Aalborg CSP – International Market Watch - Australia

Changing Energy for a Greener Future

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AALBORG CSP
- Changing Energy

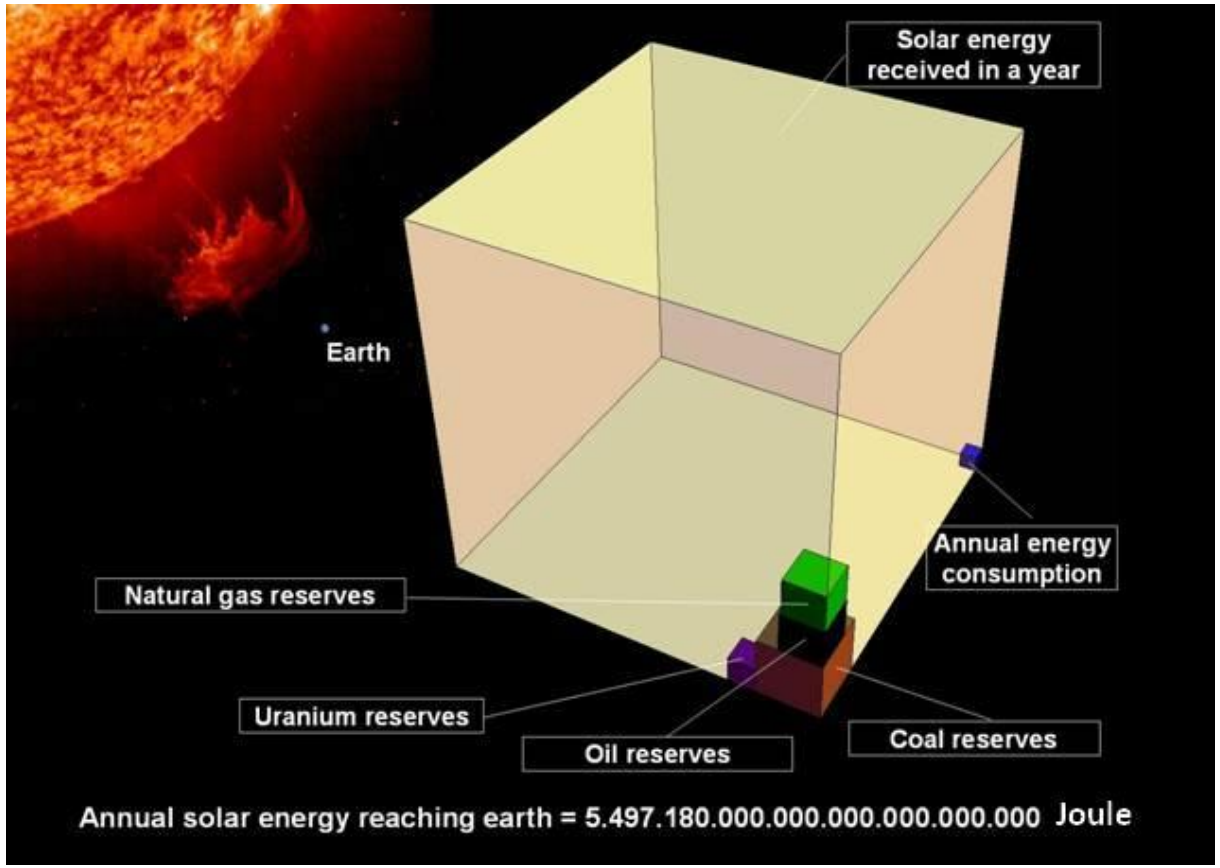
Agenda

1) Why solar energy
2) Australia experiences
3) CSHeating solutions Australia
4) CSPower critical components

