SWEDISH WORK ON LARGE SOLAR THERMAL SYSTEMS OVERVIEW AND POSSIBLE CONTRIBUTION TO IEA 45

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Swedish participants for IEA 45 work. Chalmers, SP ….

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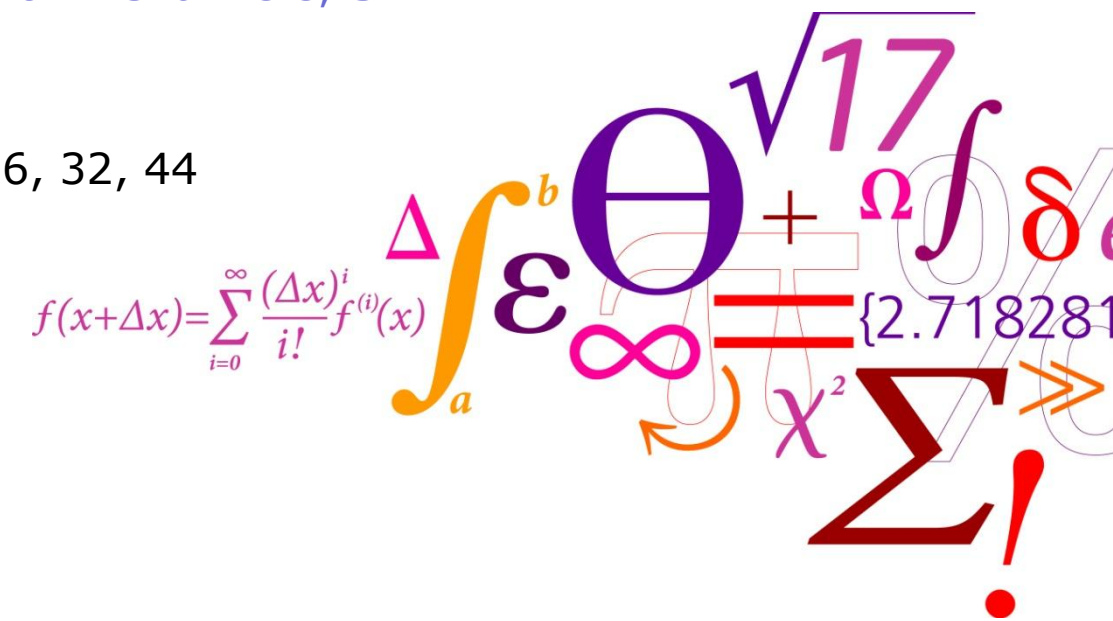

