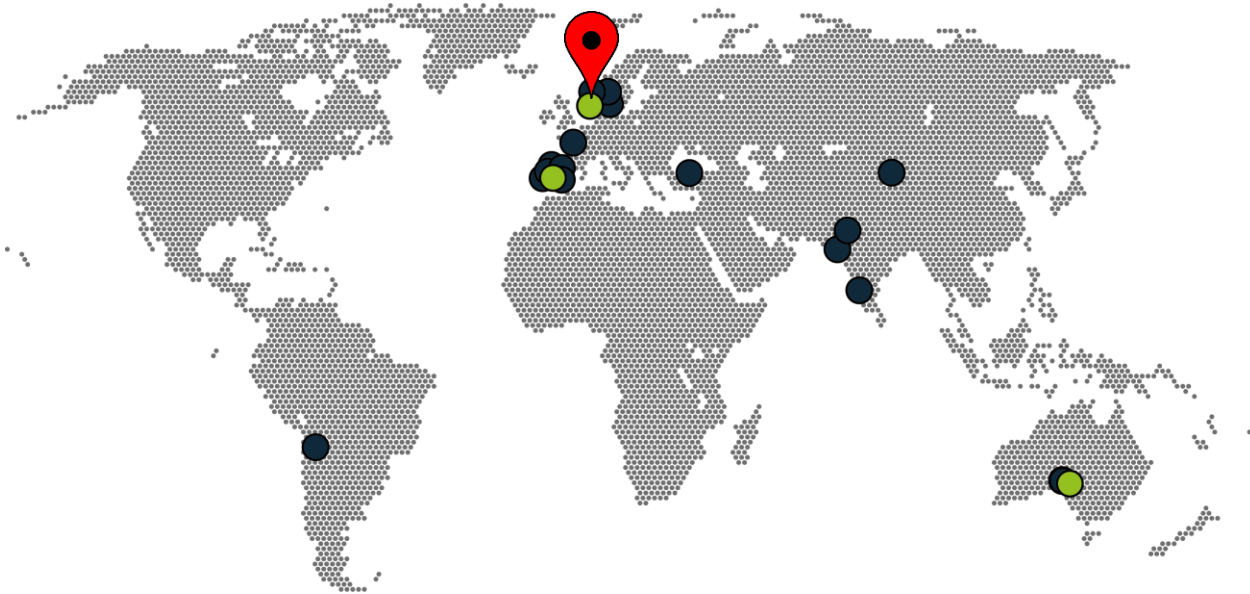


Harvesting energy
FROM THE SUN

**Optimizing Efficiency of Biomass-Fired Organic Rankine Cycle with Concentrated Solar Power
A Combined Heat and Power Case in Denmark**

GLOBAL REACH

Leading developer and supplier of innovative
RENEWABLE ENERGY TECHNOLOGIES
aiming to change the way energy is produced today.



Our company

- 1** headquarters in Aalborg (Denmark)
- 3** sales & service locations worldwide

Our projects

- 8** countries of the world
- >1,700 MWth** solar installations globally

VISION & MISSION

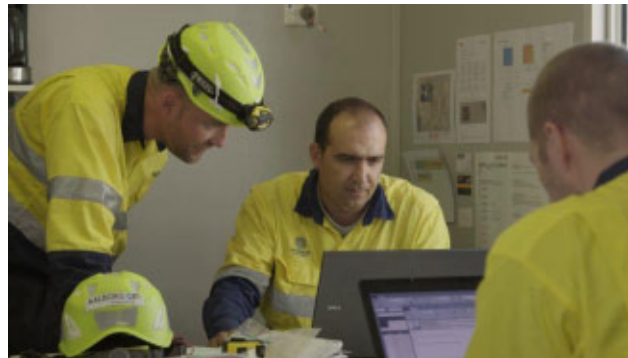
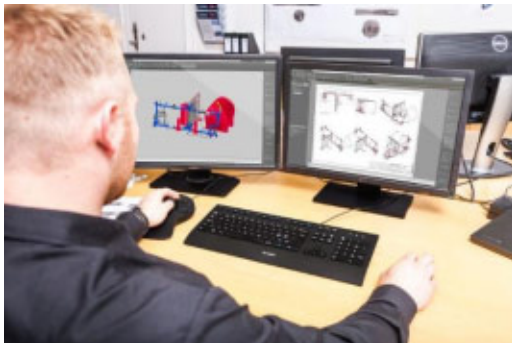
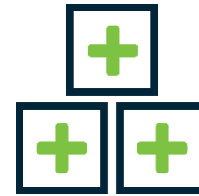
Our Vision

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.