Aalborg CSP – an integrator in Solar and Energy solutions

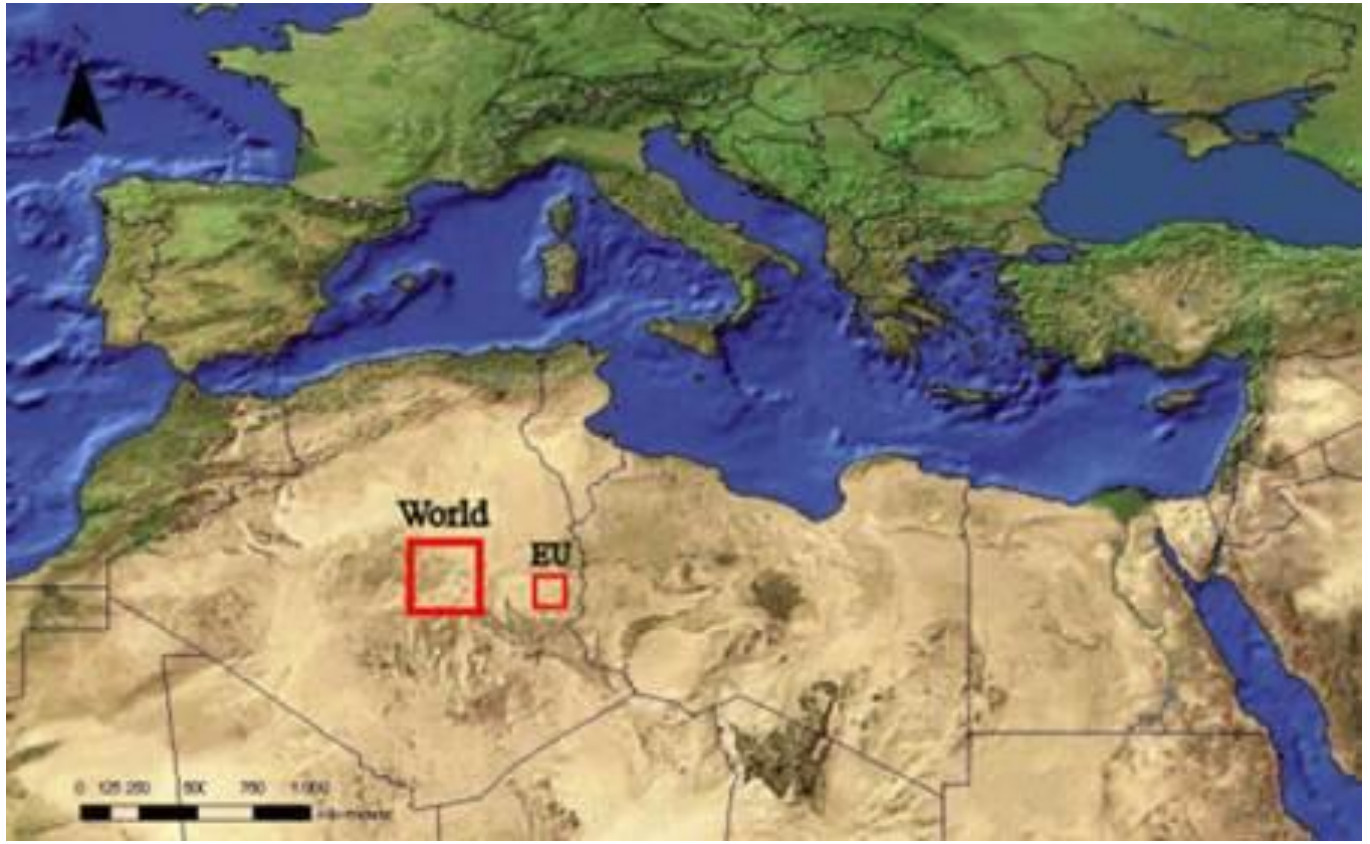
Why Solar Energy?

An abundant resource…



Why Solar Energy?

CSP in Sahara to cover global electricity demands?



VISION & MISSION

Changing energy = lowering cost for a greener future

Our Vision

Changing Energy
accelerating the world's renewable energy transition by making more competitive green energy solutions.

Our Mission

to **develop** and **supply**
green technologies
and integrated energy solutions
to lower the cost of energy
for our customers.

BUSINESS AREAS & TECHNOLOGIES

Claim market leadership by pursuing ”cost & performance leadership position” though partnerships

CSP power plant technologies

- DSG Solar tower receiver (direct steam)
- MSR Solar tower receiver (molten salt)
- Steam generator system (thermal oil)
- Steam generator system (molten salt)
- Fresnel steam island

Integrated Energy Systems

Novel configuration of renewable technologies with CSP acting as focal point of the system to holistically satisfy multiple energy demands:

- ✓ heating
- ✓ clean water
- ✓ electricity
- ✓ process steam
- ✓ cooling

Solar district heating

- CSP troughs
- Flat panels
- Combination plants
- Accumulation tank

Thermal Energy Storage (TES)

- MSR technology
- Oil-To-Salt HX
- Direct-steam-to/from-concrete storage
- Storage for CSP plants with thermal oil
- R&D – Next Gen Thermal storage technologies

Industrial CSP solutions

- Sun-powered process steam production
- Sun-powered hot water production
- Solar electricity
- Solar desalination
- Solar cooling

MSR

SGS /HX

Industrial solar & energy storage technologies in Aalborg

Strategic driver past 5 years – CSP industry – in transformation – no-growth stage.

Aalborg invests all available capital in new technologies, market diversification - and build partnerships for both for solar technology, and for integration of storage and associated technologies – eg. like desalination or cooling based on thermal energy.

Integrated solutions & asset-light business-model ready for high-growth stage.

Integrated Energy System
& District Heating
& Industrial Solar Boilers

Technology platforms ready for renewable market growth

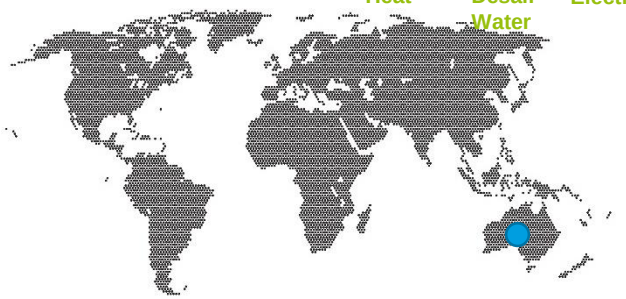
Now require financing structures similar to PV/LED for eg. operational lease/HPAs

