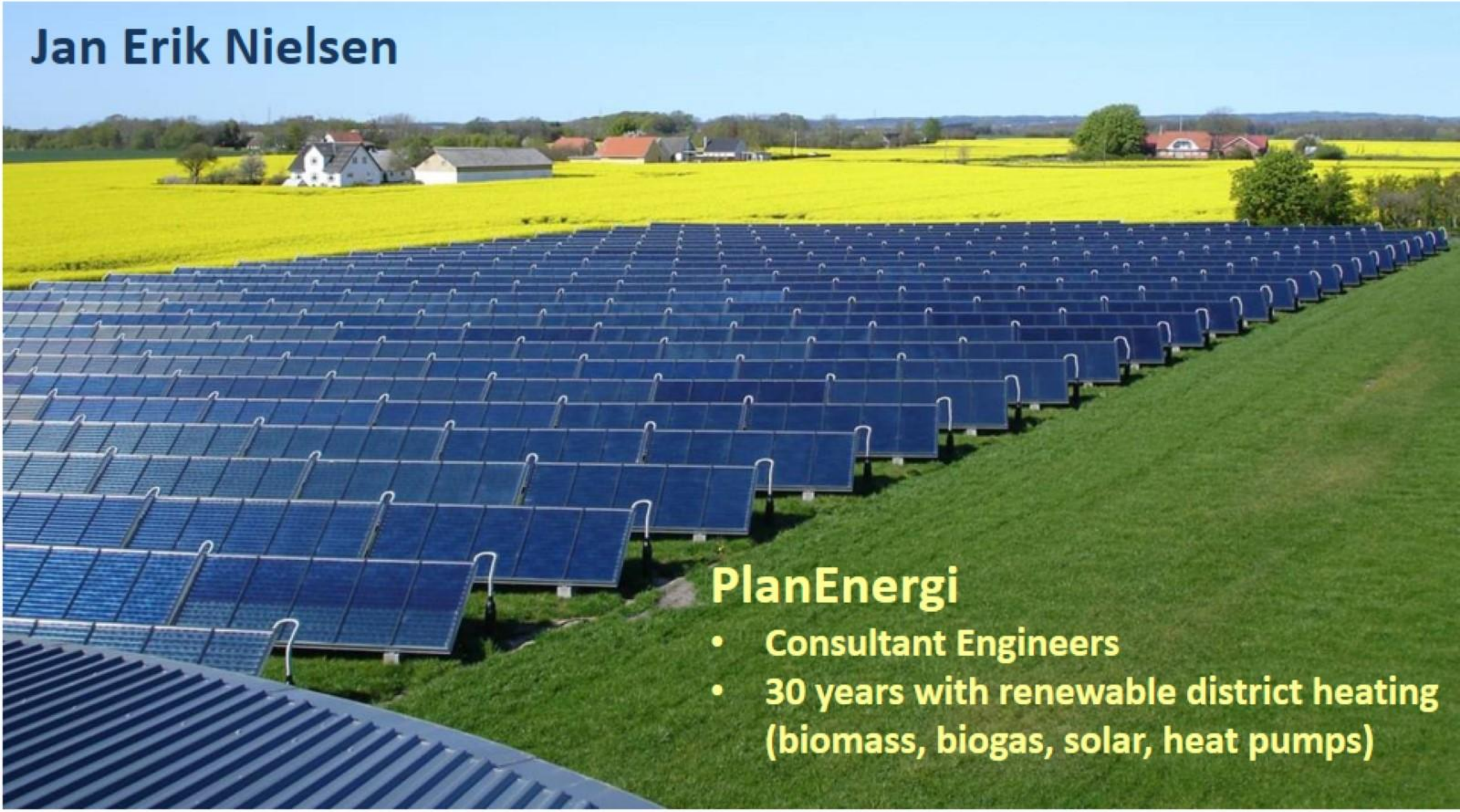
Monitoring and simulation of large solar district heating fields

An example from Denmark



Quasi-dynamic model for simulation of large solar collector fields

On-line surveillance of field performance

Basic differential equation:

$$C\, dT_m/dt = n_0 G - U_L(T_m - T_a) - mc_p(T_o - T_i)$$

C	heat capacity in the collector loop per m^2 collector	$J/(K\ m^2)$
dT_m	change of the collector loop mean temperature during a time step dt	K
dt	time step	s
n_0	zero loss efficiency	-
G	resulting radiation (taking into account shadows and IAM)	W/m^2
U_L	collector heat loss coefficient (linearized)	$W/(m^2K)$
	$U_L = a_1 + a_2(T_m{}^*)$, where $T_m{}^*$ is mean temperature in last time step	
a_1	collector 1.order heat loss coefficient	$W/(m^2K)$
a_2	collector 2.order heat loss coefficient	$W/(m^2K^2)$
T_m	collector loop mean temperature	°C
T_a	ambient air temperature	°C
m	mass flow rate in collector loop per m^2 collector	$kg/(s\ m^2)$
c_p	specific heat capacity of collector loop fluid	$J/(kgK)$
T_{out}	collector outlet temperature	°C
T_{in}	collector inlet temperature	°C

Solution:

$$T_{m,1} = T_{m,0}(1-B_1/2)/(1+B_1/2) + B_2/(1+B_2/2)$$

where

$T_{m,1}$ is collector loop mean temp. at the end of dt

$T_{m,0}$ is collector loop mean temp. at the beginning of dt

$B_1 = (U_L+2mc_p)*dt/C$

$B_2= (n_0G+U_Lt_a+2mc_pT_{in})*dt/C$

Calculated outlet temperature:

$$T_{out} = 2T_m - T_{in}$$

Calculated output:

$$Q = mc_p(T_{out} - T_{in}) * dt$$

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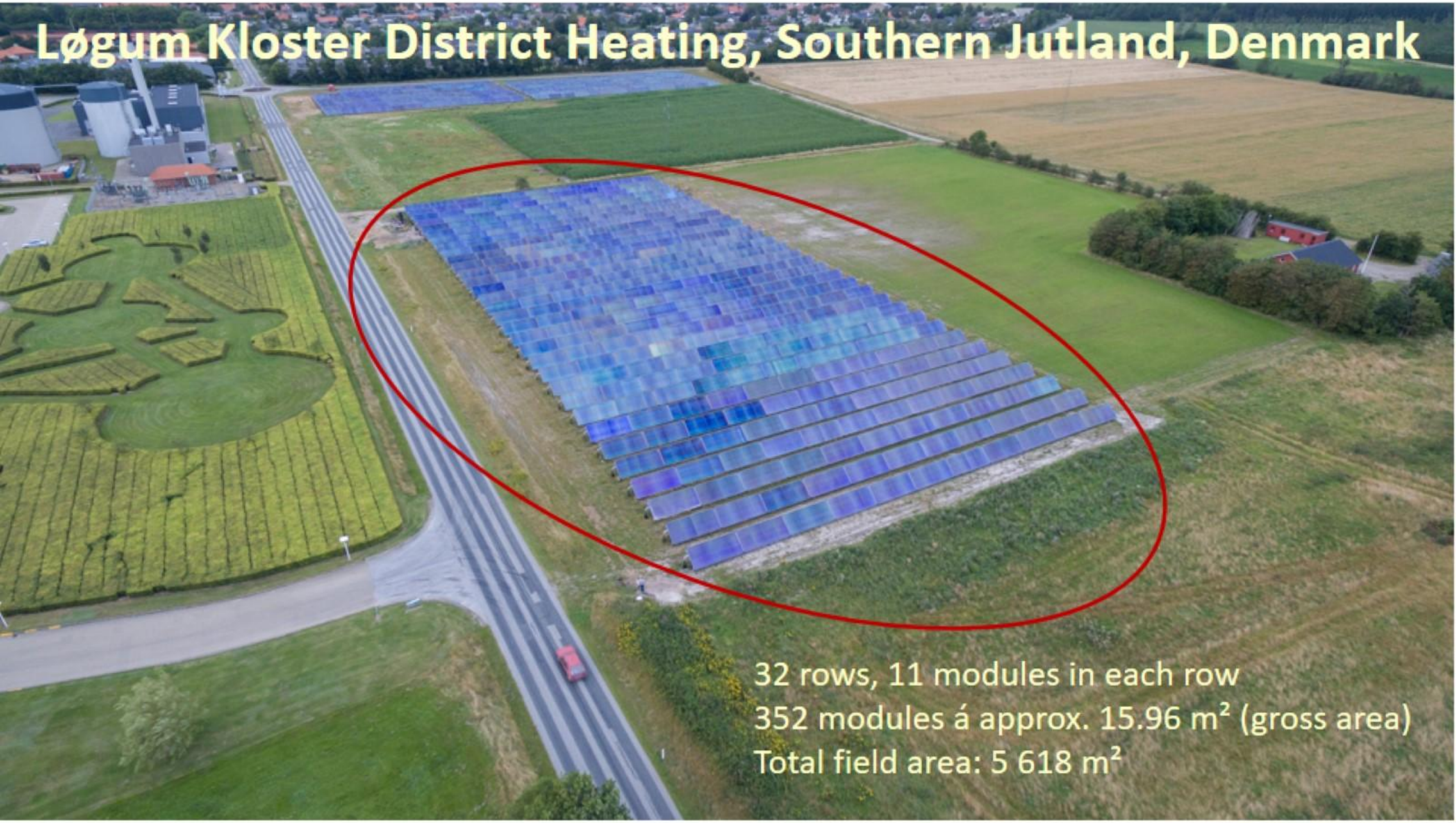

Savo large collectors

$\eta_{0,hem}$ = 0.812
a_1 = 2.936
a_2 = 0.009

Gross area = 15.96 m²

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Annex to Solar Keymark Certificate - Summary of EN ISO 9806:2013 Test Results		Licence Number	011-7S2688 F
		Date issued	2016-10-07
		Issued by	
Licence holder	Savo-Solar Oyj	Country	Finland
Brand (optional)	-	Web	www.savosolar.fi
Street, Number	Insinöörinkatu 7	E-mail	info@savosolar.fi
Postcode, City	50150 Mikkeli	Tel	+358 (0)50 410 5247
Collector Type		Flat plate collector, glazed	

Collector name	Gross area (A_G)	Gross length	Gross width	Gross height	Power output per collector Gb = 850 W/m²; Gd = 150 W/m² ϑm - ϑa 0 K	10 K	30 K	50 K	70 K	130 K
	m²	mm	mm	mm	W	W	W	W	W	W
SF500-15	15.96	2'591	6'158	213	12'960	12'477	11'424	10'257	8'976	4'440
Power output per m² gross area					812	782	716	643	562	278

Performance parameters test method	Steady state - outdoor		
Performance parameters (related to AG)	η0,hem	a1	a2
Units	-	W/(m²K)	W/(m²K²)
Test results	0.812	2.936	0.009

Incidence angle modifiers test method		Steady state - outdoor								
Bi-directional incidence angle modifiers	Yes									
Incidence angle modifier	Angle	10°	20°	30°	40°	50°	60°	70°	80°	90°
Transversal	$K_{\theta T,coll}$	1.00	1.00	1.00	0.99	0.97	0.91	0.75	0.42	0.00
Longitudinal	$K_{\theta L,coll}$	1.00	1.00	1.00	0.99	0.98	0.94	0.84	0.59	0.00

Heat transfer medium for testing	Water-Glycole		
Flow rate for testing (per gross area, A_G)	dm/dt	0.020	kg/(sm²)
Maximum temperature difference for thermal performance calculations	$(\vartheta_m-\vartheta_a)_{max}$	130	K
Standard stagnation temperature (G = 1000 W/m²; ϑ_a = 30 °C)	ϑ_{stg}	210	°C
Effective thermal capacity, incl. fluid (per gross area, A_G)	C/m²	10.2	kJ/(Km²)
Maximum operating temperature	$\vartheta_{max,op}$	225	°C
Maximum operating pressure	$p_{max,op}$	1000	kPa

Testing laboratory	SPF, CH-8640 Rapperswil	www.spf.ch	
Test report(s)	C1704LPEN C1704QPEN	Dated	28.09.2016 28.09.2016

