SOLAR PAYBACK - TRAIN-THE-TRAINER
SOLAR HEAT FOR INDUSTRIAL PROCESSES

System Simulation

Fanny Hübner, M.Sc.

Pedro Horta, Ph.D.

Fraunhofer Institute for Solar Energy Systems ISE

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Experimental vs. Computational Simulation

- Simulation is a procedure to analyse a certain system or process
- Derived from latin “simulatio” and means ”appearance”, “deception“
- Experimental simulation (physical model)
  - Example: Car crash test
- Computational simulation (mathematical model)
  - Most common meaning
  - Virtual simulation model decribes real process

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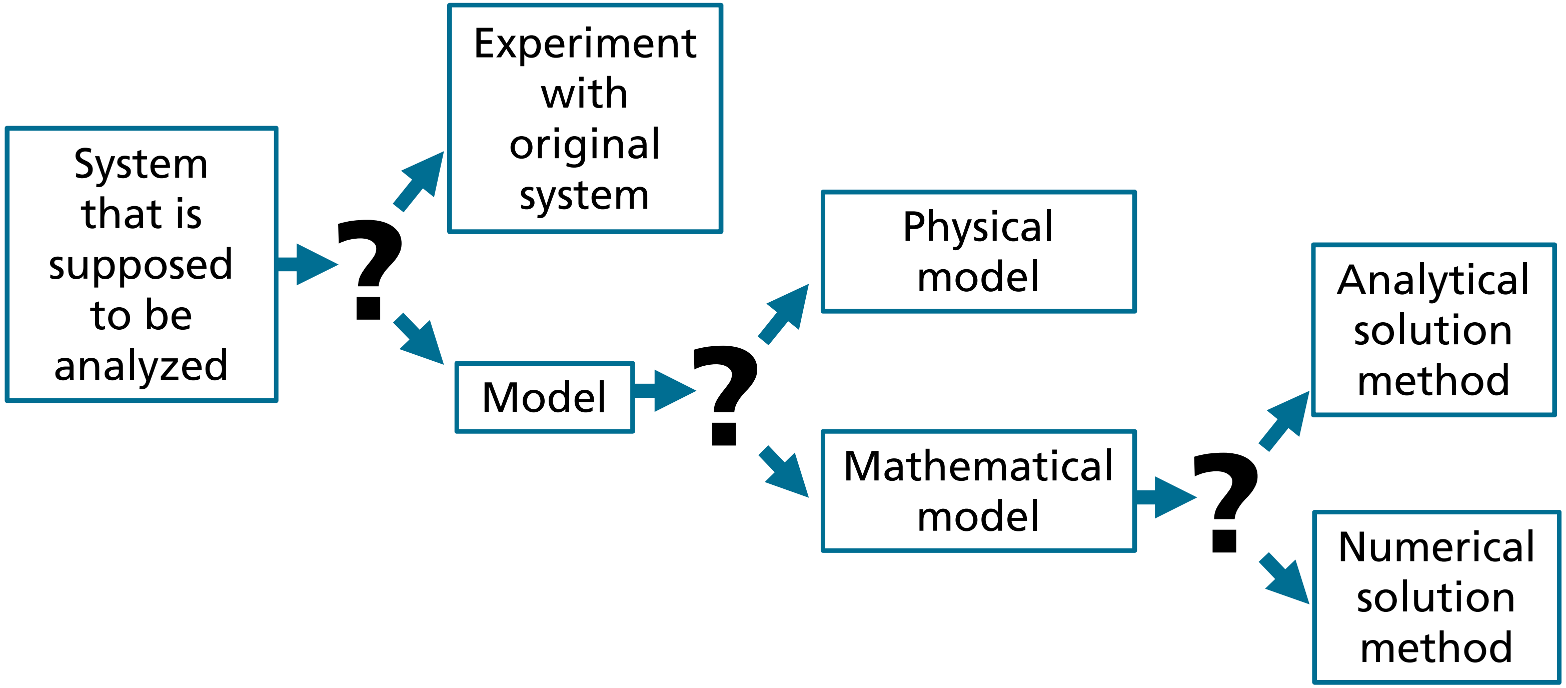
Decision Process