INTEGRATED ENERGY SYSTEM FOR DESERT-FARMING

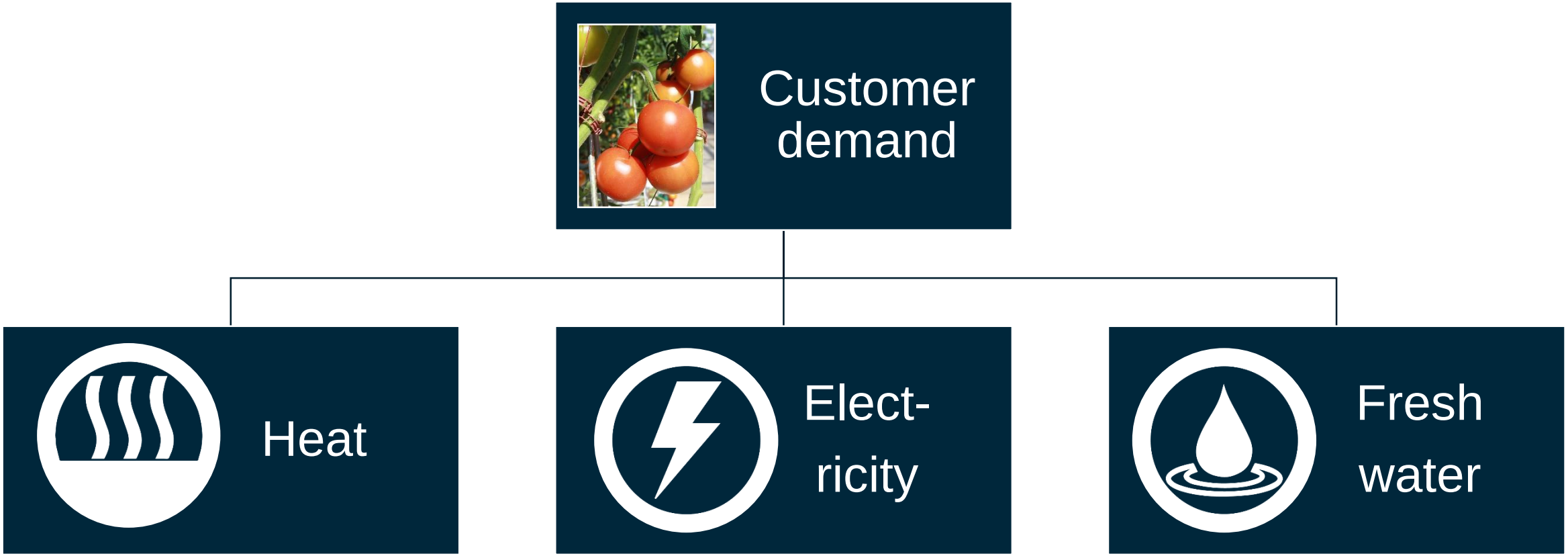
In October 2016, the world's first Integrated Energy System based on CSP - designed and delivered by Aalborg CSP - went into operation to secure sustainable operation of Sundrop Farms' greenhouse facilities in the Australian desert.

Location: Port Augusta, Australia
End user: Sundrop Farms
Status: operational
Capacity: 36 MWth
Greenhouses: 200,000 m^2
Tomatoes produced: 17,000 tons / year
CO_2 savings: 16,000 tons / year

Final energy output:

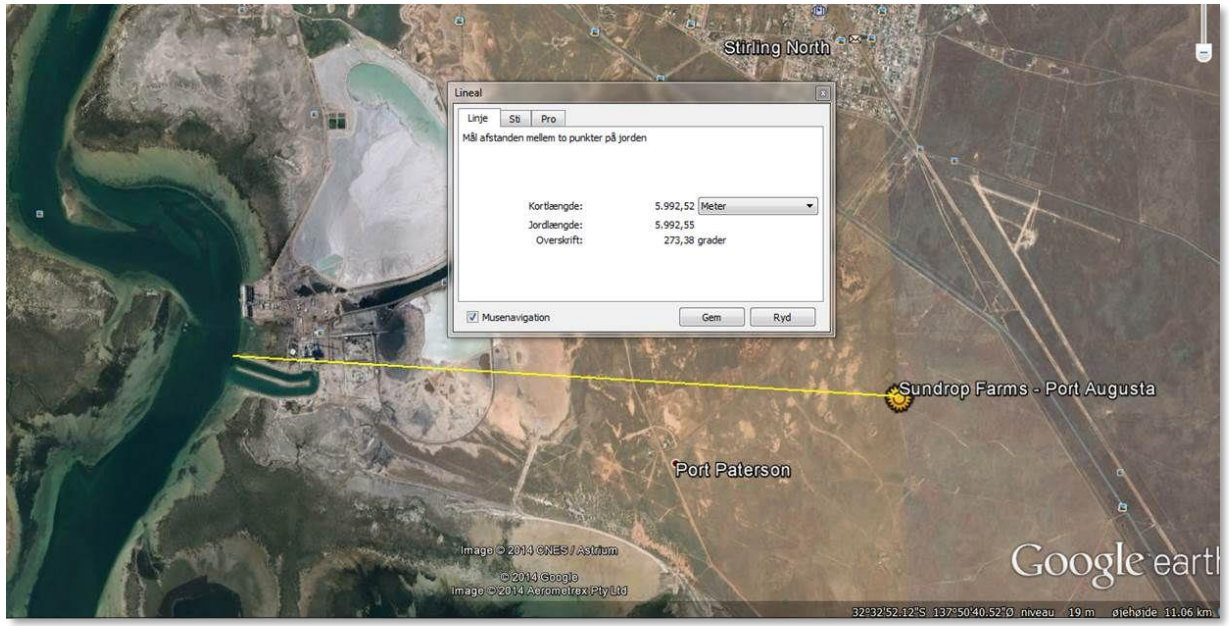


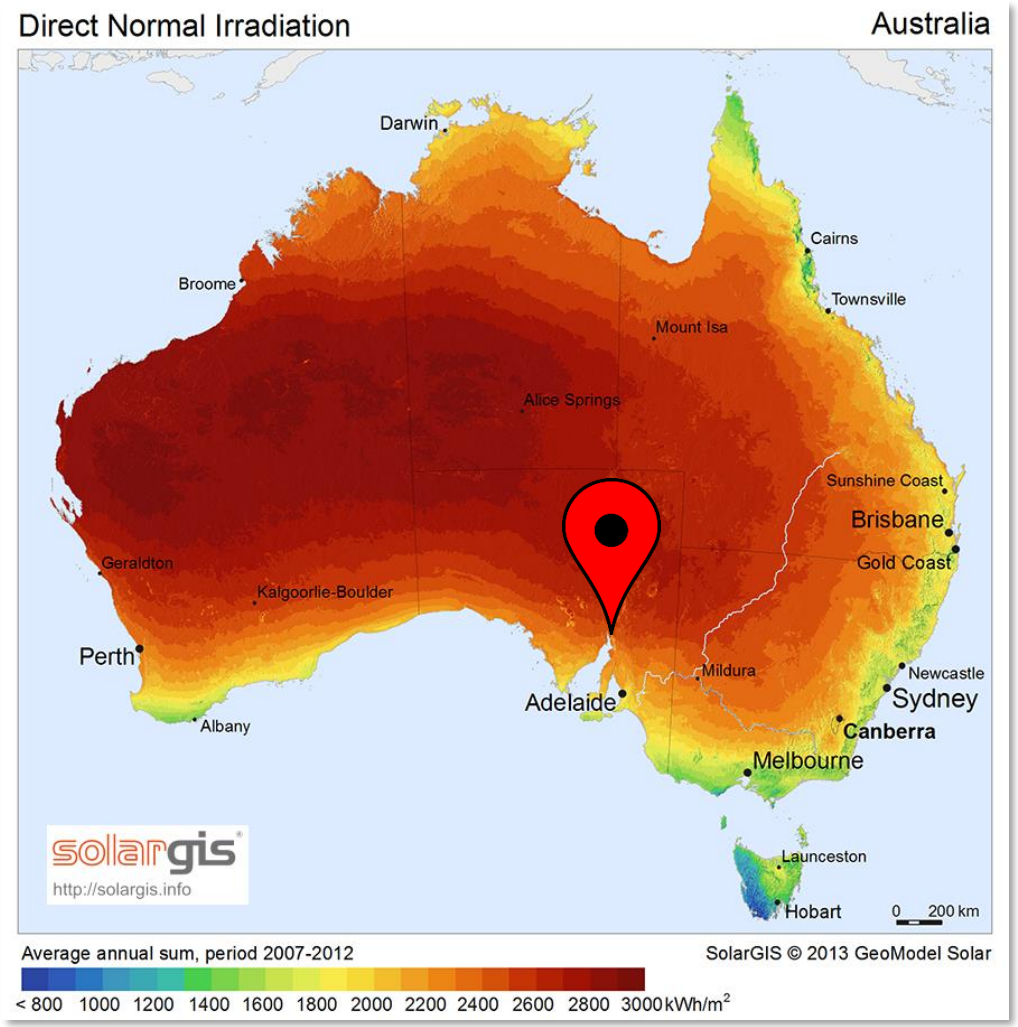
Desert farming in Australia – From idea to realization



Resources to work with

- **Location:** Port Augusta, AU
- **Solar resources:** excellent DNI
- **Seawater:** 3km from site





