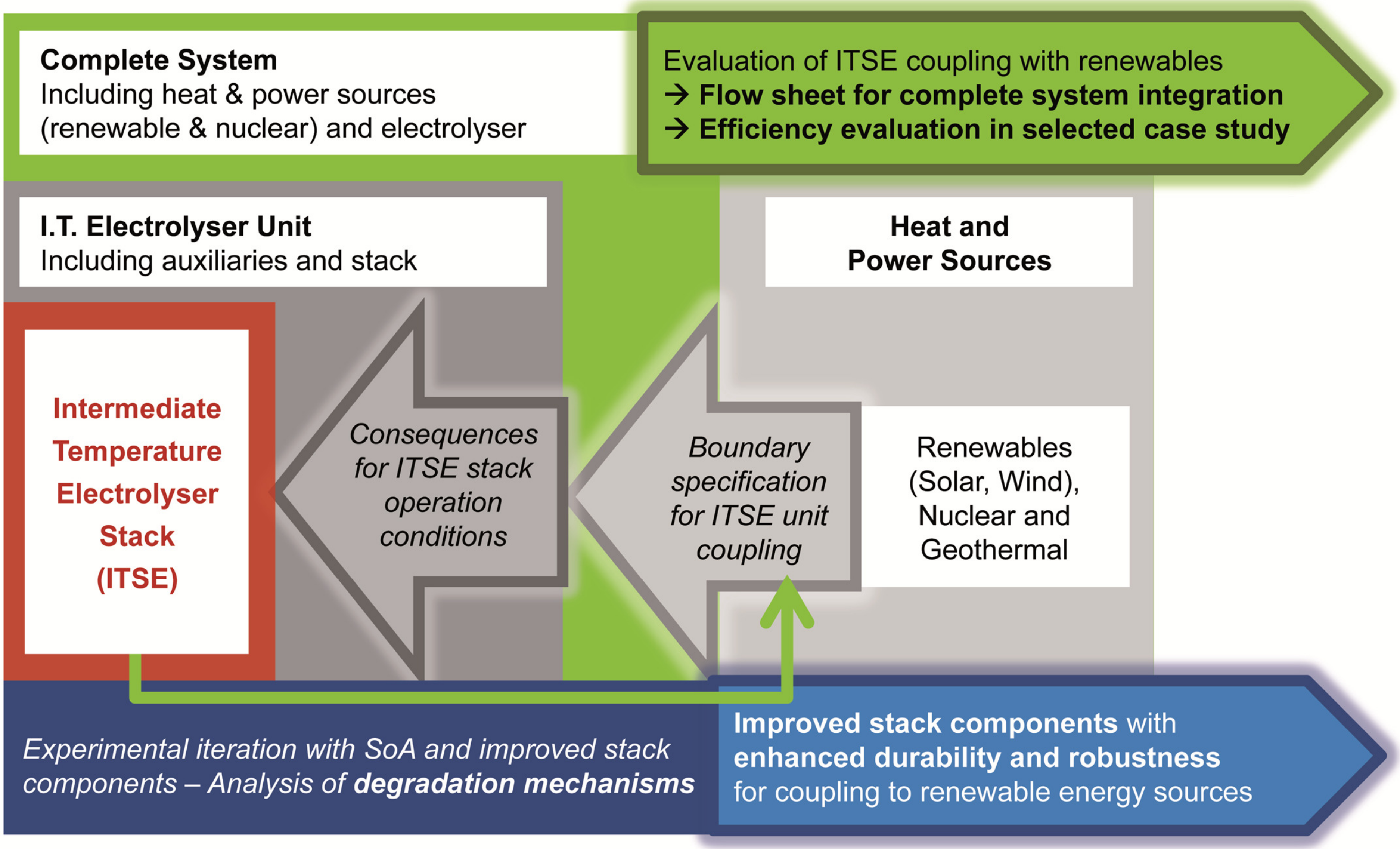
Objective

The ADEL project targets hydrogen production that is

- cost-competitive
- high energy efficient and sustainable
- based on renewable energy sources or nuclear

Intermediate Temperature Steam Electrolysis (ITSE)

- optimize electrolyser life time and cost by
  - decreasing operating temperature
  - maintain satisfactory performance level
- achieve high energy efficiency at the levels of
  - the electrolyser unit itself and its operating window
  - the energy system composed by heat and power sources and the device



The **most energy efficient coupling solutions** will be used as basis to specify a proof of concept demonstrator including a ITSE stack.