FROM IDEA TO REALITY



FROM BOILERS TO CSP & CSH



1988
Traditional boiler design and delivery



2007
Entry to the CSP market with solar boilers: 5x50MWe steam generators, 20+10MWe central receivers, Spain



2011
CSP for district heating optimized for local conditions, Denmark



2013
50MWe and 25MWe steam generators, India



2014
Development of different thermal energy storage technologies begins



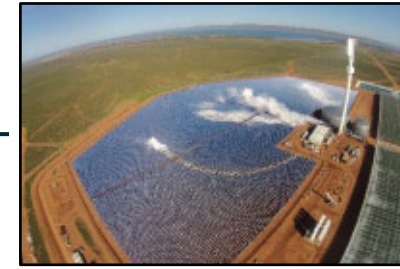
2017
Molten salt solar boiler project in China



2017
Different district heating projects with flat solar panels, Denmark



2016
CSP combined with biomass-ORC, Denmark



2016
The first integrated energy system based on CSP in the world, Australia



2015
CSP combined with flat panels for district heating, Denmark

16.6 MWt CSP COMBINED WITH BIOMASS + ORC



1st
of its kind
in the
world

AAL-Trough™ 3.0

Location: Brønderslev, Denmark

Capacity: 16.6 MW_t

Area: 26,929 m²

Temperature: 330 °C

Status: operational since 12/2016

Households: ~4,500

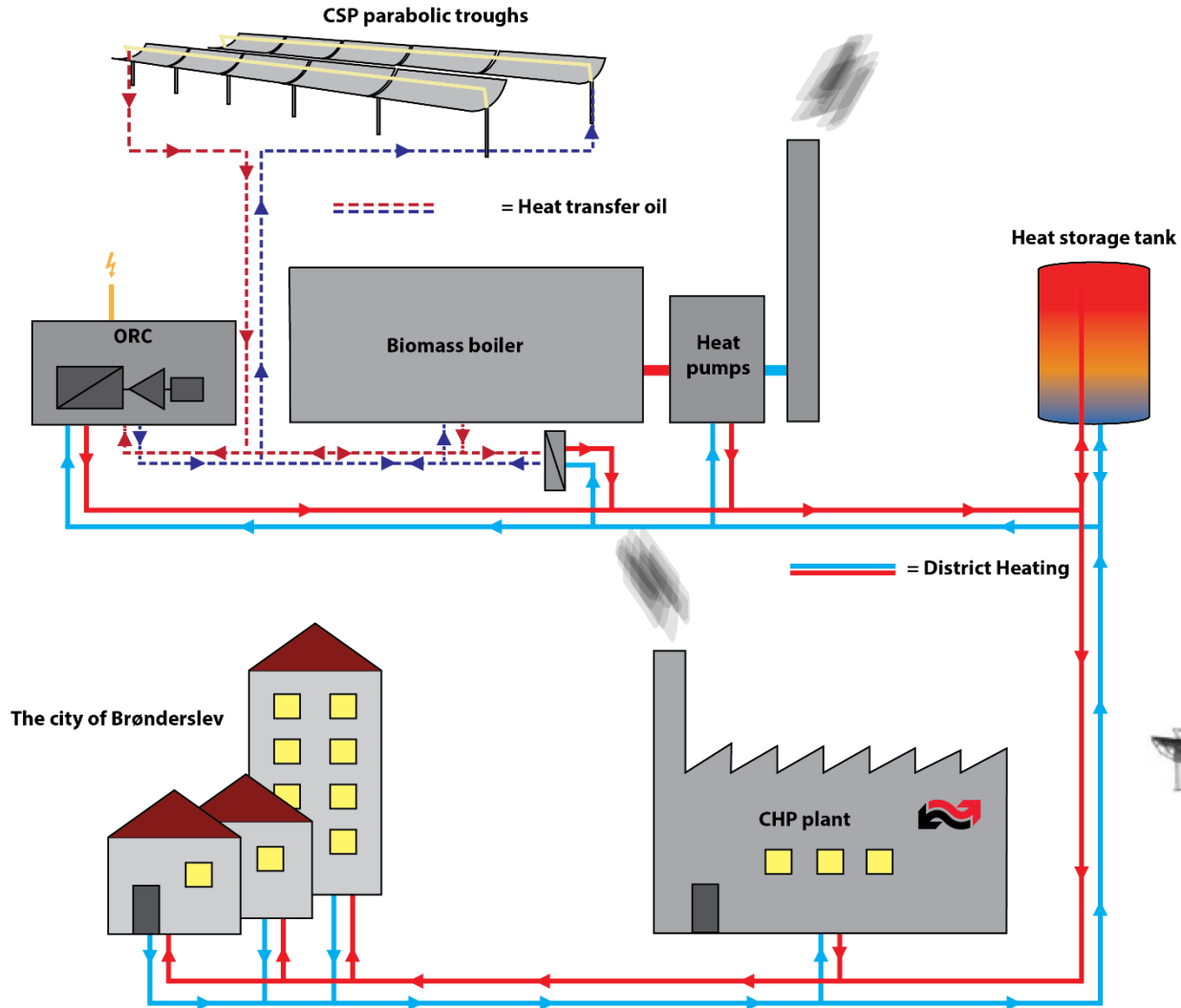
Land: 9HA

Row distance: 15 m

Area: 26,929 m²

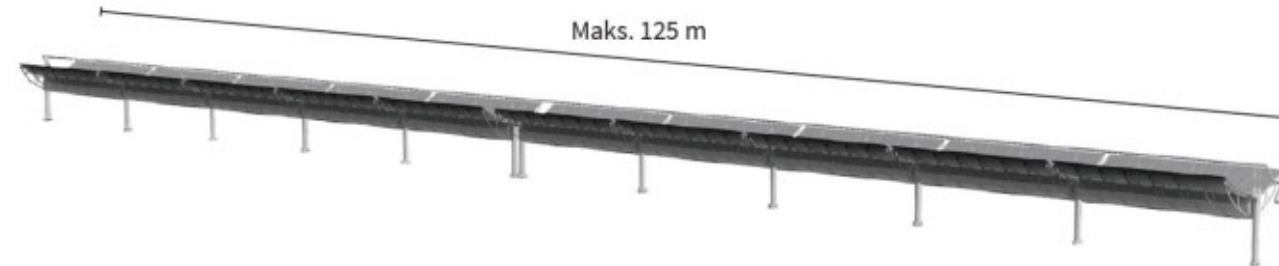
Row length: 125 m

SCHEMATIC OVERVIEW



The ORC plant can convert 20 MW thermal energy to 4 MW power and 20-22 MW heat

Biomass-boiler:	2 x 10 MWth
ORC:	4 MWe
Heat pump 1:	900 kW
Heat pump 2:	1.100 kW
CSP solar field:	16,6 MWth
Medium:	thermal oil



→8● 4**8.92*■ □9.9*3→2- □4* *4.9■□22□■*5.4.



→8.● 4.**8.92*■ □9.9*3.→2-□ □4.* *4.9□→22.□■*5.4.