From idea to reality – in 22 months

BEFORE

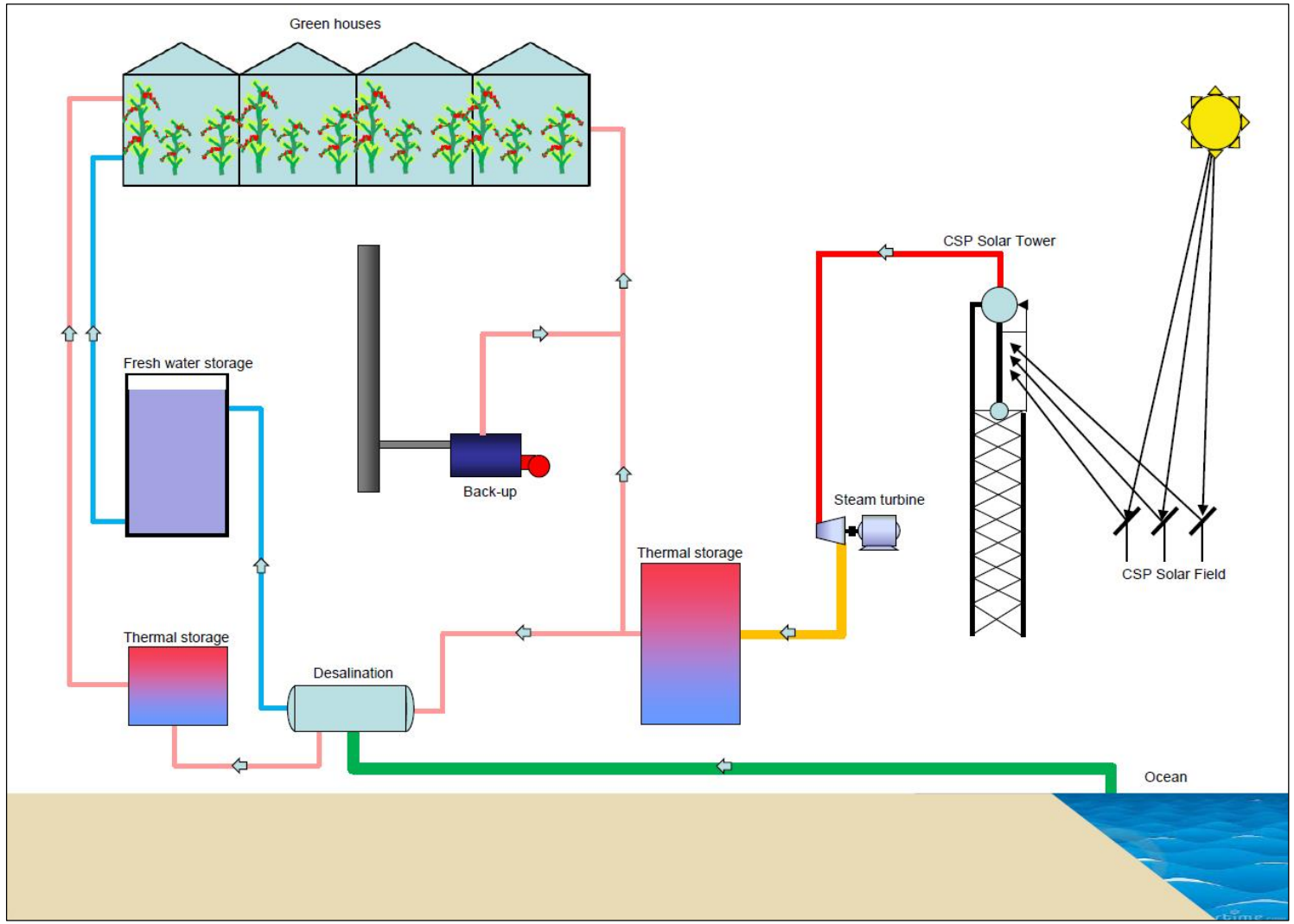
AFTER

- Feasibility study
- Pre-engineering
- Engineering design
- Procurement & Manufacturing
- Final delivery
- Operation & Maintenance

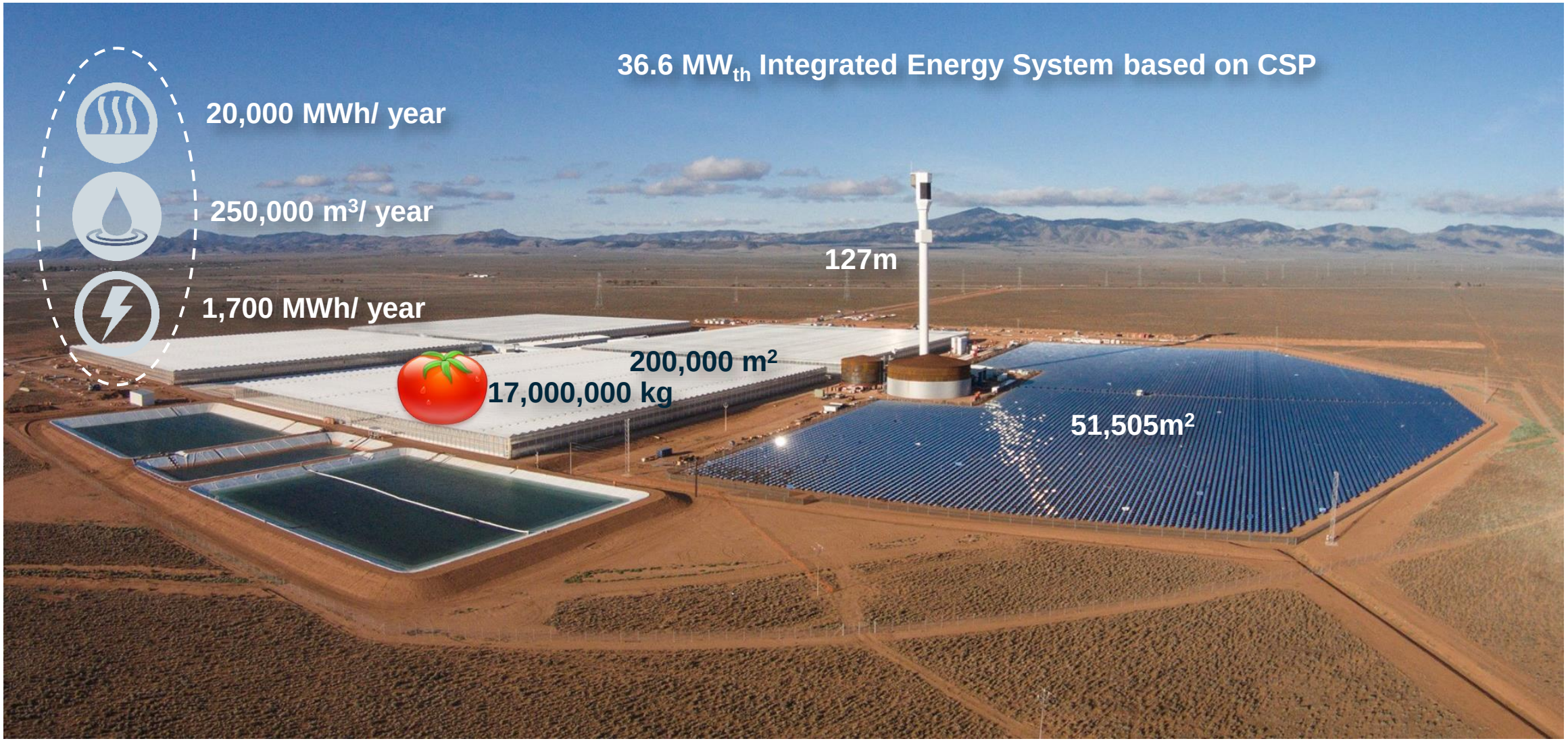
Feasibility study	First components arrive on site	Solar field construction	Solar tower construction	Commissioning begins	OPERATIONAL
Dec ‘14	Jun ‘15	Oct ‘15	Jan ‘16	May ‘16	Oct ‘16