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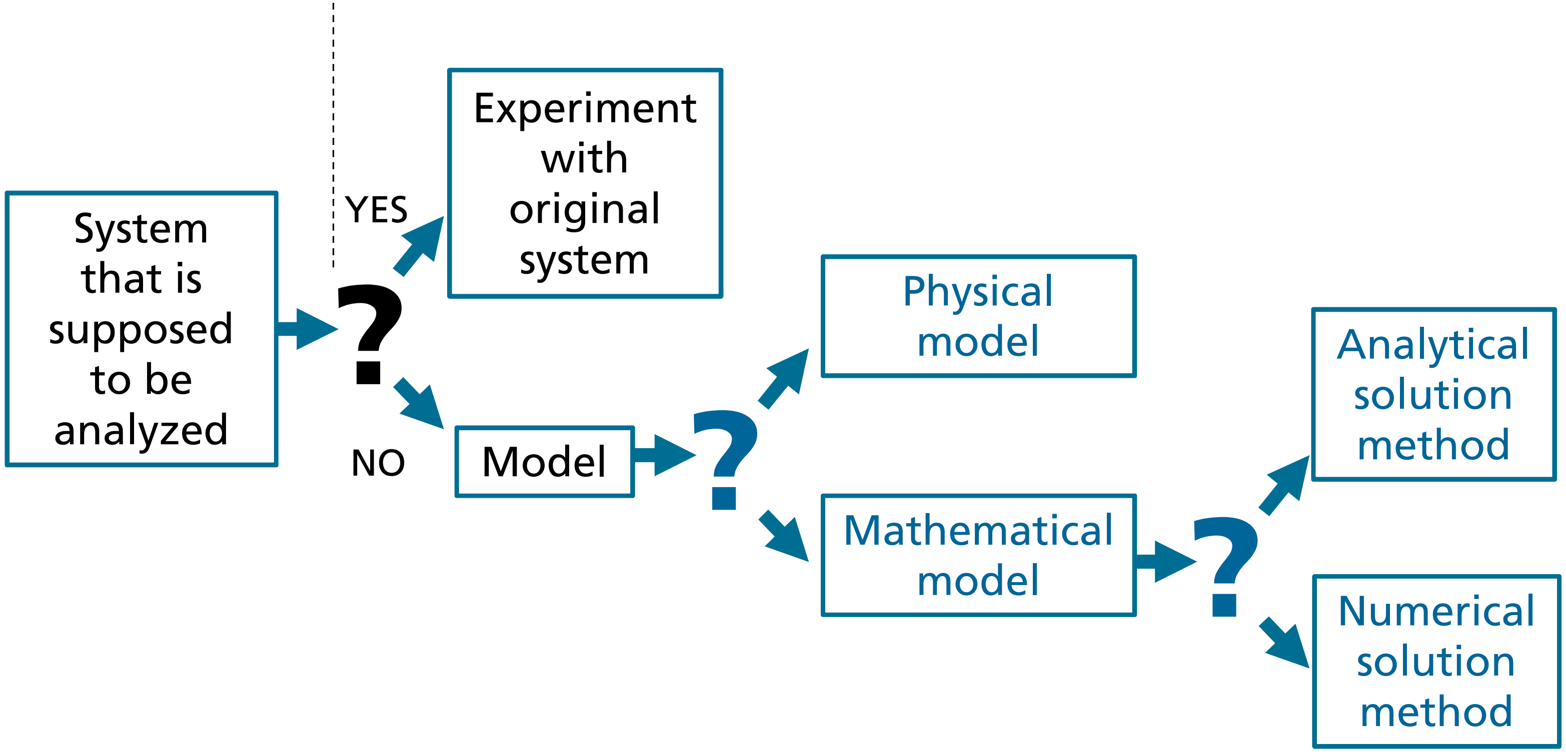
Decision Process

Is it possible, economically feasable and safe to do experiments at the real system?