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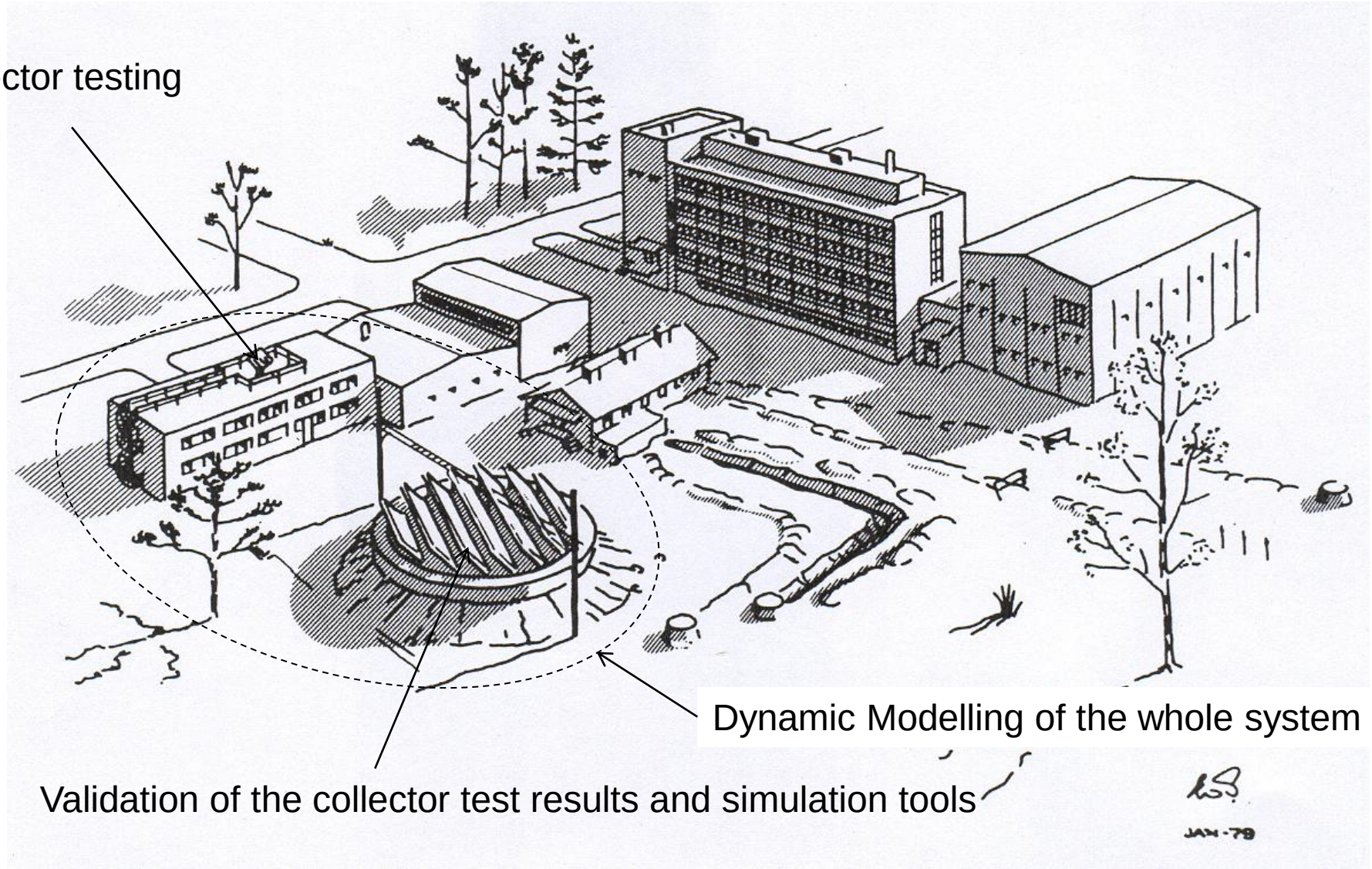
1977- 1979 Low Energy Office with Solar Seasonal Storage System



Swedish Experiences - Large Solar Systems

- Lambohov
- Växjö
- Lyckebo

Seasonal storage

- Falkenberg
- Nykvarn
- Kungälv

Large Collector fields

- Södertörn test field for collector arrays
- Knivsta ETC collector array testing

Collector array testing

- Development of large area flat plate collectors including reflectors inbetween rows. Chalmers - Vattenfall - Continued to cost optimized products in Denmark.

- Medium sized system demonstation plants and detailed evaluation.

- New medium sized systems connected to local substations.

Previous Swedish IEA participation concerning collectors and collector arrays and systems.

- IEA Task VII MINSUN simulation and optimisation programme. Seasonal storage system demonstration and evaluation.
- IEA Task VI ETC collector system monitoring, modelling and and evaluation. Input output evaluation method. Minsun improved
- IEA Task III Collector modelling and testing
- IEA task 14 Dynamic modelling and testing of collectors
- IEA task 26 TRNSYS type 132 collector model
- IEA Task 32 TRNSYS type 832 -”-
- IEA Task 44 TRNSYS type 136 unglased collectors below dewpoint

- Collector array part of MINSUN (UMSORT) still alive as detailed simulation benchmark tool.