Schematic layout

- Solar field
- Tower
- Receiver and steam drum
- Steam turbine
- Thermal storages
- Desalination
- Heating for greenhouses
- Backup boiler



Operational since October 2016

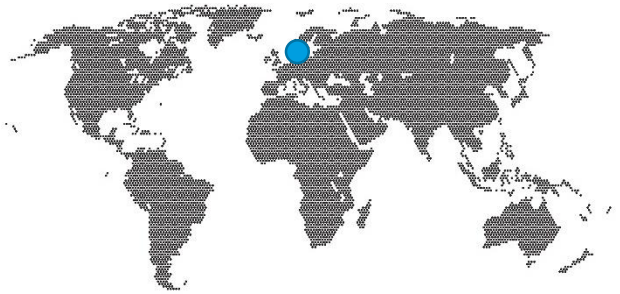


CSP FOR COMBINED HEAT AND POWER

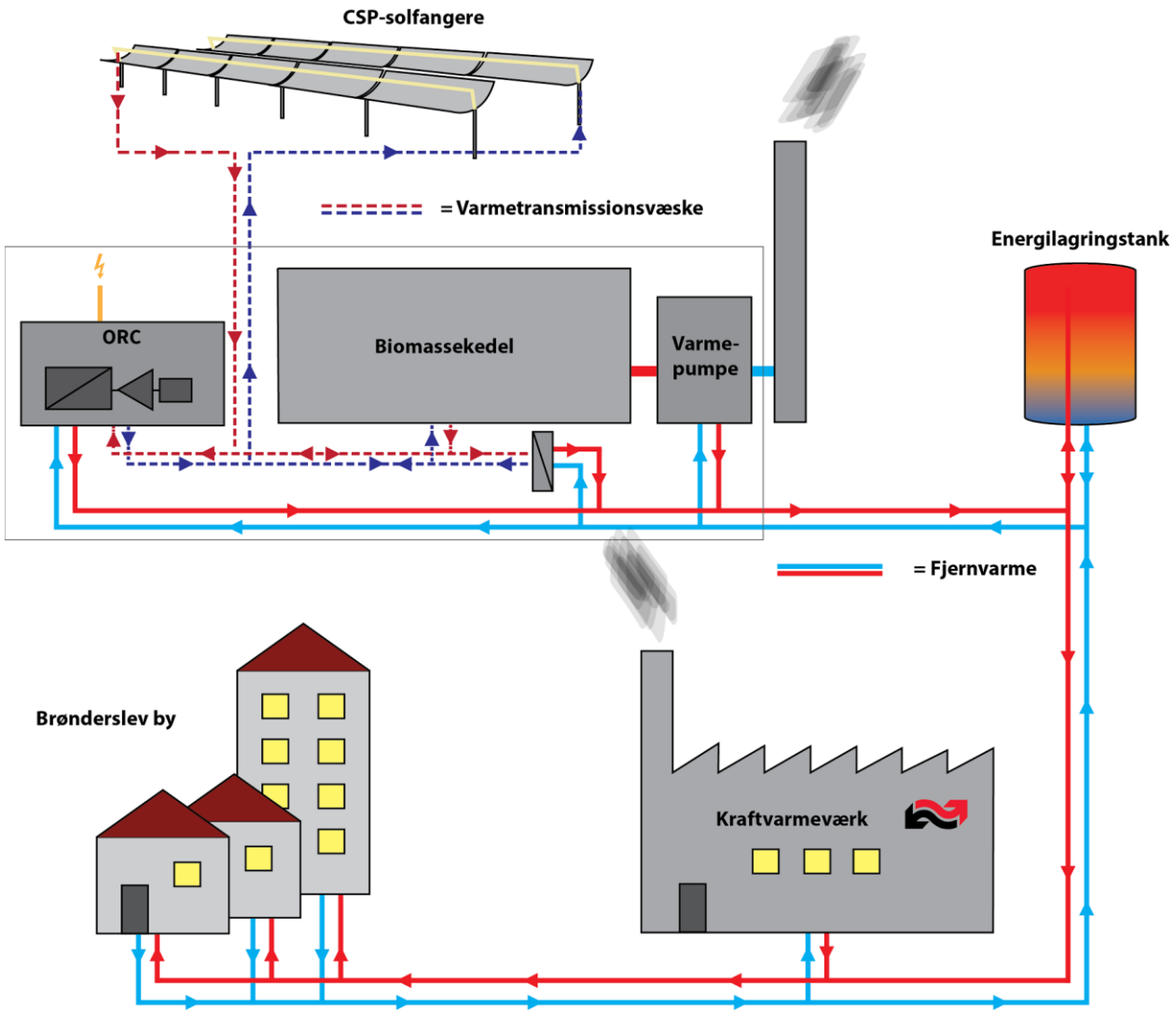
Aalborg CSP designed and delivered a CSP system to be integrated with a biomass-organic rankine cycle (ORC) plant for combined heat and power generation – the first one in the world to combine these two technologies in a large-scale setting.