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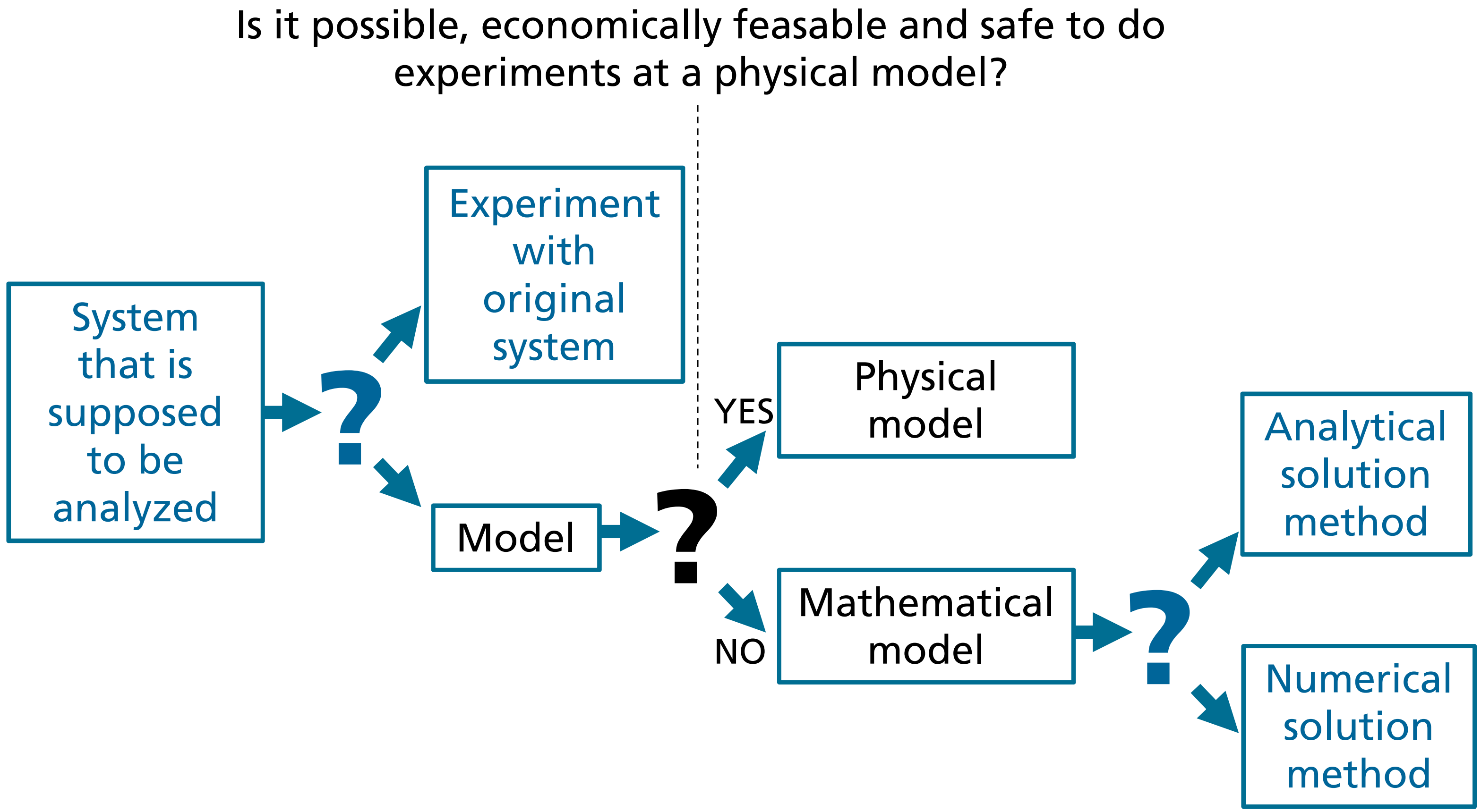
Decision Process