The Quasi Dynamic Collector (QDT) equation in the EN 12975-2 standard. *Power output*

Power output

Optical - Solar radiation terms

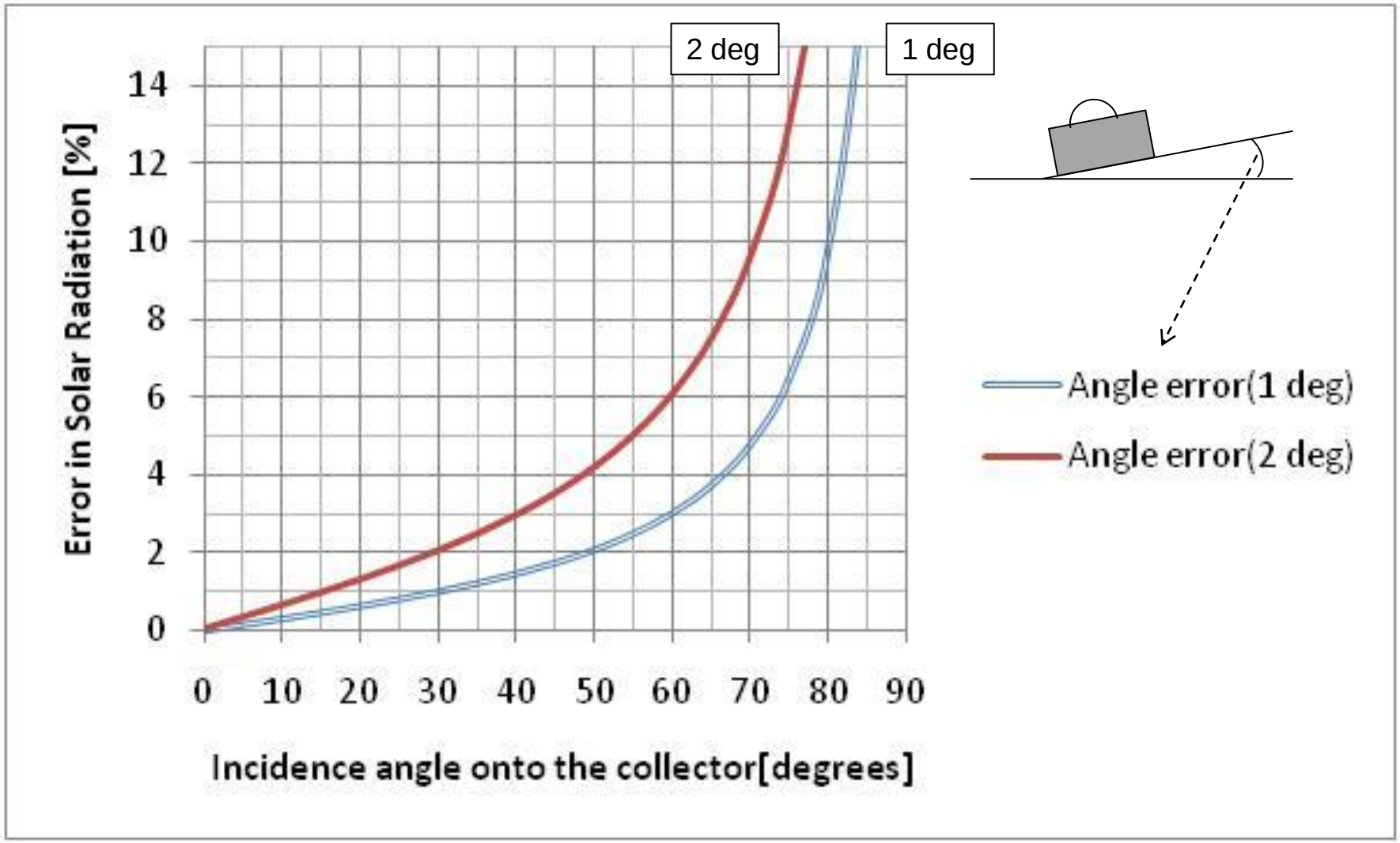
$$Q_t/A_a = F'(\tau\alpha)_{en} K_{qb}(\theta_L,\theta_T)G_{bT} + F'(\tau\alpha)_{en} K_{qd}G_{dT} - c_6\, w_{coll}\, G_T -$$

$$- c_1 (t_m - t_a) - c_2 (t_m - t_a)^2 - c_3\, w_{coll} (t_m - t_a) + c_4 (E_L - \sigma T_a^4) - c_5\, dt_m/dt$$