Location: Brønderslev, North of Denmark
Client: Brøndersev Forsyning
Status: operational
Capacity: 16.6 MWth
CSP aperture area: 26,929 m^2

Final energy output: Heat, Electricity



Overview of the plant



Biomass:	2 x Euroterm	10 MWth
ORC:	Turboden	4 Mwe
CSP solfield:		16.6 MWth
HTF:		Therminol 66
Operation temperature:		up to 312 °C

AALBORG CSP

- Changing Energy

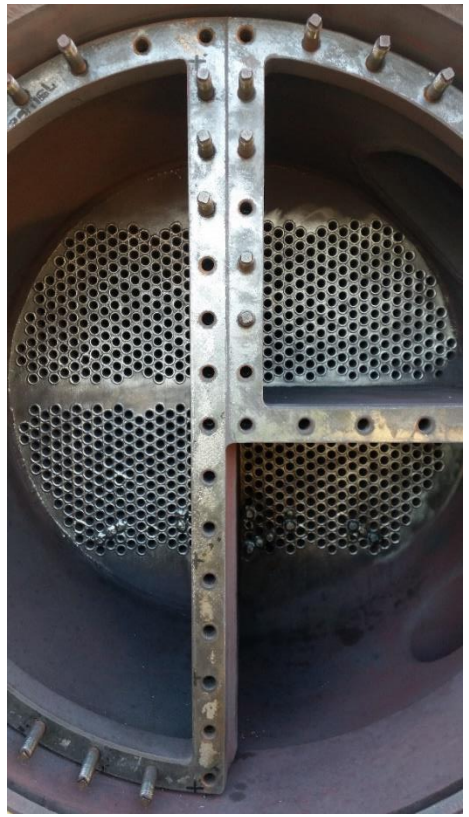
Power Plant technologies (MSR, HX, SGS)

- Performance leadership
- Cost leadership

Gives best technology for leadership when growth market is here

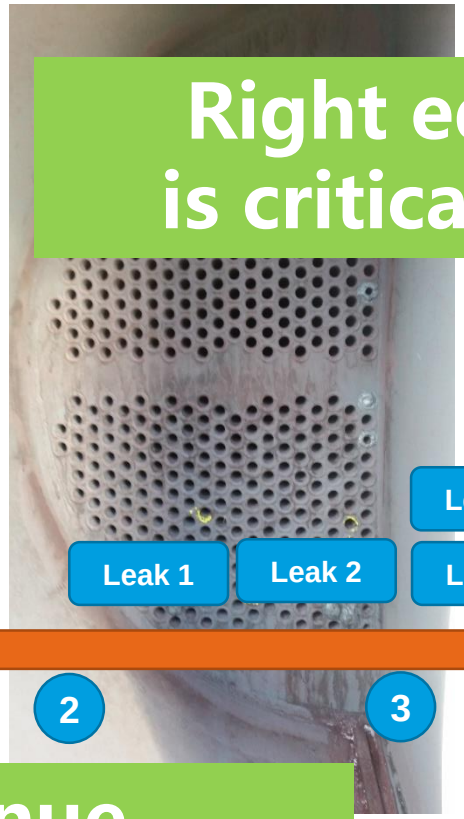
TEMA SGS/HX Leakages - the biggest CSP quality problem

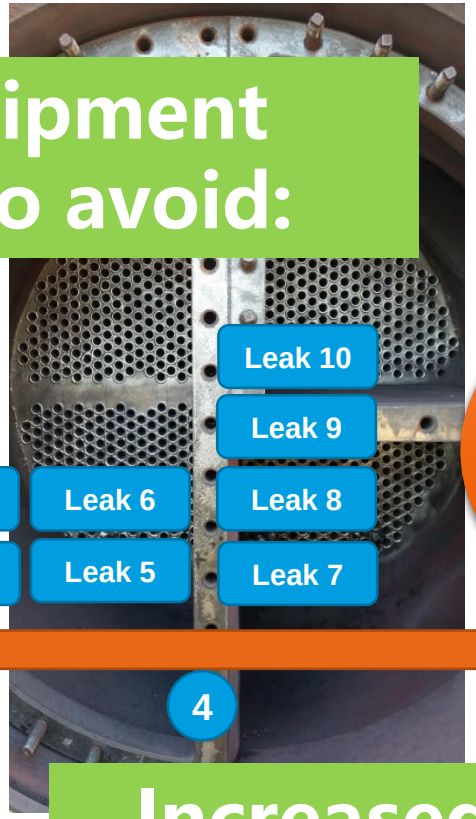
LEAKAGES AND FAILURE OF SGS & HEAT EXCHANGERS IS CAUSING MAJOR PROBLEMS FOR EPC AND OWNERS