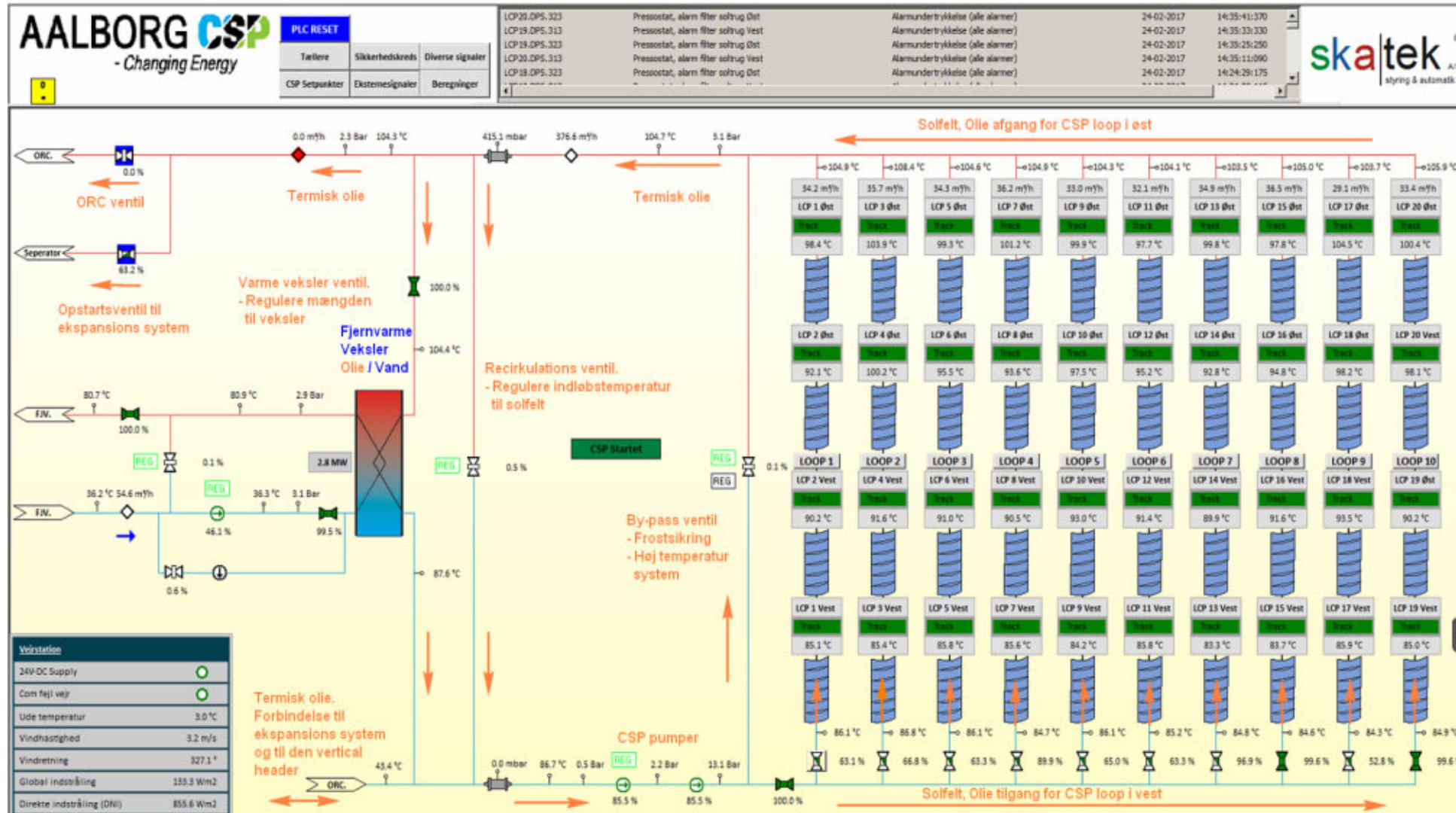
CSP solar field Brønderslev



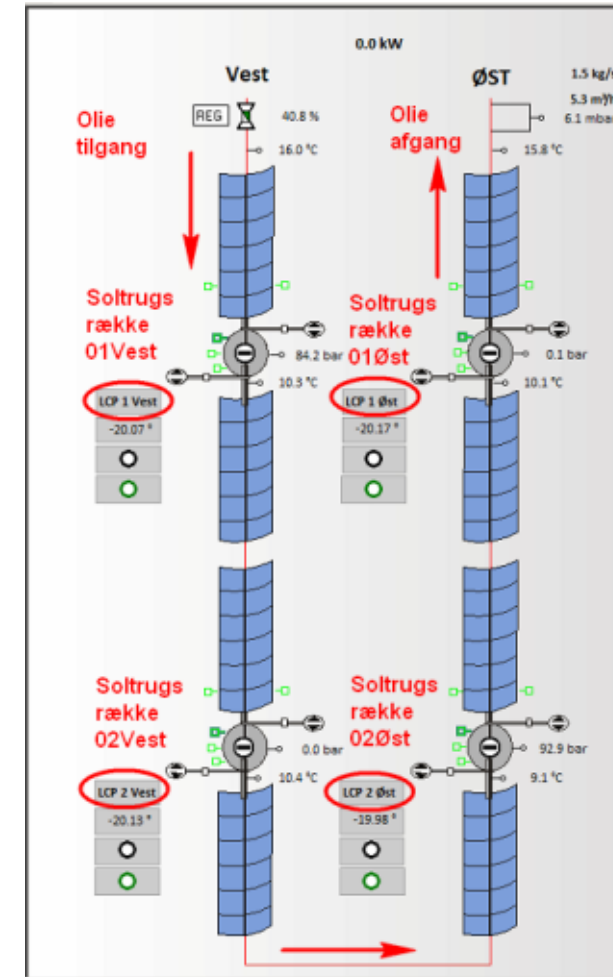
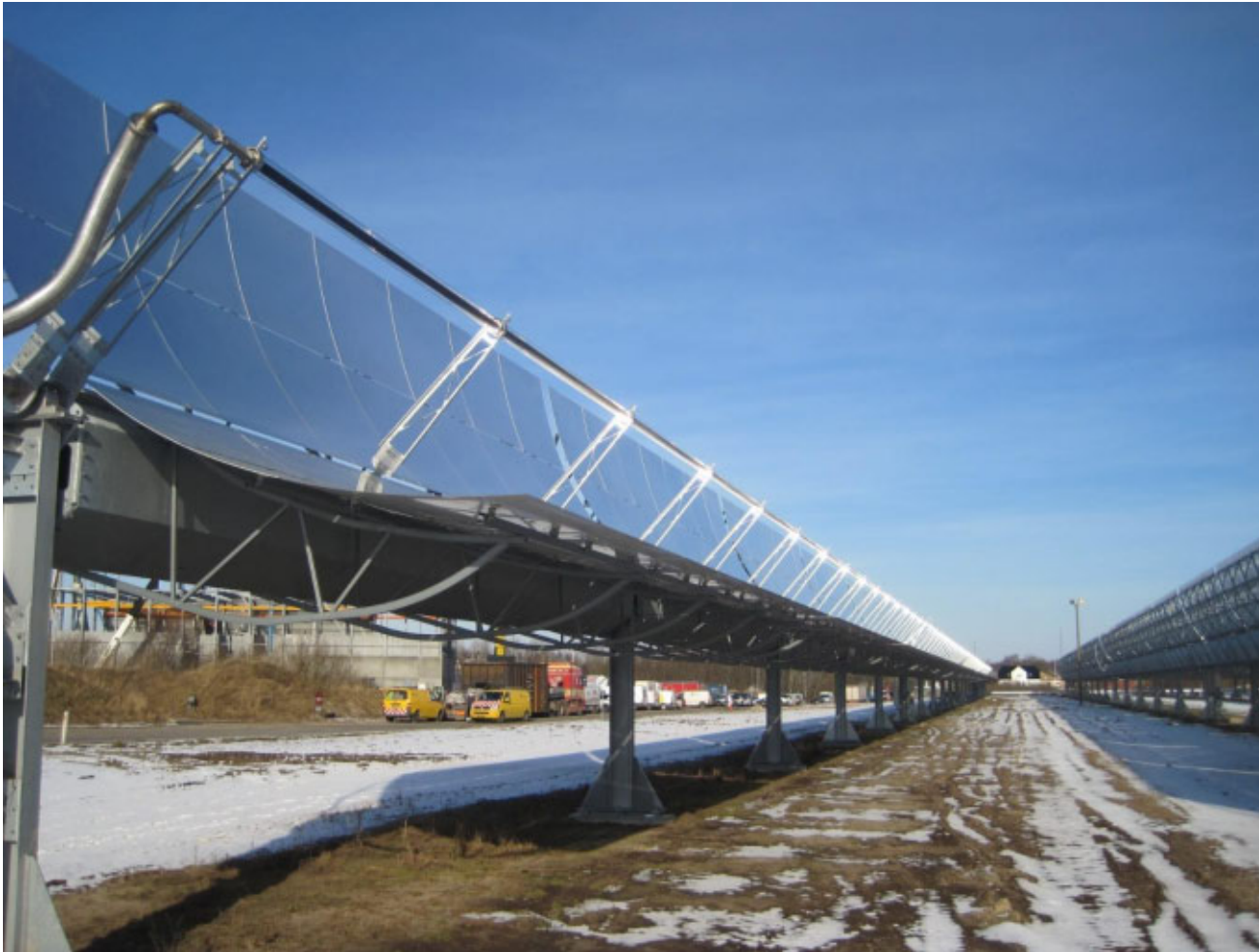
The current solar plant is installed with approx. 29° offset from the geographical North/South axis, facing towards the East.