Comments of testing laboratory — Datasheet version: 5.01, 2016-03-01

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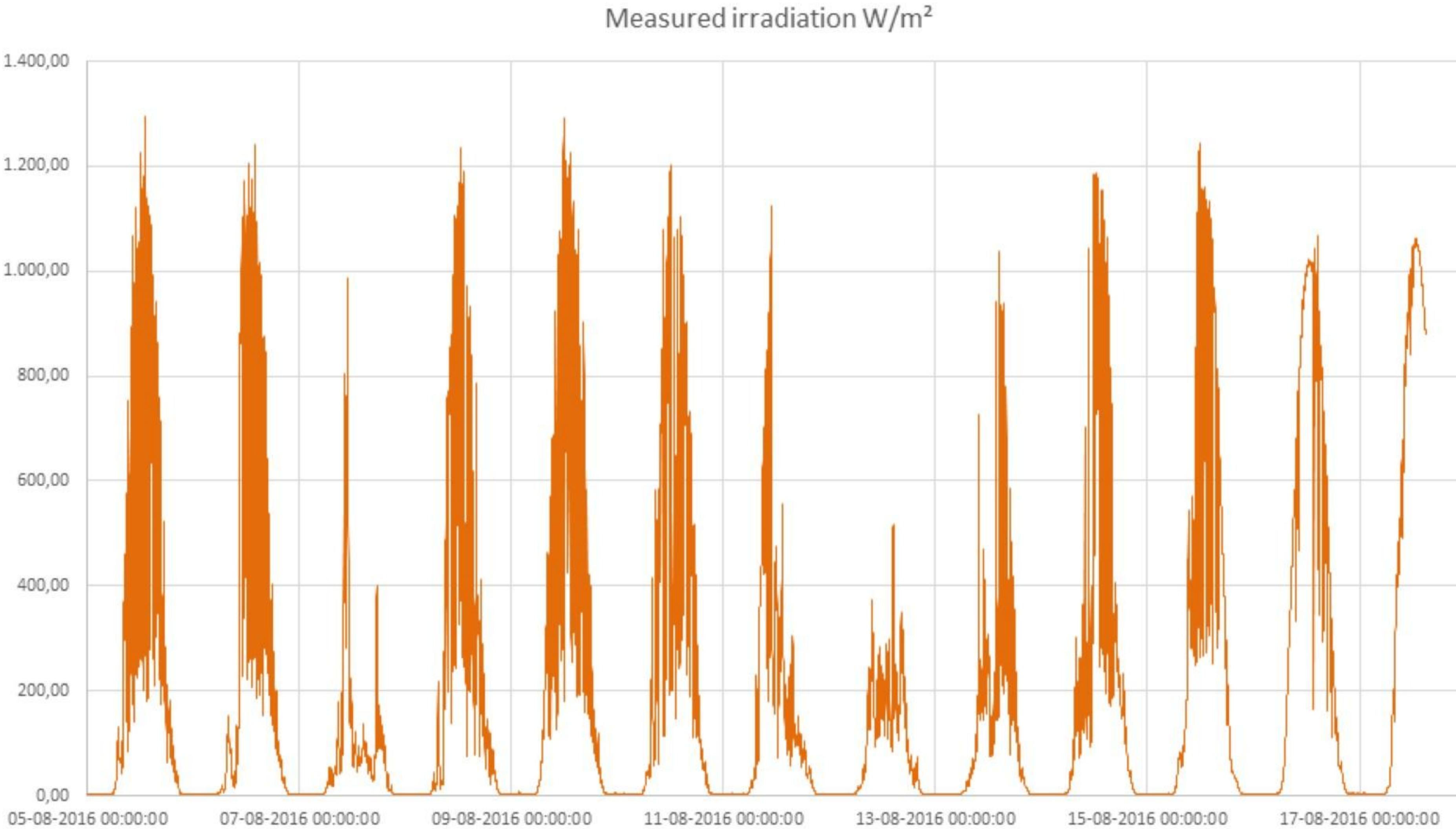

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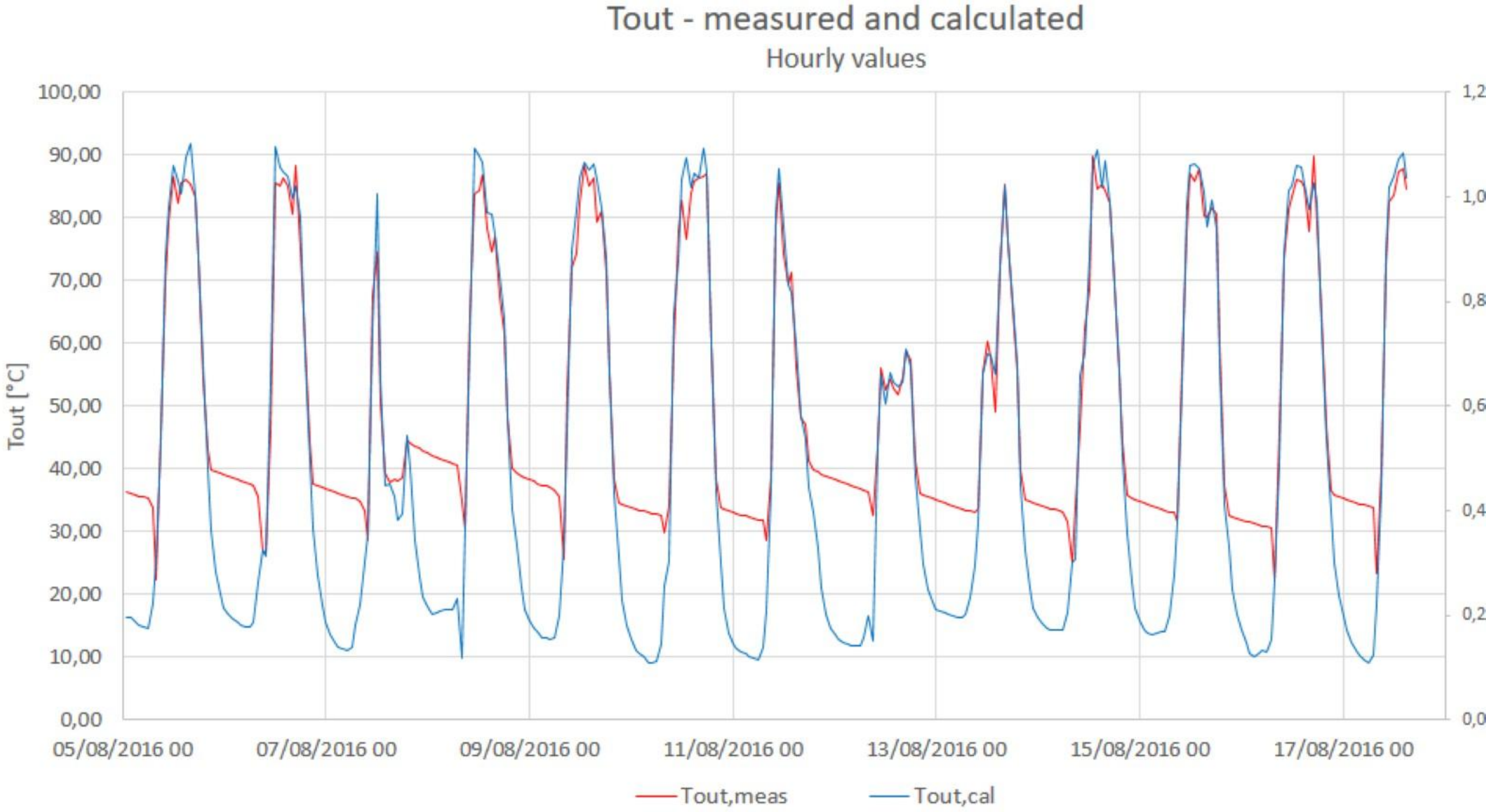