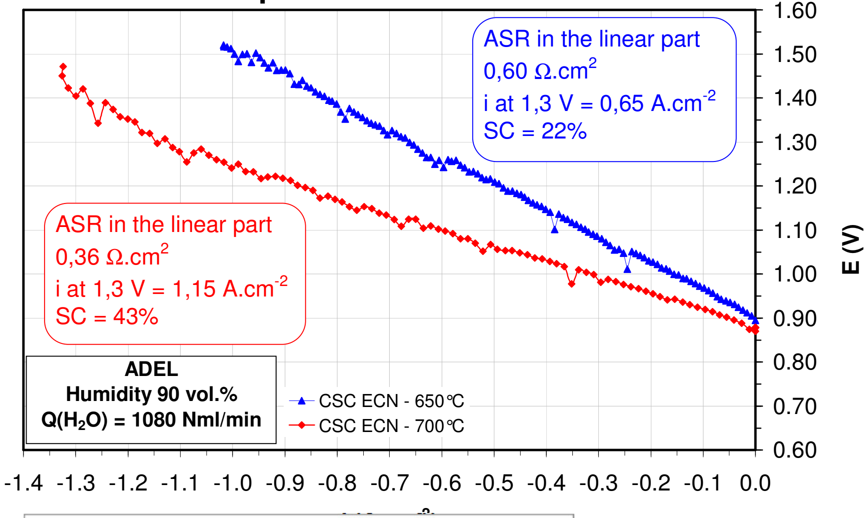
New Energy World JU fuel cells & hydrogen for sustainability