Land used:	9 HA
Distance between rows:	15 m.
40 Solar Collector Assemblies (SCA):	120 m
CSP field aperture area:	26,929 m ²

SCADA System



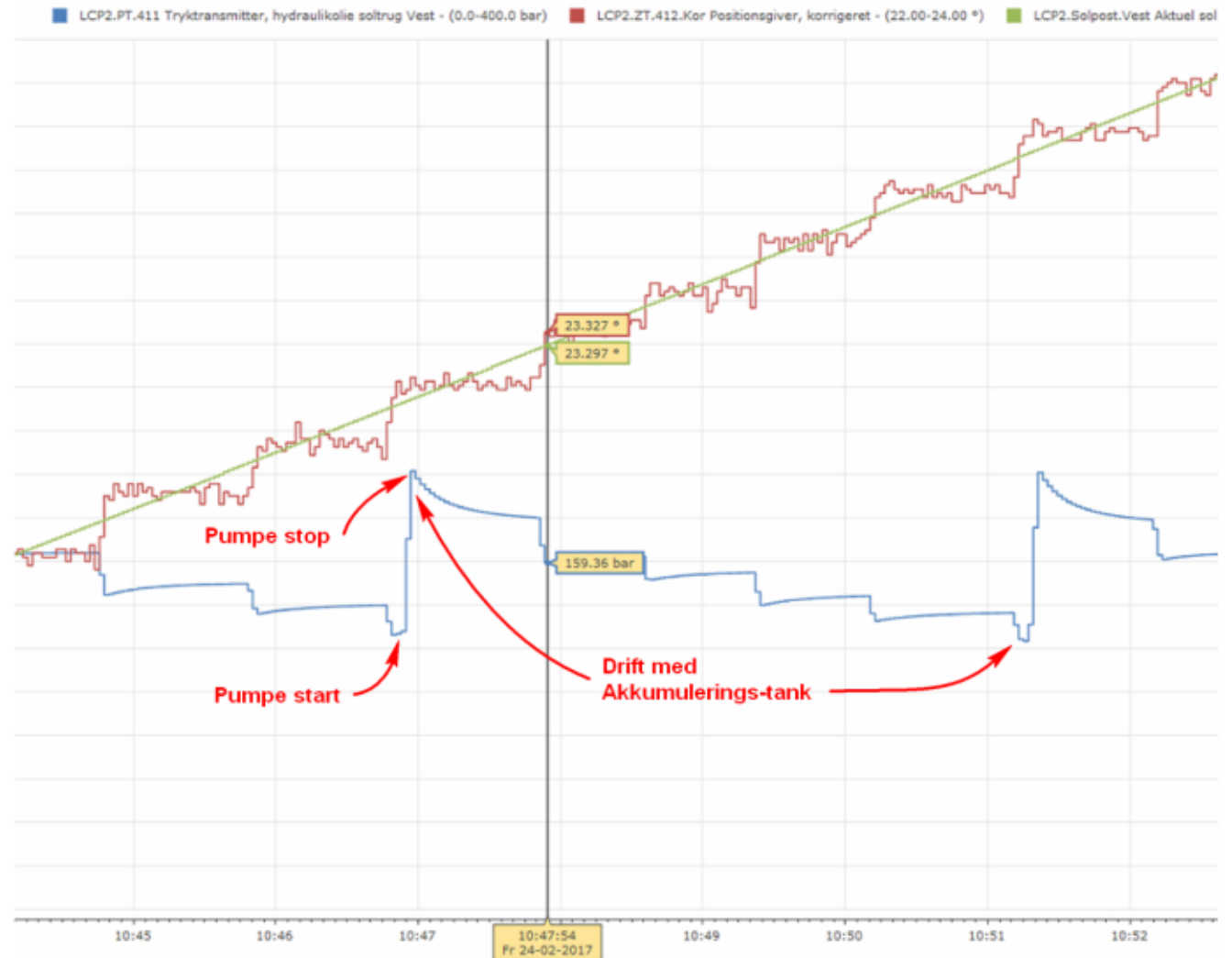
CSP array and CSP loop



Drive Unit

Hydraulic System

- System defocuses 1° to the east in case of power failure
- High and low speed



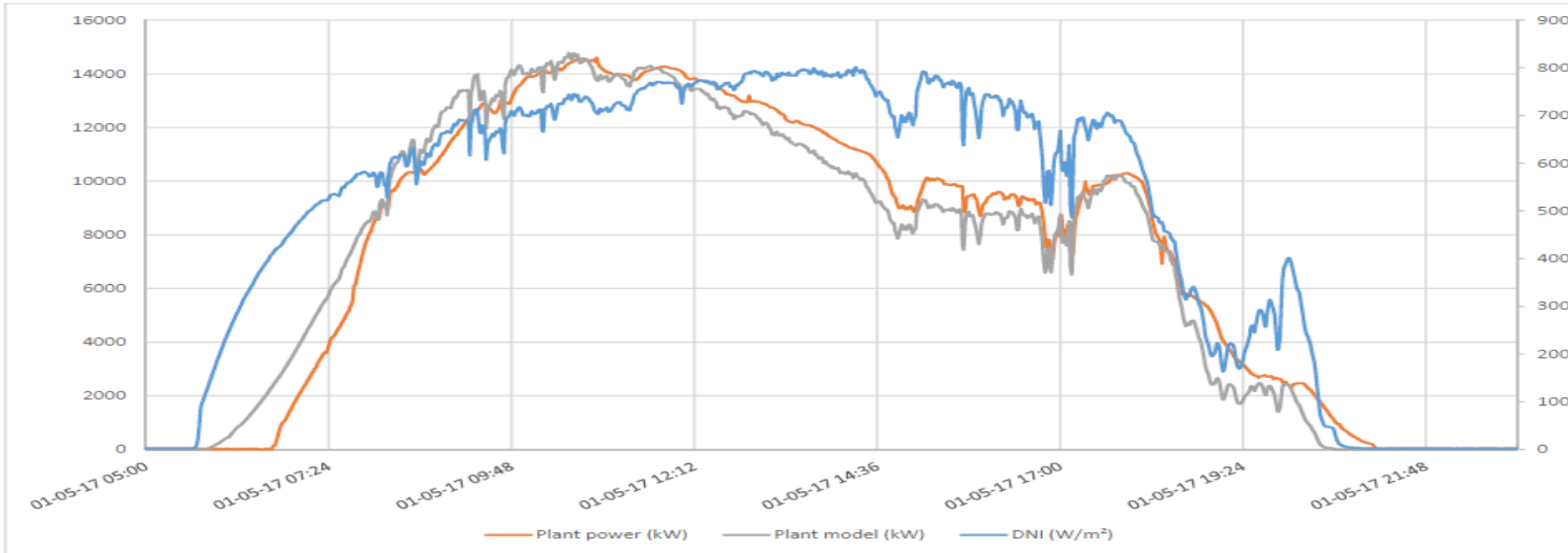
The DNI Solar Sensor and Weather Station