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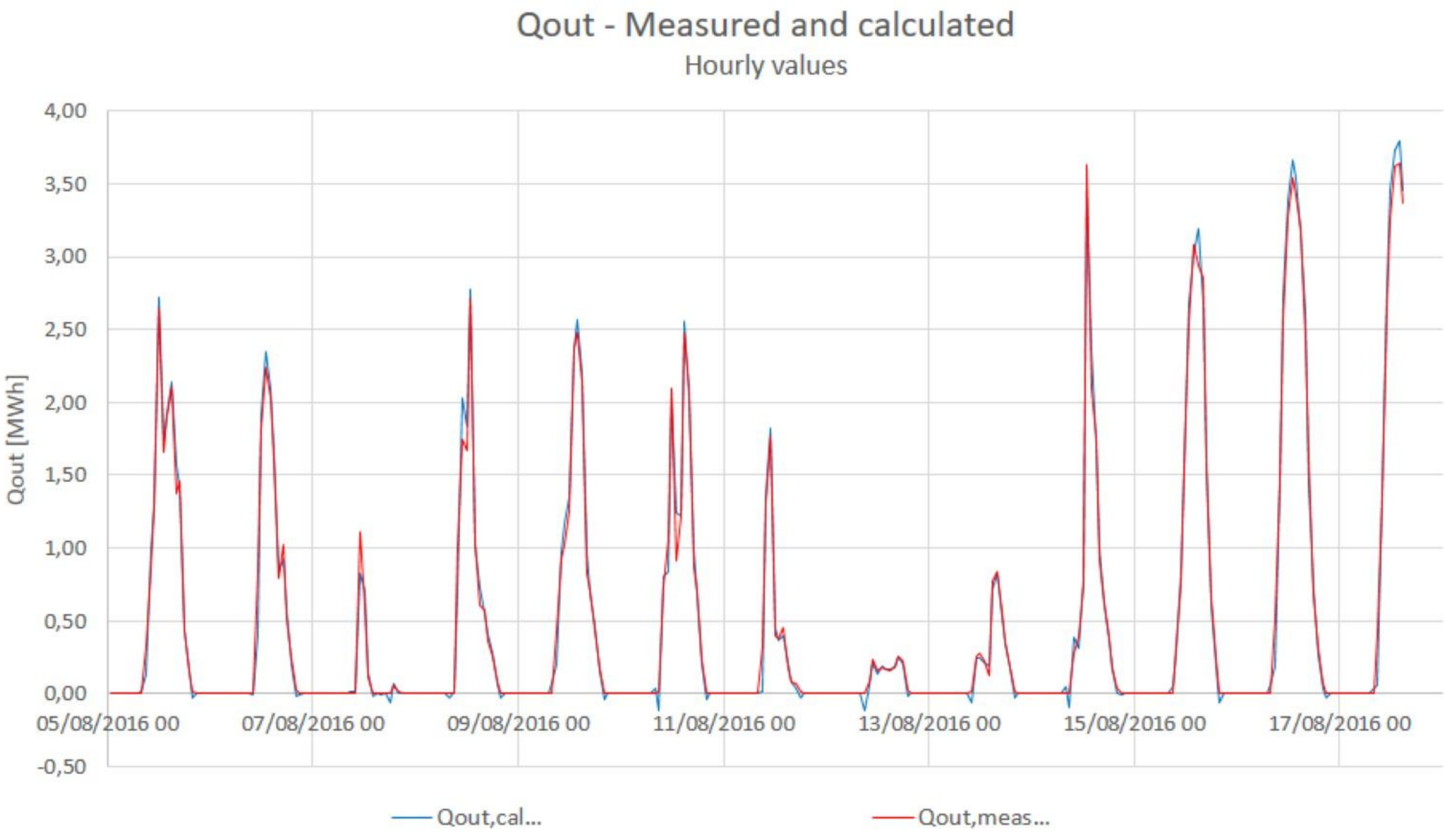