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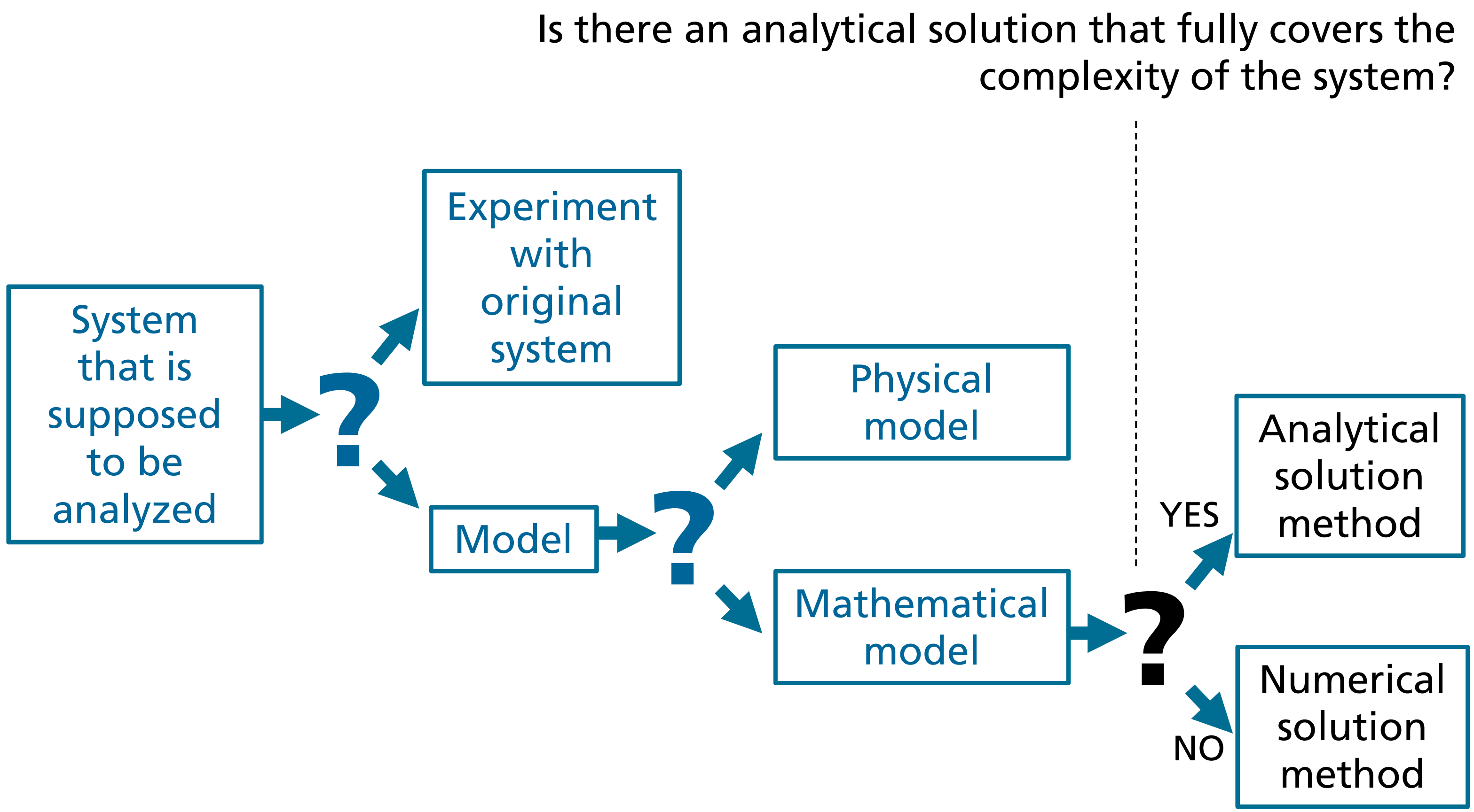
Decision Process



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Relevance for Solar Technologies

- Thermal yield is very site specific
  - Irradiation throughout the year
  - Solar angles (seasons)
  - Site assessment