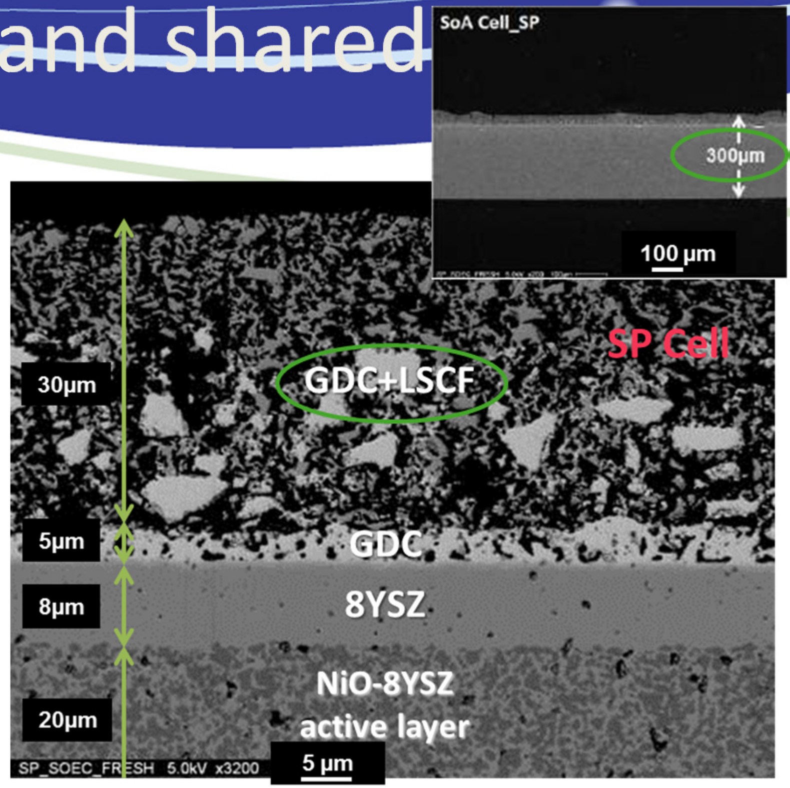
SEVENTH FRAMEWORK PROGRAMME

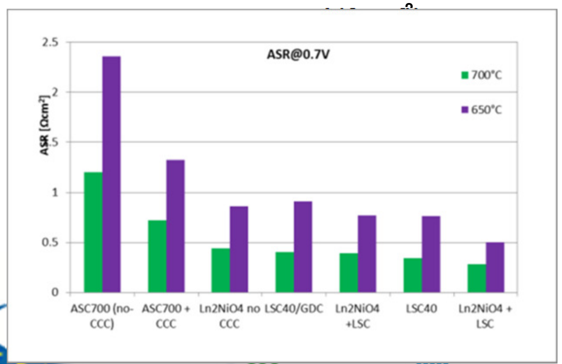
adel Advanced Electrolysers

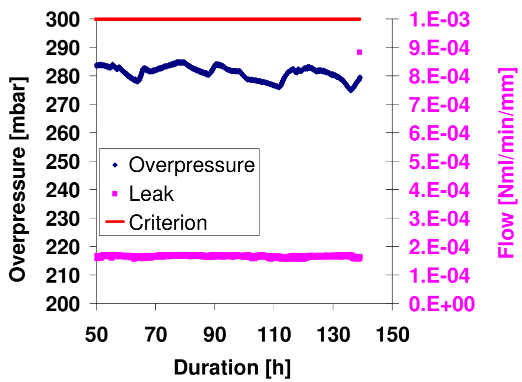
Testing and Characterisation protocols defined and shared

→ Common language and comparable results









SOFCPOWER SOLID OXIDE FUEL CELLS

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fuel cells & hydrogen for sustainability

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Promising materials for cells, seals, MIC and coating identified

- **Good chemical compatibility** between SoA coatings and O_2 electrodes
- **Contact resistance** of SoA SP O_2 electrode to be further reduced

  → Guidelines for improvement for 2G materials: **candidates already available**

- **Highly efficient protective coating** preventing Cr poisoning
- **Good corrosion resistance** of Crofer 22 APU / PC / LNF

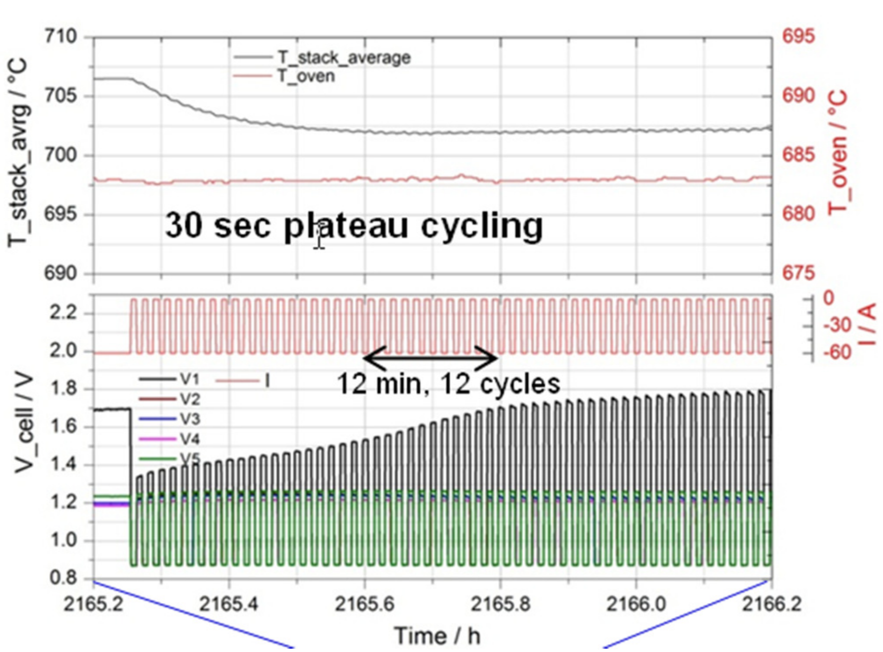
  → Similar combinations with K41X IC and LSMC CC to be tested to select the best one