DNI = Direct Normal Irradiance



Sun position sensor

Measured vs. Calculated Performance



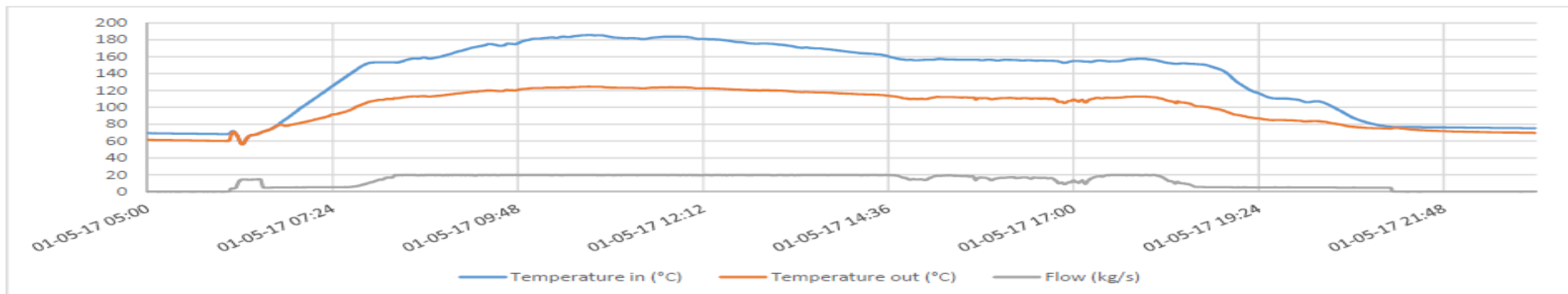
Example: May 1, 2017

Solar heat measured

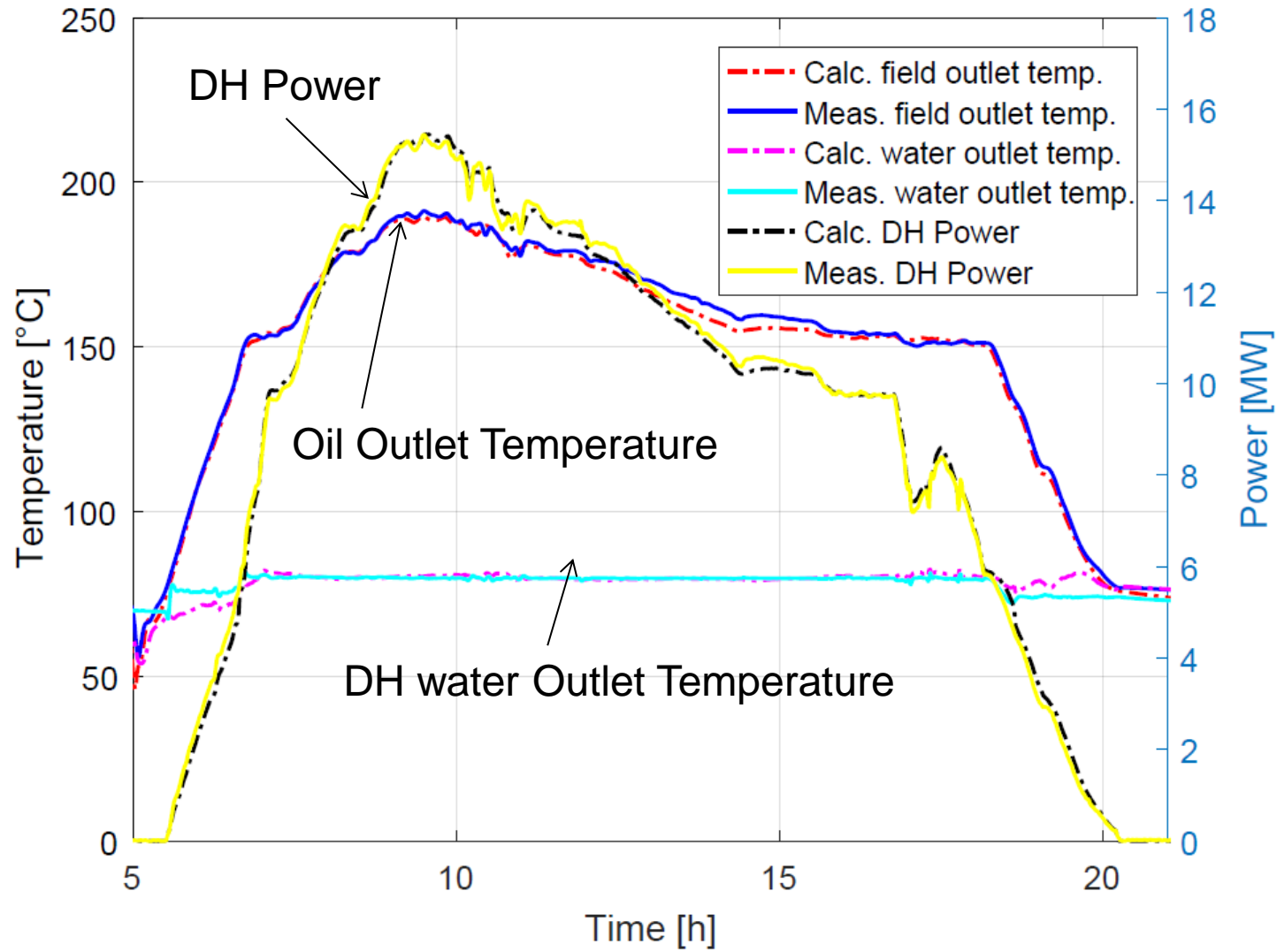
132,6 MWh

Solar heat calculated

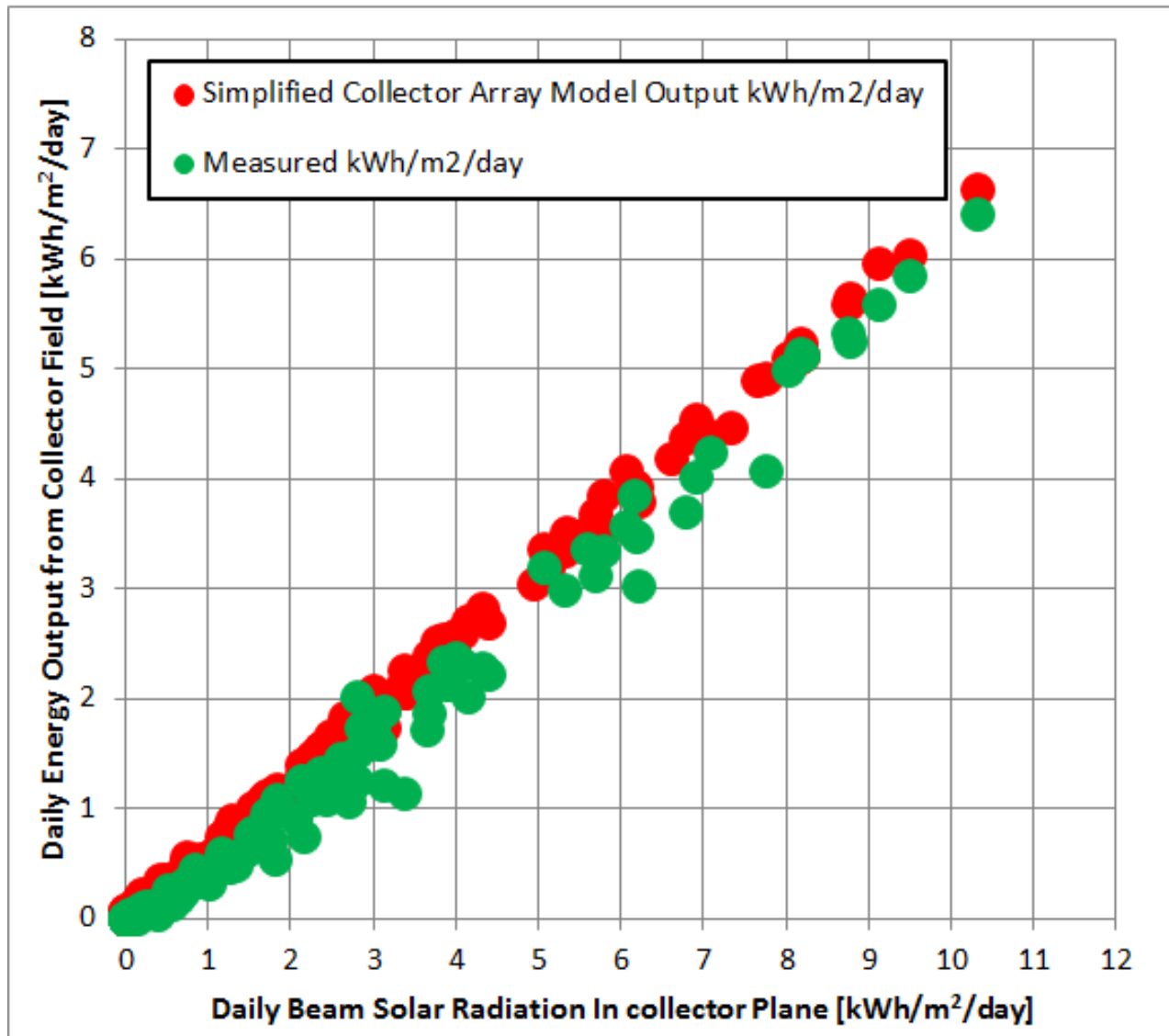