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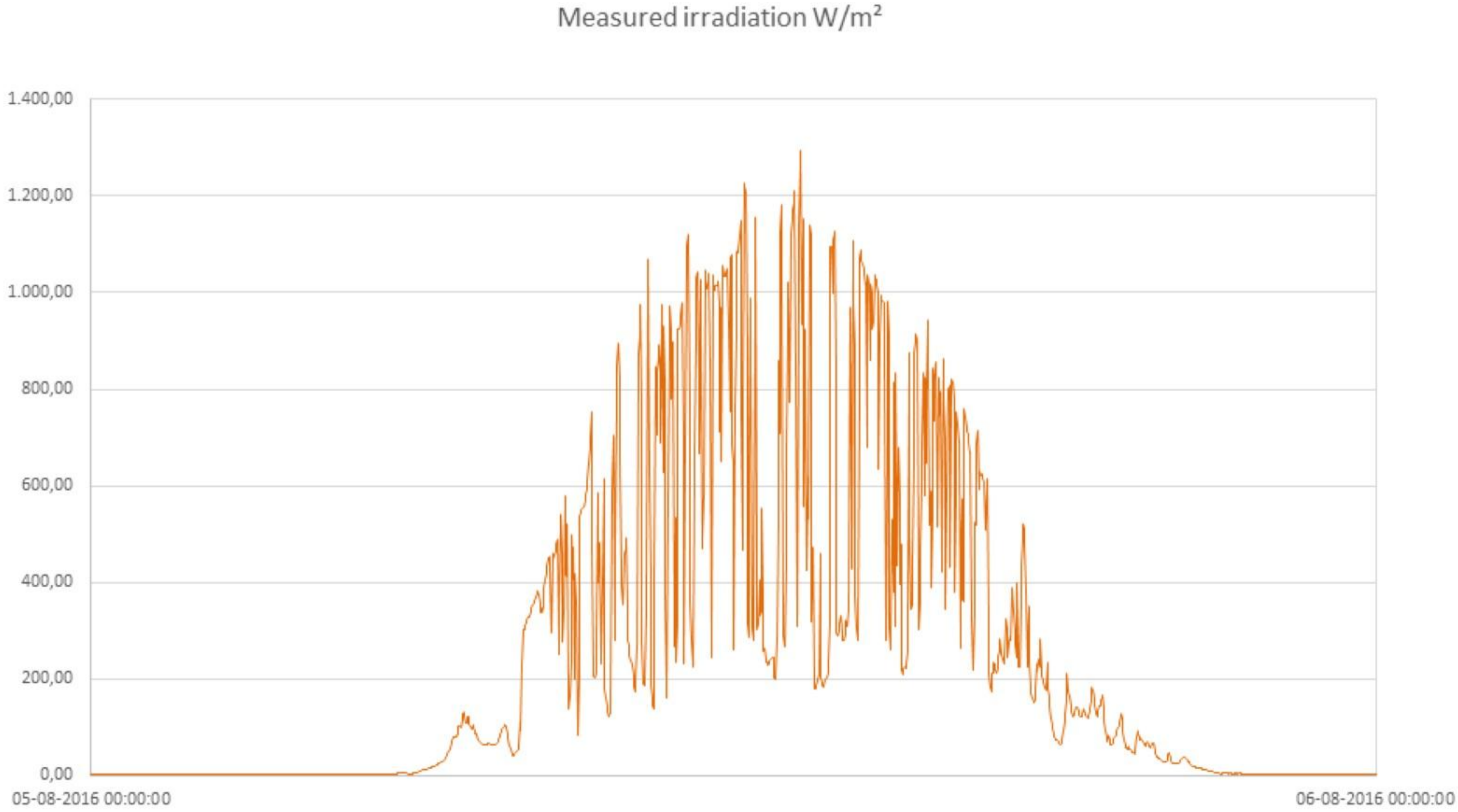

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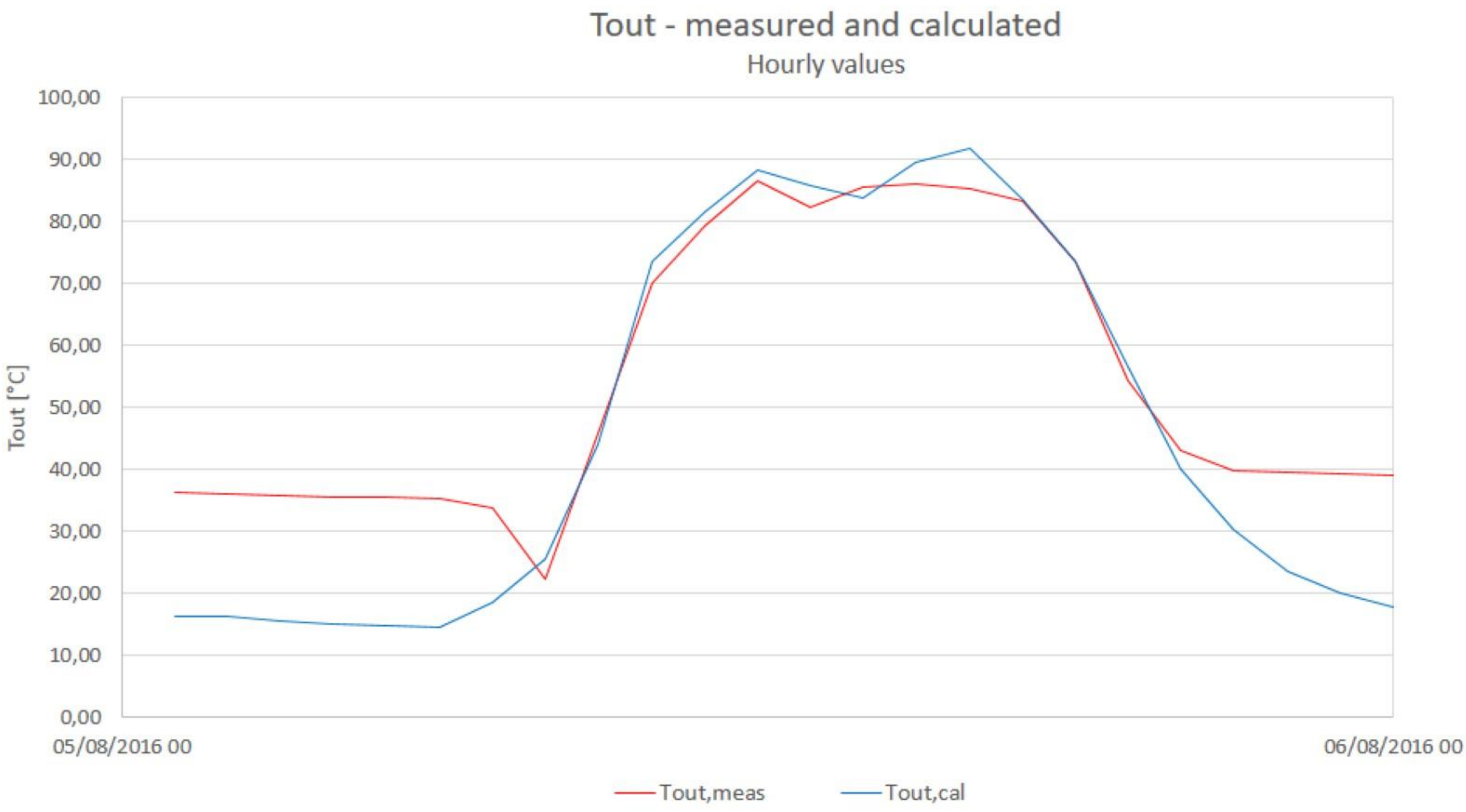