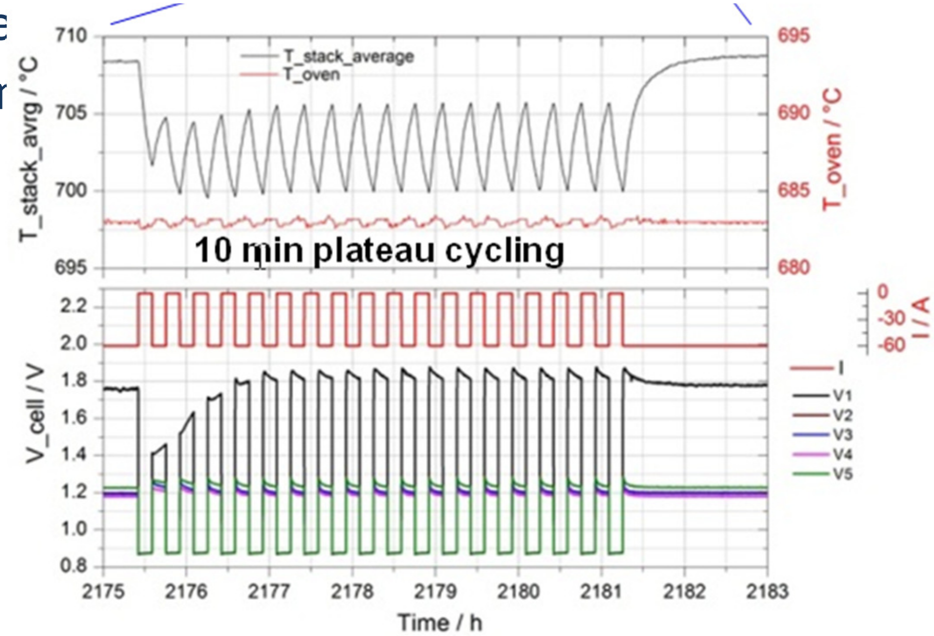
- **Satisfactory tightness** with SoA glass and ceramic glass sealants:

  → Thermal cycling (RT – 700° C) to be done on selected seals

SOE stacks tolerate load cycles well!

- Transient operation with 10 minutes plateau
- With 10 minute plateau the stack temperature follows the load cycle