- Increased control complexity
  - Back-up heater, storage …
  - Increased optimization potential
  - More complex design

- Lower experience level

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Goals of system simulation

- System design
  - Calculate system behavior before it is built
  - Build an optimized system from the beginning
- Test operating strategy
  - The effects of a change of operation strategy can sometimes hardly be foreseen
- Obtain more information about system
  - Example: Direct steam generation (steam quality)
  - Optimize system control

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Reasons for simulation

- Evaluation of system is possible before it is built

- Investigations of the real system or a small scale physical modell are
  - not possible
  - too time consuming
  - too dangerous
  - too expensive

- Increase knowlege about system

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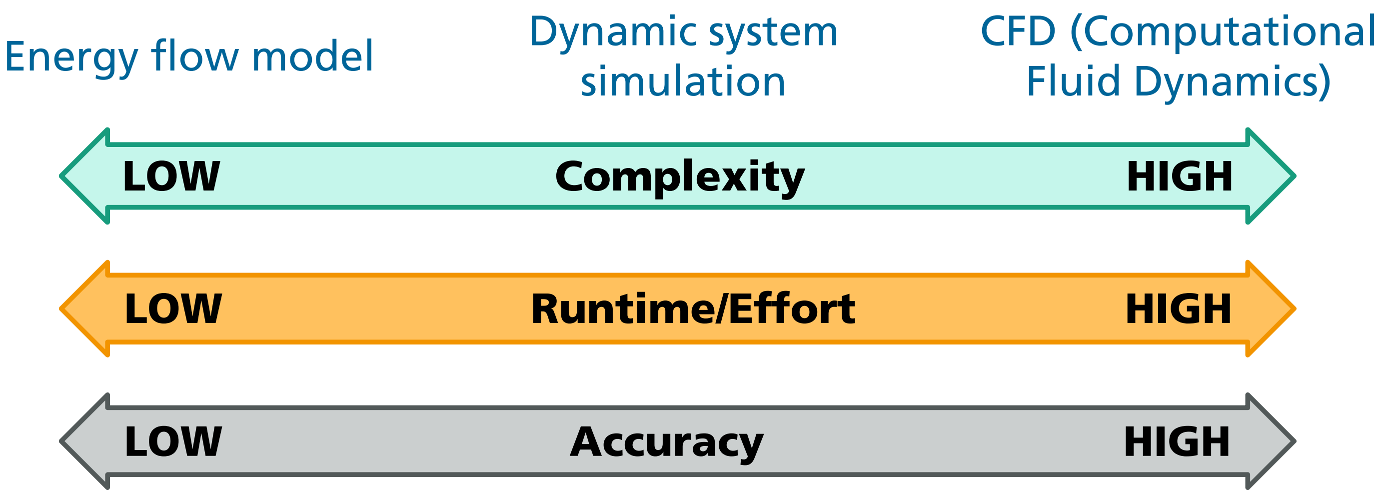
System Simulation
Level of Detail

- Simulations means simplication , but how simple?
  - ➢ **As simple as possible, as detailled as necessary!**

- Three main types of simulation



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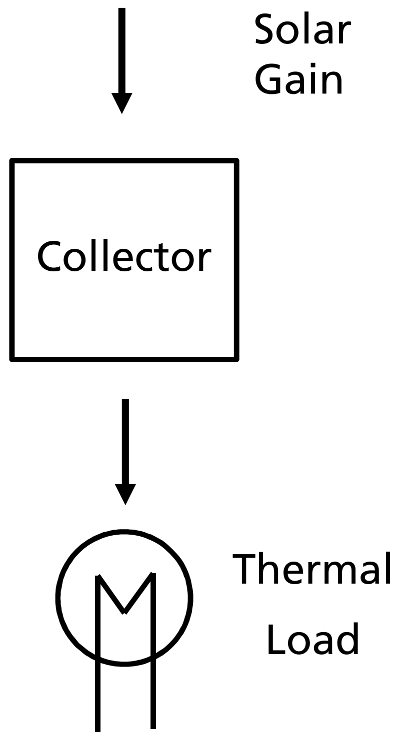
System Simulation
Energy Flow Simulation