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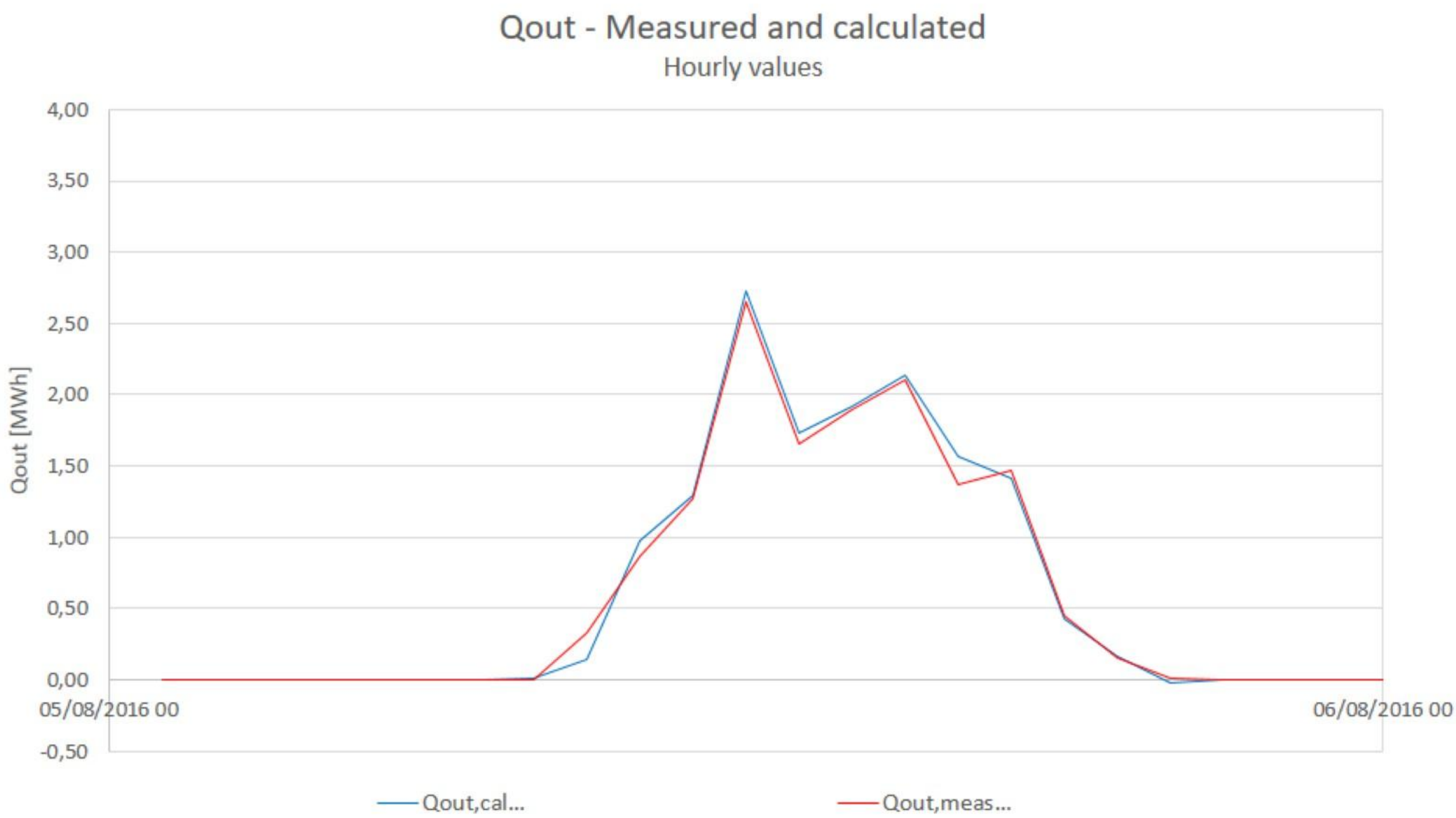

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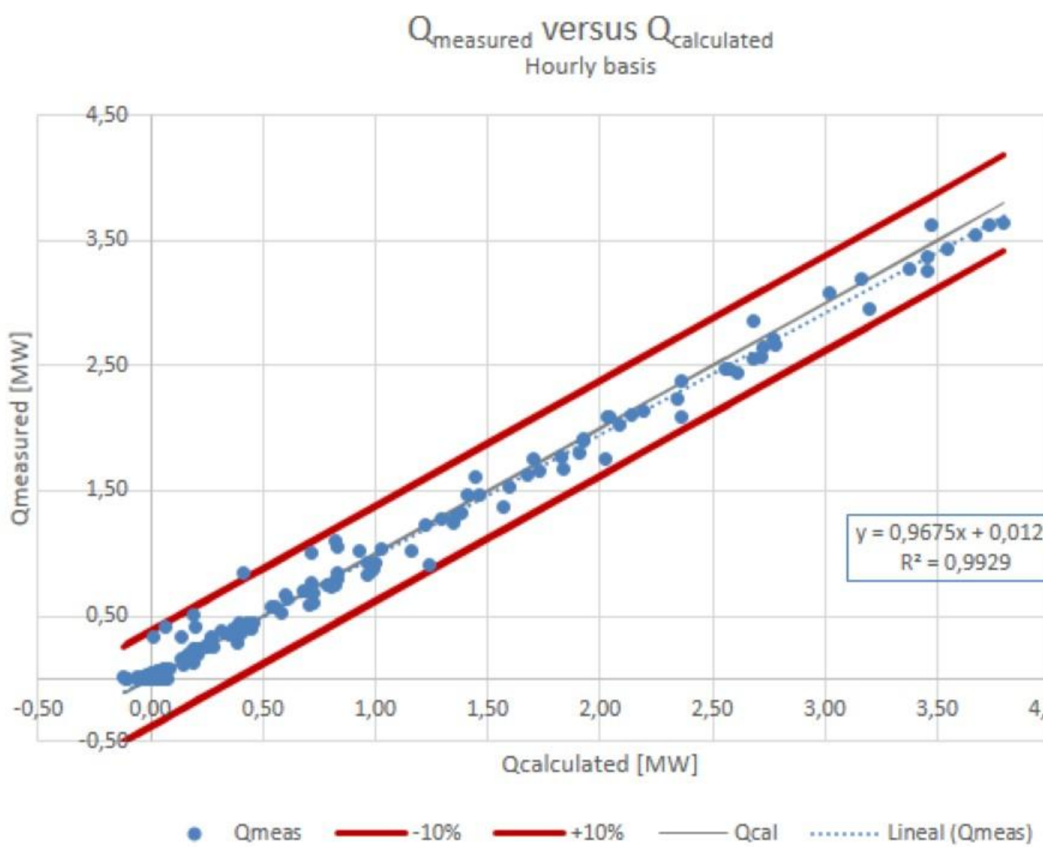