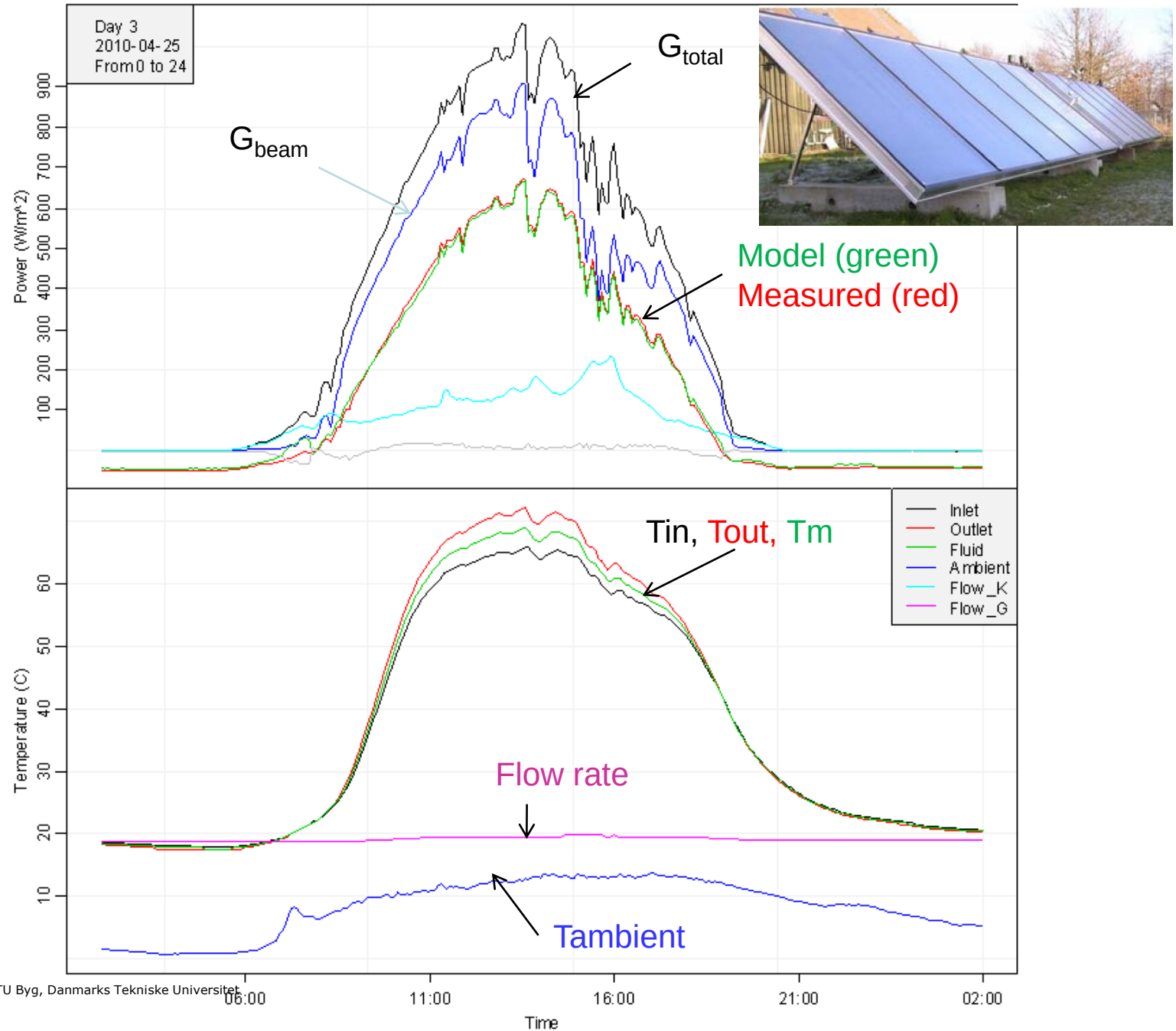
Heat loss terms

- ***Variables in the equation***:
- G_{bT} = beam solar radiation in the collector plane [W/m2]
- G_{dT} = diffuse solar radiation in the collector plane [W/m2]
- G_T = total (beam + diffuse) solar radiation in the collector plane [W/m2]
- θ_L, θ_T = Biaxial incidence angles for beam radiation onto the collector plane in longitudinal and transversal direction from the normal. Index L is usually defined along ETC tubes/reflectors and T is perpendicular to the tubes/reflectors. Index L and T are replaced by EW and NS on the input page in the tool to make sure how the collector is turned on the tilted plane. Different options are possible for some ETC and also low concentrating collectors.