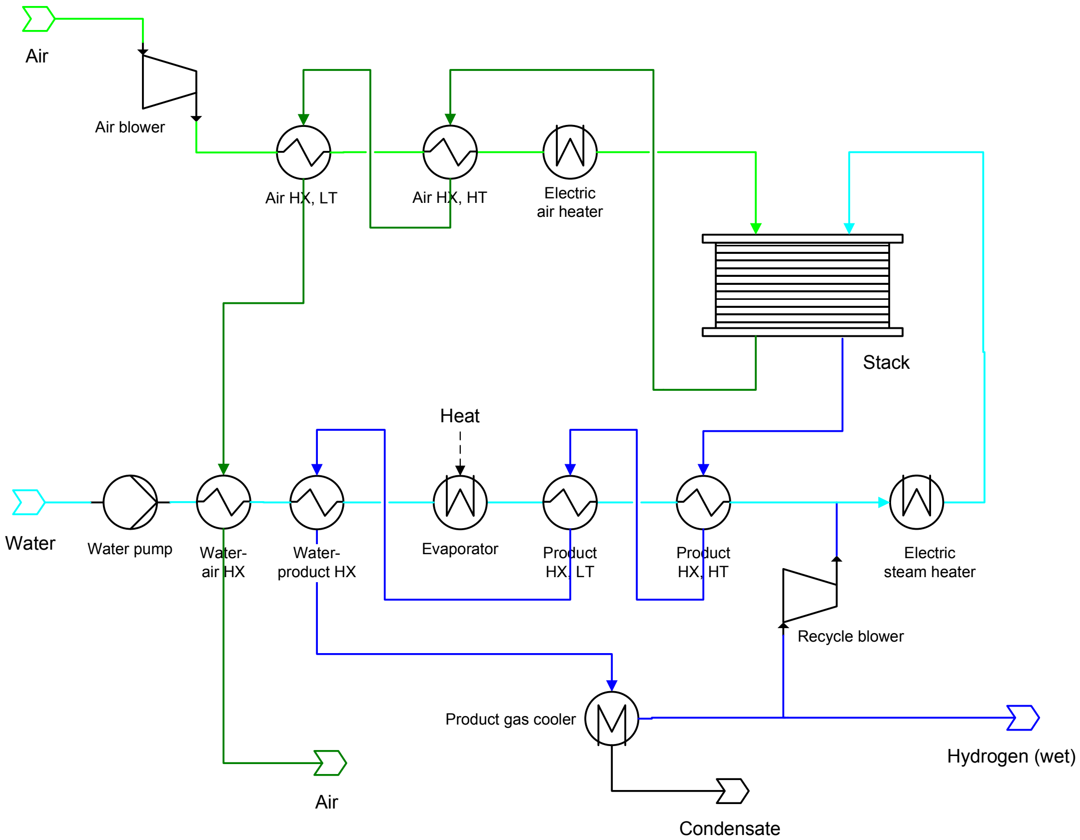


☺ A total of 756 loadcycles (30 second and 10 minute accumulated) have been performed with **no additional degradation** detected

2 Short stacks successfully tested in steam electrolysis mode at 700° C

- High performances reached by TOFC short stack with SOFC600 cells at 700° C (-1 A cm^{-2} below 1.3 V)
- Performance of SP stack significantly improved at intermediate temperature by integrating SOFC600 cells (-0.8 A cm^{-2} below 1.3 V)
- Durability of TOFC and SP stacks tested for 2000 and 1400 hours at 700° C and -0.6 A cm^{-2}
  - some differences observed in the stack behaviours but degradation rates, although reasonable, above ADEL target
- Transient operations run for the first time on electrolysis mode on short stacks without additional degradation detected

Optimised flowsheet used in the unit model



- Assumptions on unit characteristics:
  - High degree of heat integration (recuperation)
  - Sweeping air (O_2 removal)
  - H_2-recycle (hydrogen electrode protection)

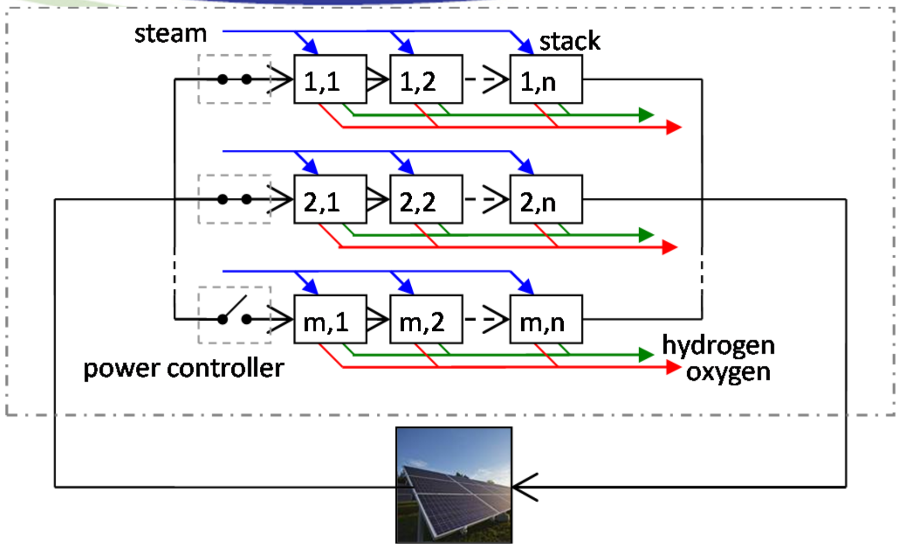
- Results for the external heat source:
  - Feeds the evaporator (steam generator)
  - Super-heating requires relatively low power