TEMA SGS/HX Leakages - the biggest CSP quality problem

REGARDLESS OF MANUFACTURING QUALITY FATIGUE ISSUES WILL OCCURE FOR TEMA U-TUBE TYPE EQUIPMENT





Right equipment is critical to avoid:

Leak 1 Leak 2 Leak 3 Leak 4 Leak 5 Leak 6 Leak 7 Leak 8 Leak 9 Leak 10

~5 years exchange of tubebundle requires

Average time to performance failure: Years

1 2 3 4 5

Lost revenue

Increased O&M cost

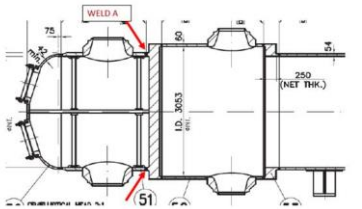
TEMA SGS/HX Leakages - the biggest CSP quality problem

POOR MANUFACTURING QUALITY CAUSE FAILURE TO MEET PROJECT SCHEDULE AND NEED REPAIR/REPLACEMENT

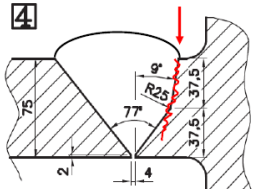
- Solana 280 MWe => Failure TEMA U-tube type during commissioning
- Mojave 280 MWe => Failure TEMA U-tube type within 1 year after COD
- Shams 110 MWe => Failure TEMA U-tube type within 2 years after COD
- Gemasolar 20 MWe => Failure TEMA U-tube type within 2 years after COD
- Tonopah 110 MWe => Failure TEMA U-tube type within 2 years after COD
- Kaxu 100 MWe => Failure TEMA plate type within 2 years after COD
- Bokpoort 50 MWe => Lack of performance TEMA U-tube type – fixed 2 years after COD

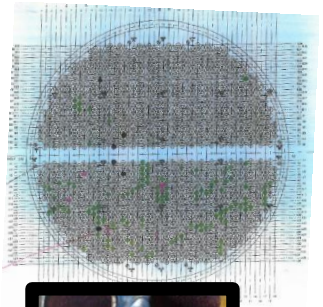
- Noor 1 160 MWe=> Failure TEMA U-tube type within 1 year after COD
- Noor 2 200 MWe=> Problems TEMA U-tube type during commissioning
- Noor 3 150 MWe=> Problems TEMA U-tube type during commissioning

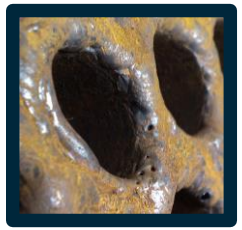
ALL TEMA TYPE SUPPLIERS HAS ISSUES: MAC, Foster Wheeler, Babcock-TEi, Lointek

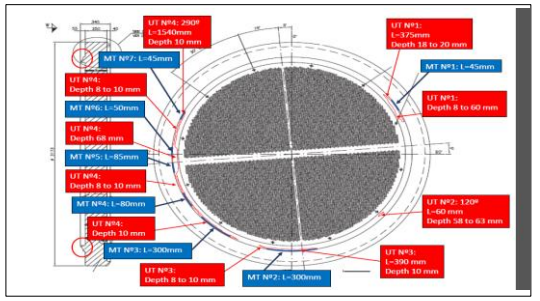


Crack position









AALBORG CSP - Changing Energy

Aalborg CSP Header-and-Coil has a perfect track record

THE TECHNOLOGY SOLUTION TO REMOVE THIS PROBLEM IS TO USE ASME DESIGN BASED HEADER-AND-COIL

OPERATION TIME WITHOUT LEAKS – HEADER & COIL

- **2009: Solnova 1 : SUP+ECO (SGS1)**
- **2009: Solnova 3 : SUP+ECO (SGS1)**
- **2010: Solnova 4 : SUP+ECO (SGS1)**
- **2010: HE 1 : SUP+ECO (SGS2)**
- **2011: HE 1 : SUP+ECO (SGS2)**
- **2012: MS 4.2: SUP+EVA+ECO (SGS3)**
- **2013: Godawari: SUP+EVA+ECO+RH (SGS3)**
- **2014: Cargo: SUP+EVA+ECO+RH (SGS3, constr.)**
- **2014: MS Pilot 4: EVA+ECO**

Total operation time of operation without leakage:

>200 years operation time without leakage

No leaks since 2009 in Header/Coil

Aalborg Header/Coil type SGS/HX

Similar to conventional power plant Boilers – coils absorb thermal stresses

- Designed to ASME/EN/GB

PRODUCED IN CHINA FOR 10 YEARS
SAME CAPEX AS TEMA U-TUBE

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THANK YOU FOR YOUR ATTENTION

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