130,1 MWh



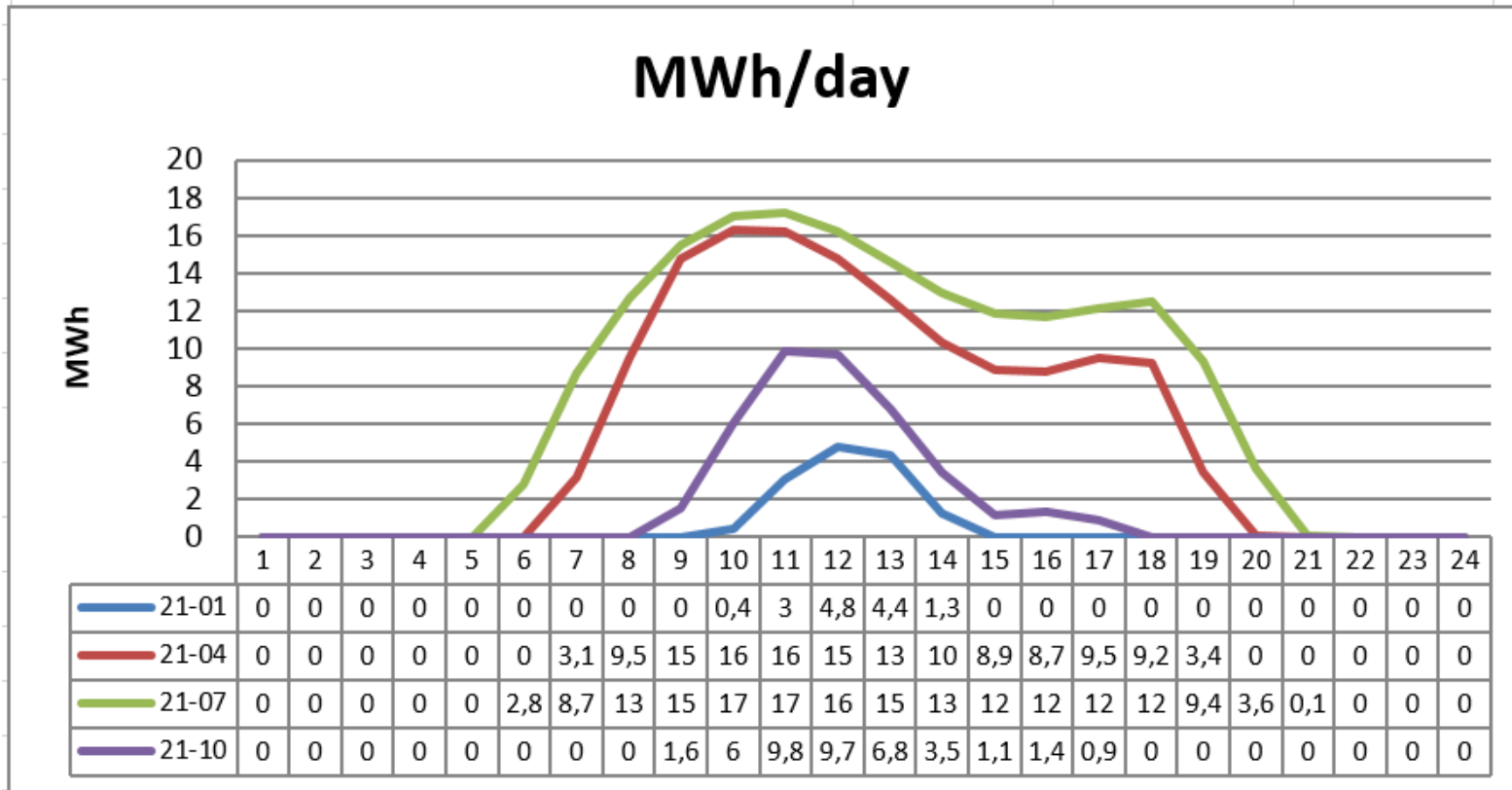
Detailed TRNSYS model validation - CSP Collector field performance



Simplified Daily Input/Output Performance Check (May-September 2017)



SEASONAL PRODUCTION OF THE CSP PLANT



Expected production on a clear day:

21 January: 14 MWh

21 April: 138 MWh

21 July: 180 MWh

21 October: 41 MWh

The angular rotation of the solar panel to the east relative to N / S causes production to be greatest in the morning

THANK YOU FOR YOUR ATTENTION

Visit us at our Stand

Jes Donneborg

e-mail: jdo@aalborgcsp.com

Tel.: (+45) 4015 2736