  → **no high-temperature heat source required**

System architecture for covering operating ranges

- Unit operating power range depends on the allowable stack temperature range

- Using modules extends the power range of the whole system

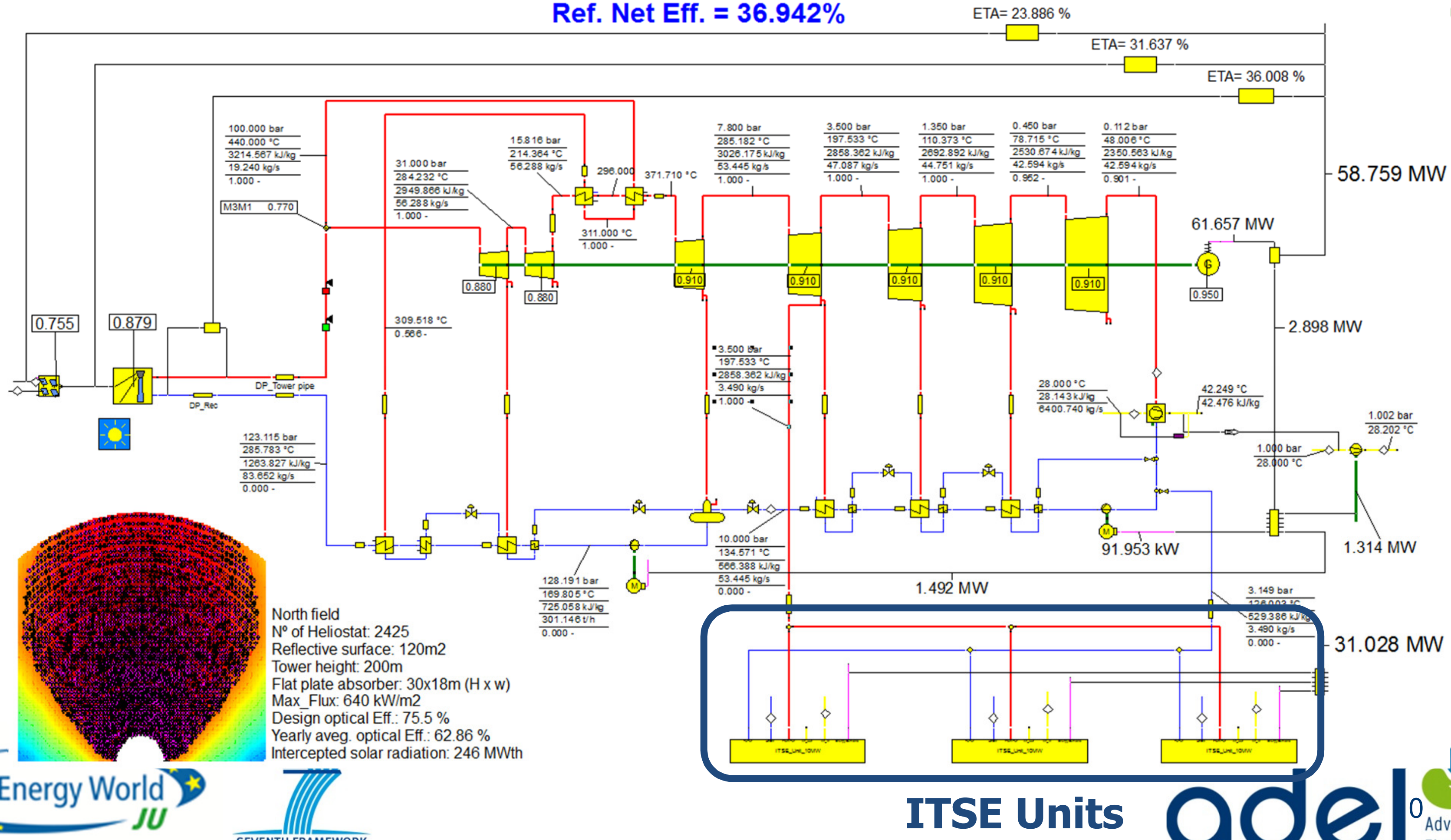


- Stable heat supply is required (mainly to evaporate water)

- Flexible electricity supply is compatible

Direct Steam Generation Tower Power

Superheated sycle at 100bar _440ºC
Ref. Net Eff. = 36.942%



North field
Nº of Heliostat: 2425
Reflective surface: 120m2
Tower height: 200m
Flat plate absorber: 30x18m (H x w)
Max_Flux: 640 kW/m2
Design optical Eff.: 75.5 %
Yearly aveg. optical Eff.: 62.86 %
Intercepted solar radiation: 246 MWth

Relationship among partners

- «Materialists» and «Systemists» have found a common language
- Constructive iterative discussions have allowed to select the right objectives of work for all partners implied
- => Generally satisfactory progress towards the objectives

Challenges next steps

- WP1:
  - integration of components into stacks
  - optimisation of materials performance
  - major: **durability understanding** development of counter strategies
- WP2:
  - Adjust system models to standard interfaces (30 bar!)
- WP3:
  - Specify demonstrator with relevant boundary conditions
- WP4:
  - Disseminate SOE specific knowledge again on a high level international Workshop

Dissemination

- Web-Site: adel-energy.eu
- Publications in reviewed papers
- 2 Public Workshops
  - Sevilla, Spain, October 2011
  - Corse/Korsika, France, May 2013
- Participation in conferences such as the European Fuel Cell Forum in Lucerne (www.efcf.com)

MAIP targets

Hydrogen Production & Distribution

- Appropriate H2 supply chain (including fuel purity) ✔
- to match Transport, Stationary and Early Markets requirements. For 2015 10 - 20% of general H2 -