- w_{coll} = wind speed in the collector plane [m/s]
- $t_m = (t_{in} + t_{out})* 0.5$ mean fluid temperature between inlet and outlet of the collector [°C]
- E_L = long wave or thermal radiation (incident from sky + ambient) in the collector plane [W/m2]
- T_a = ambient temperature close to the collector (in the shade) [K]
  (Kelvin is specified only to have correct thermal radiation calculations results)
- t_a = ambient temperature close to the collector (in the shade) [C]
- t = time during measurements and simulation. [s]

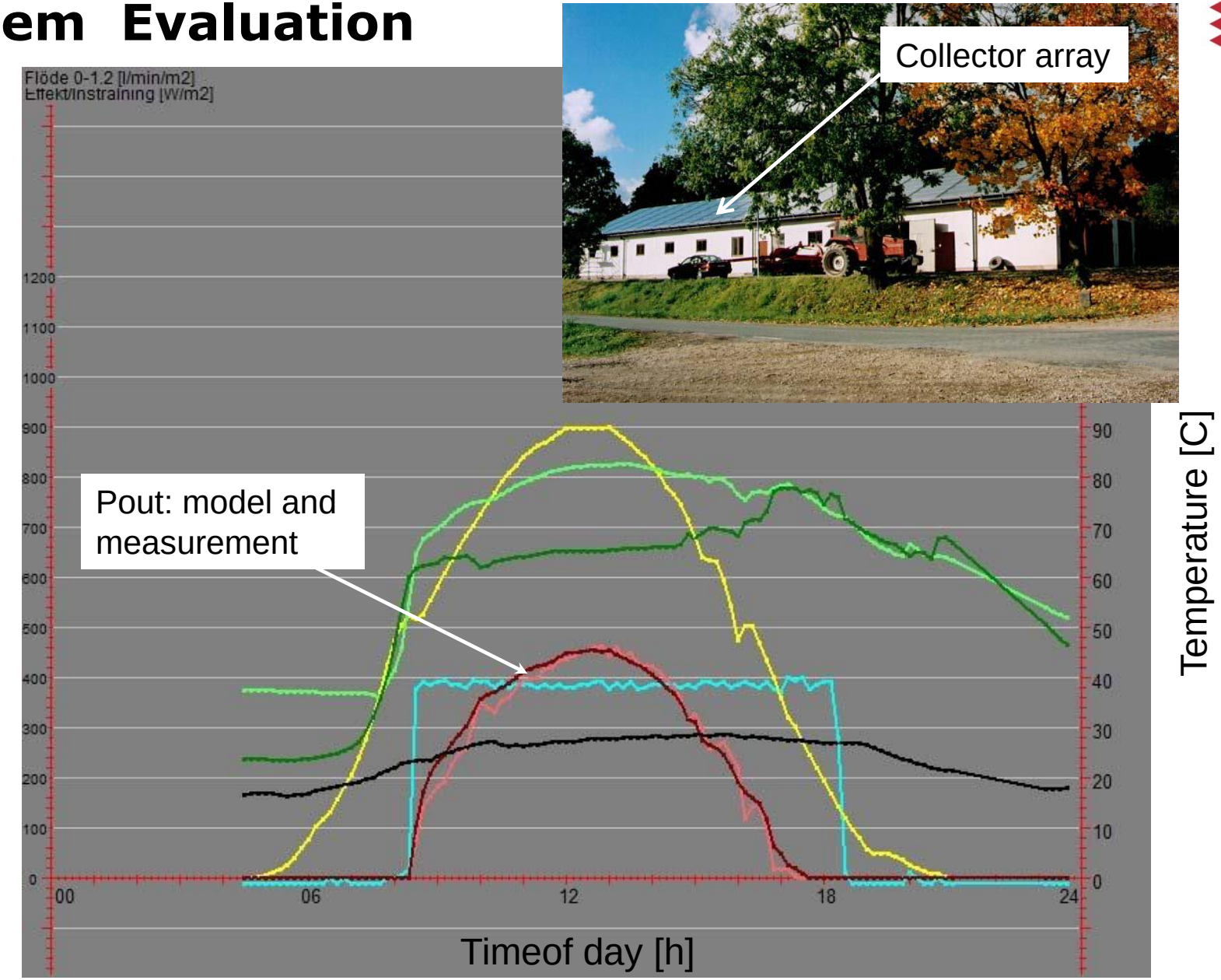
Solar sensor mounting angle - error (Should be parallel to the collector plane)