- Solar gain is added to energy at input to calculate output
  - Tempertures/mass flows unknown
- Transient behaviour of system is neglected

➢ Fast and simple simulations with low level of detail



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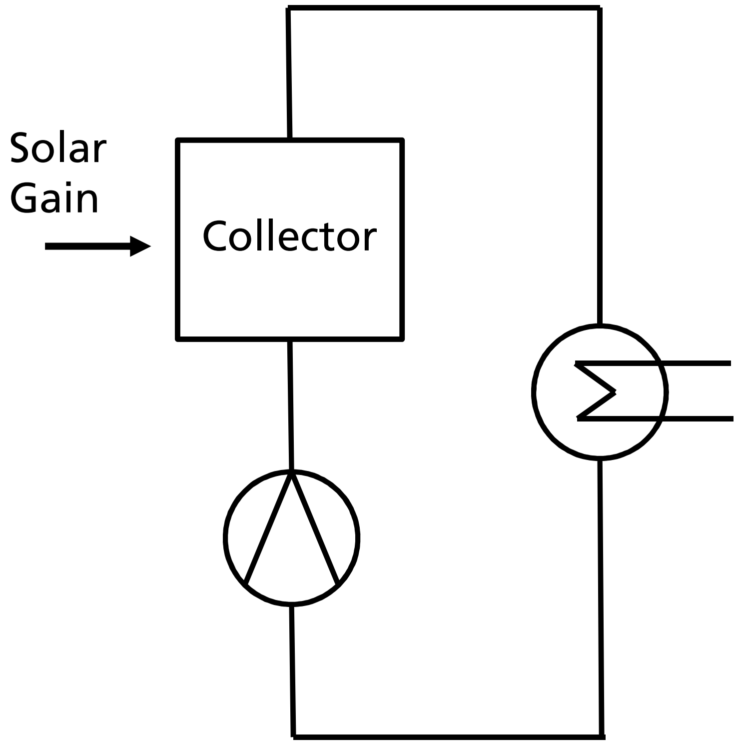
System Simulation
Dynamic System Simulation

- Solar gain is added to energy at input to calculate output
  - Tempertures/mass flows known

- Transience of the system is considered
  - Thermal capacity of fluid within pipes and pipe walls
  - Control limitations

➢ Still quite simple simulations with medium level of detail



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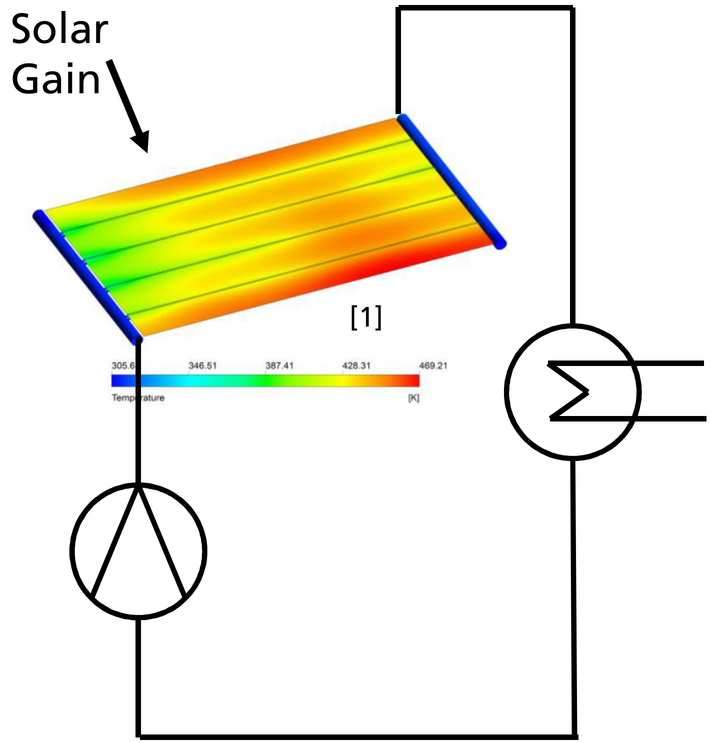
System Simulation
Computational Fluid Dynamics