- demand produced via carbon free/carbon lean processes ✔
- Cost of H2 delivered at refuelling station < €5/kg (€0.15/kWh) ?

Generally well aligned project with mid to longterm orientation

Electrolysis statements

- Hydrogen production from excess electricity is key
  - Intermittant/dispatchable operation is required
  - Grid balancing has an economic value
  - Intermode energy switch from electricity to mobility and/or heat reduces generally the carbon footprint
- Excess electricity to fuel by electrochemistry is of strong interest
- Electrolysis is a bridging technology and hydrogen is one energy vector towards low-carbon energy generation
  - Enabling more renewable and nuclear generation

SOE statements

- Electrolysis simulation and flow sheeting allow to orient materials search towards relevant objectives (T, p, I, durability)
- Simulation tools need to be validated against experimental performance
- Intermediate temperature stack operation (SOE@600° C) might not be required from a system point of view
- Pressurised SOE operation seems to be relevant from system side
  - kinetically increased stack performance and reduced BoP costs
  - does it affect degradation?

Next projects

Understanding of durability and degradation factors on stack/materials level

=> synergies with SOFC

Analysis of technology with standard interfaces (30 bar)

=> specific pressurised stack technology required?

Defintion and Integartation of boundary conditions

=> operating modes (how can we serve best the grid)

=> is the value of H2 application dependent or market driven?

Demonstration of technology at a reasonable scale (2-10 kW)

=> providing base for extrapolation to commercial scale

Thank you for your attention

Contact

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