Collector Test Data from DTU. EN 12975 QDT Dynamic Model Check



Model and parameters can be used also for System Evaluation

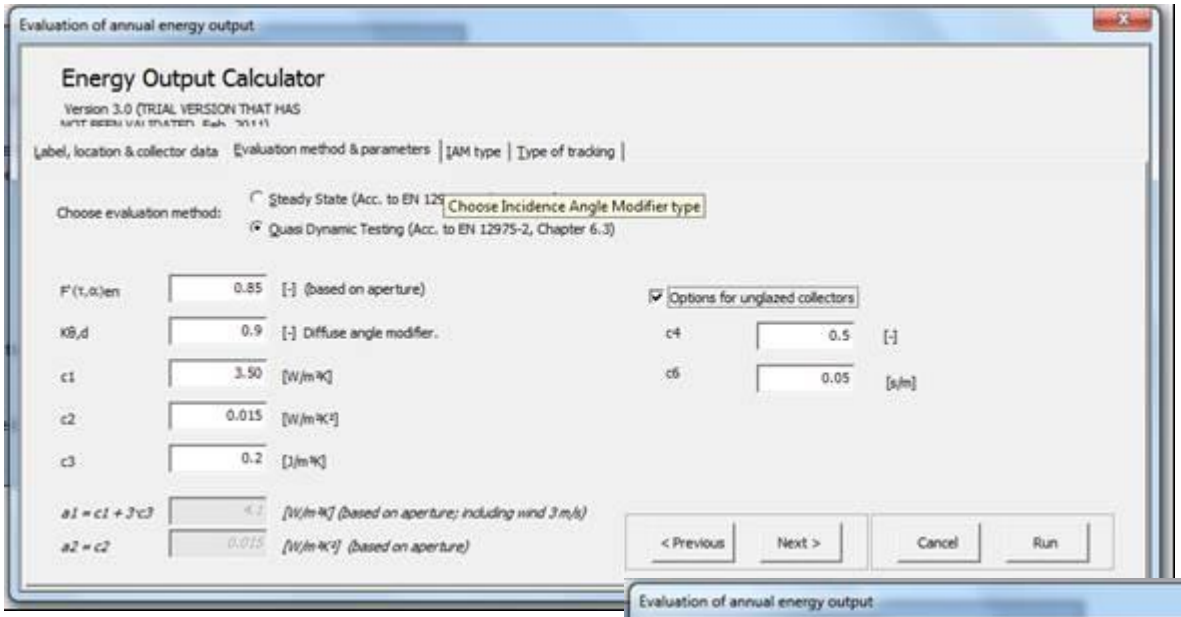


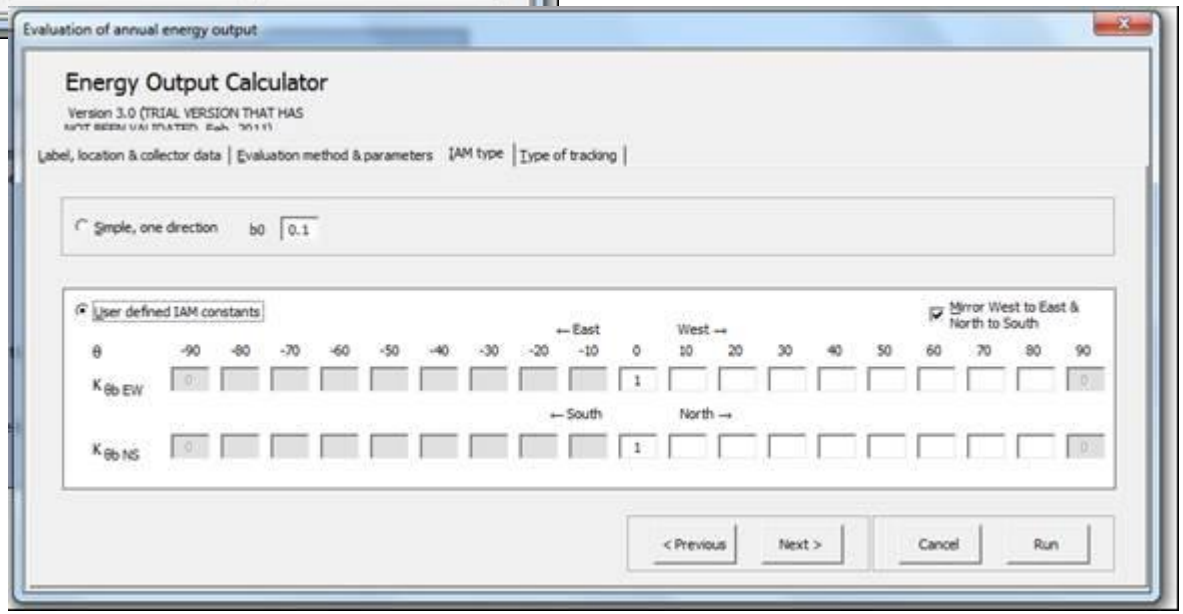
Quality assurance of collector array performance

The same Model and Parameters are used in all steps:

- In Research/Development testing
- In Product Testing - EN12975 EN/ISO world standard?
- In Standardised Annual Performance Calculation Tool
- Simulation for prestudies and in teaching (Winsun)
- System design/sizing (TRNSYS Type 832)
- System check and evaluation
- Built into the controller if advanced ones.
- Follow up after some years.
- On line simulation in a system. (applied from 1979..)

Standardized Energy Output Calculation Tool for Collectors. Solar Keymark and EN 12975



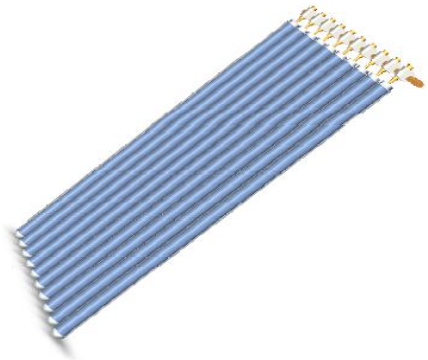


Extreme Collector designs covered by the model and calculation tool:

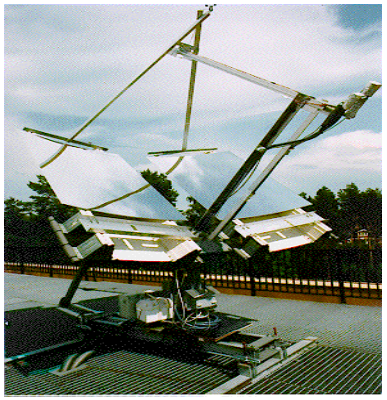
Unglazed Collectors

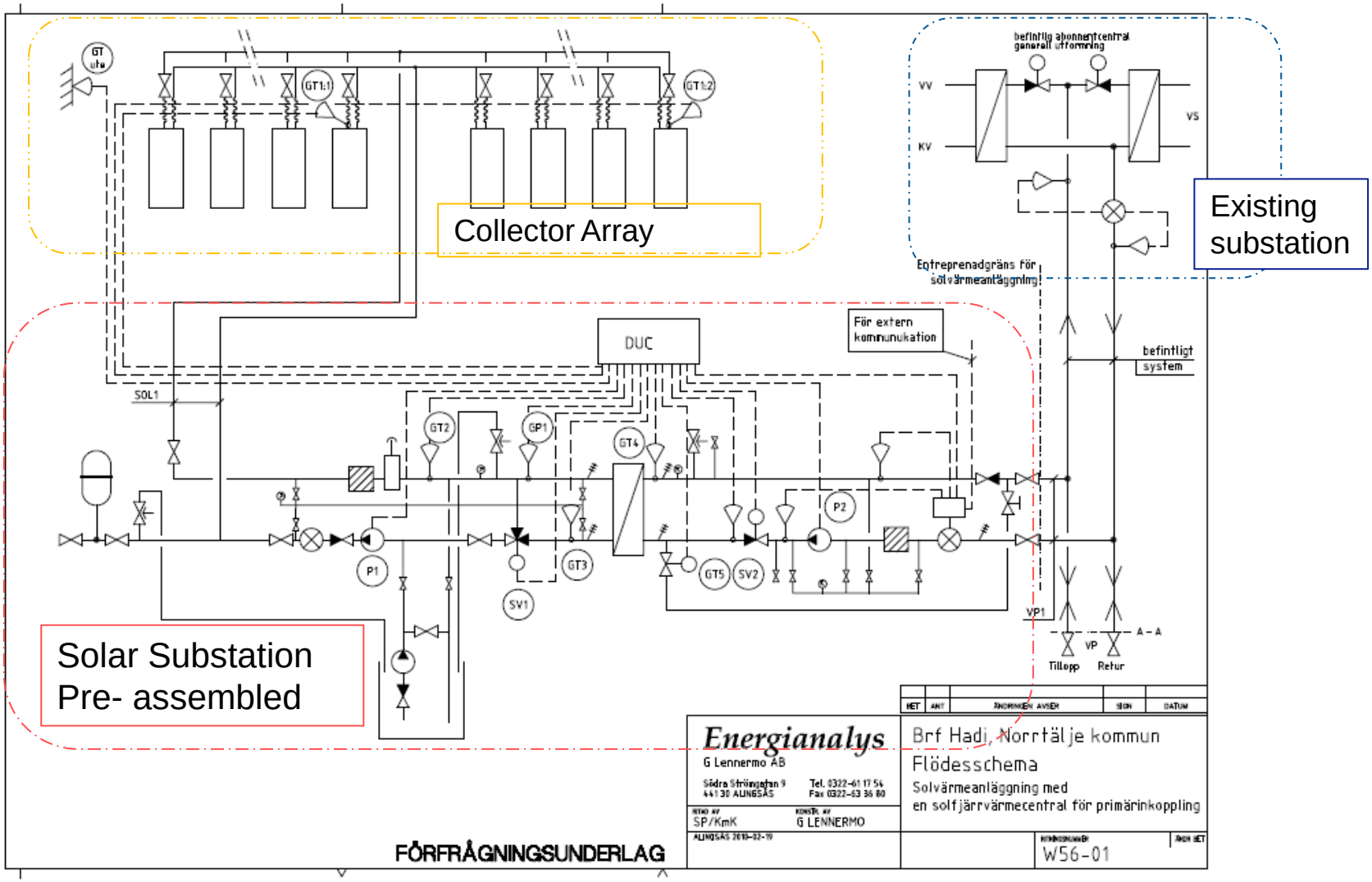
Double asymmetric CPC collectors

Vacuum tube collectors with round absorbers



Concentrating collectors



PVT- and Air collectors will come….

Planned IEA 45 Work: Evaluation and improvement of new medium sized collector arrays, connected to local district heating substations.