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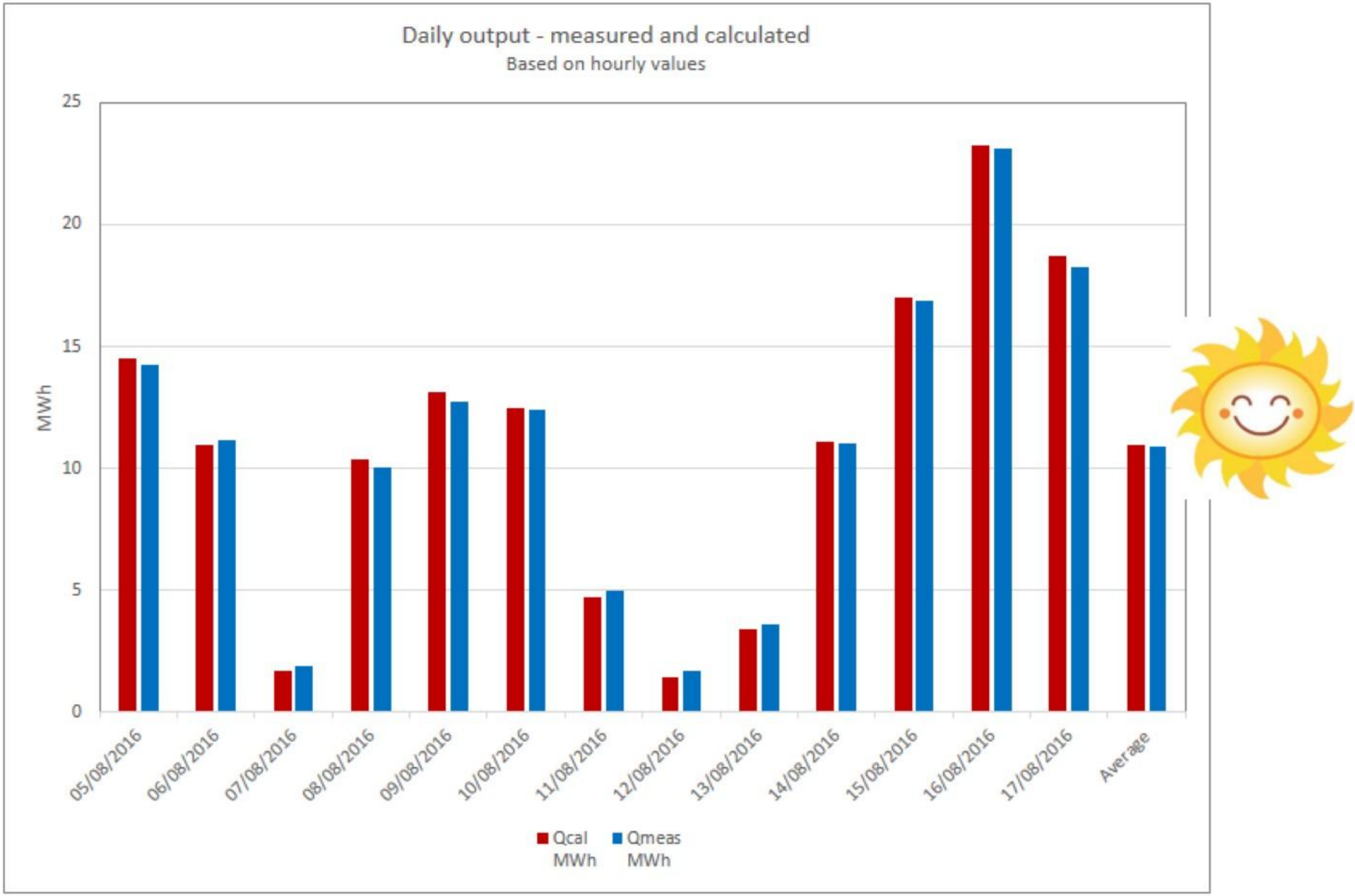

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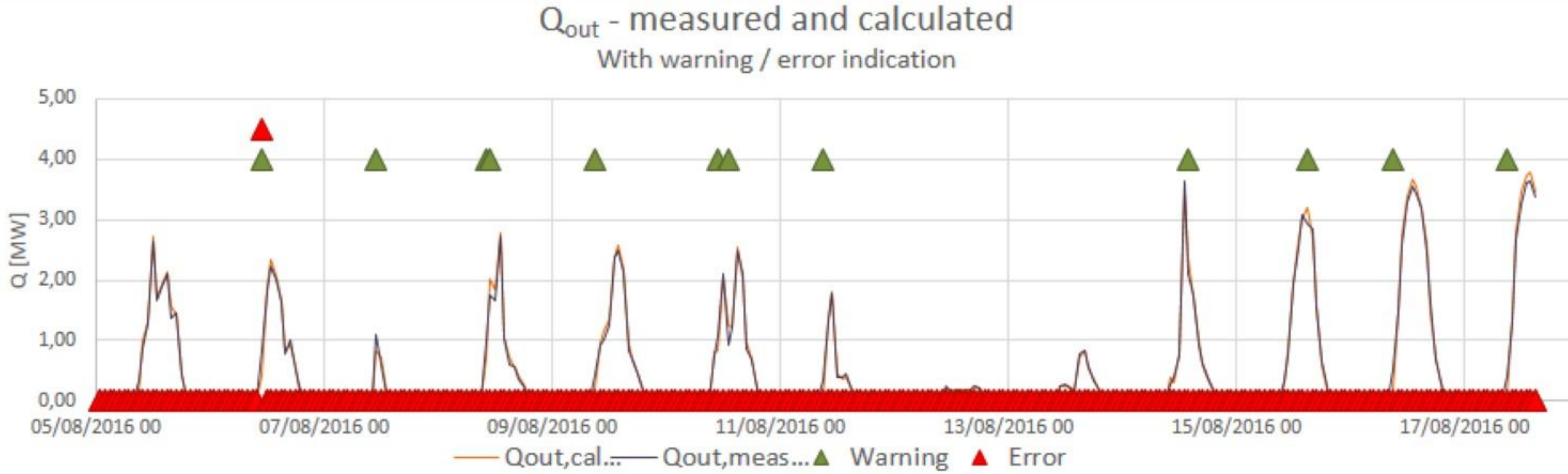

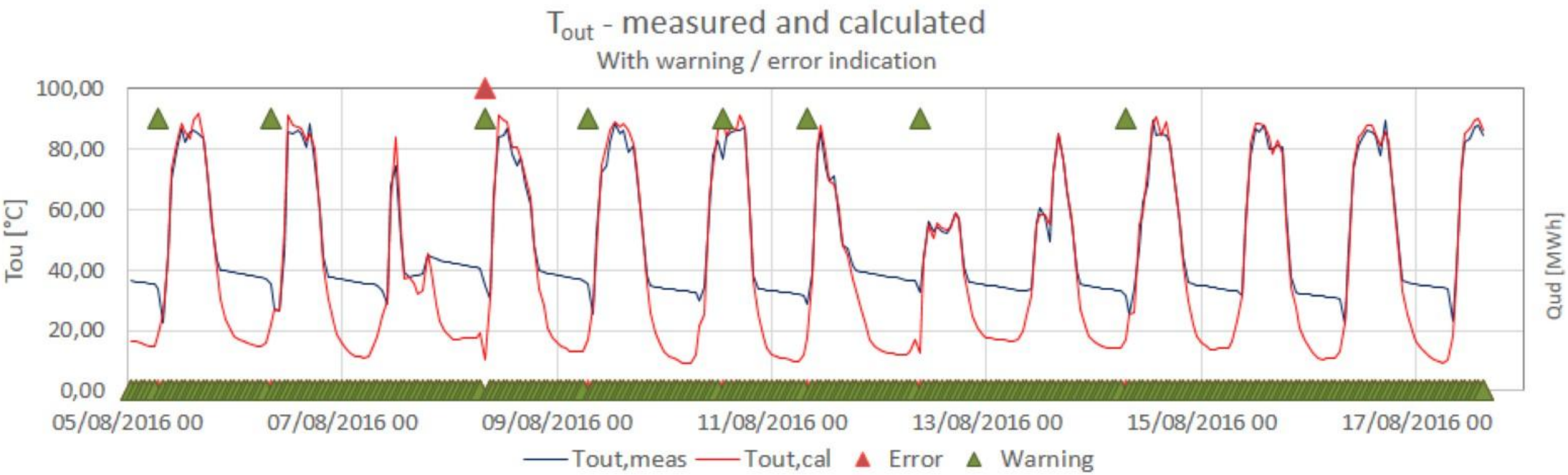

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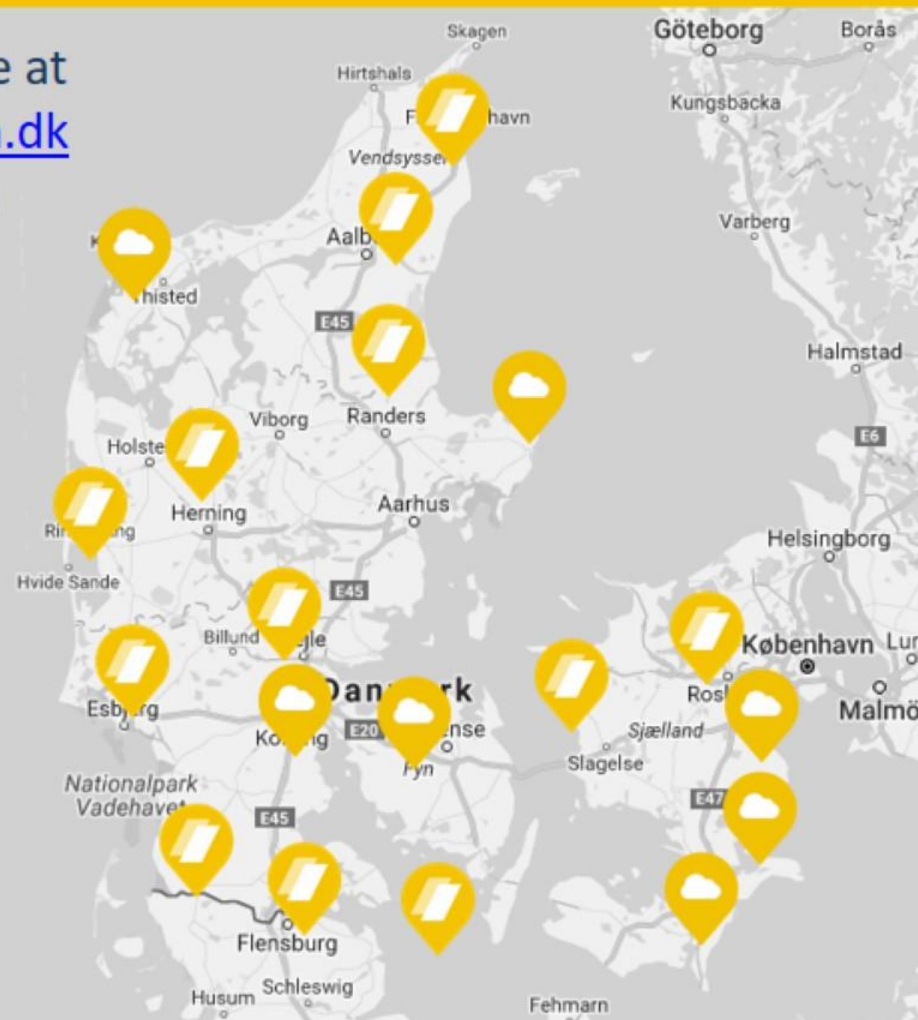

USING THE MAP
Move the cursor over the cities to see the current solar production.

Click on the city for more information and historical data.

GET YOUR PLANT ON THE MAP

SOLVARME PARTNERS

PlanEnergi

SOLVARMEPRODUKTION

5 MW

Thank you for your attention

jen@planenergi.dk

www.planenergi.dk