- First CAD model of all components is created
- Model is devided up in a big number of elements
- For each element mass, energy and momentum equation is solved
- Fluid flow at each part of system is known
- ➢ Slow and complex simulations with very high level of detail



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[1] Ranjitha P., Somashekar V., Jamuna A.B., Numerical Analysis of Solar Flat Plate Collector for Circular Pipe Configuration by using CFD, International Journal of Engineering Research & Technology (IJERT), Vol. 2 Issue 12, 2013

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System Simulation
Typical Software

Best suitable for solar system design

Energy flow model | Dynamic system simulation | CFD (Computational Fluid Dynamics)

LOW ← Complexity → HIGH

Excel
EES Engineering Equation Solver

TRNSYS 18
T*SOL
ColSim Fraunhofer ISE
POLYSUN

ANSYS
STAR-CCM+
OpenFOAM

…or many other simulation and programming tools

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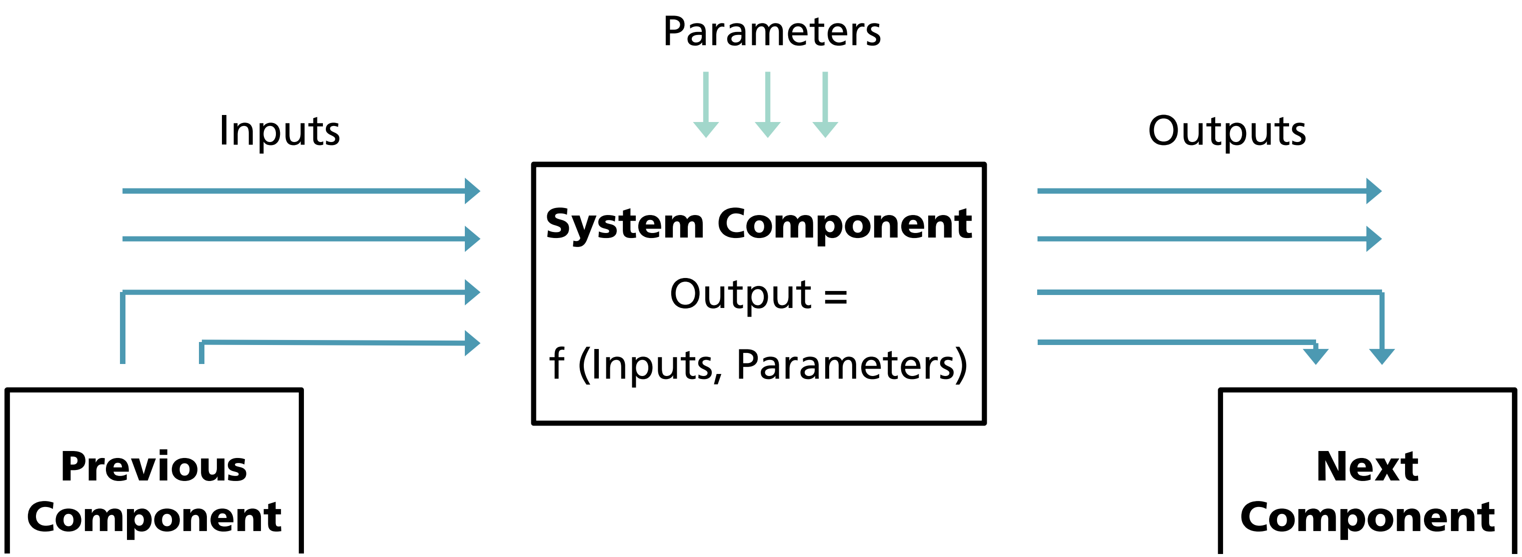
System Simulation
Inputs, Outputs and Parameters

Principle:



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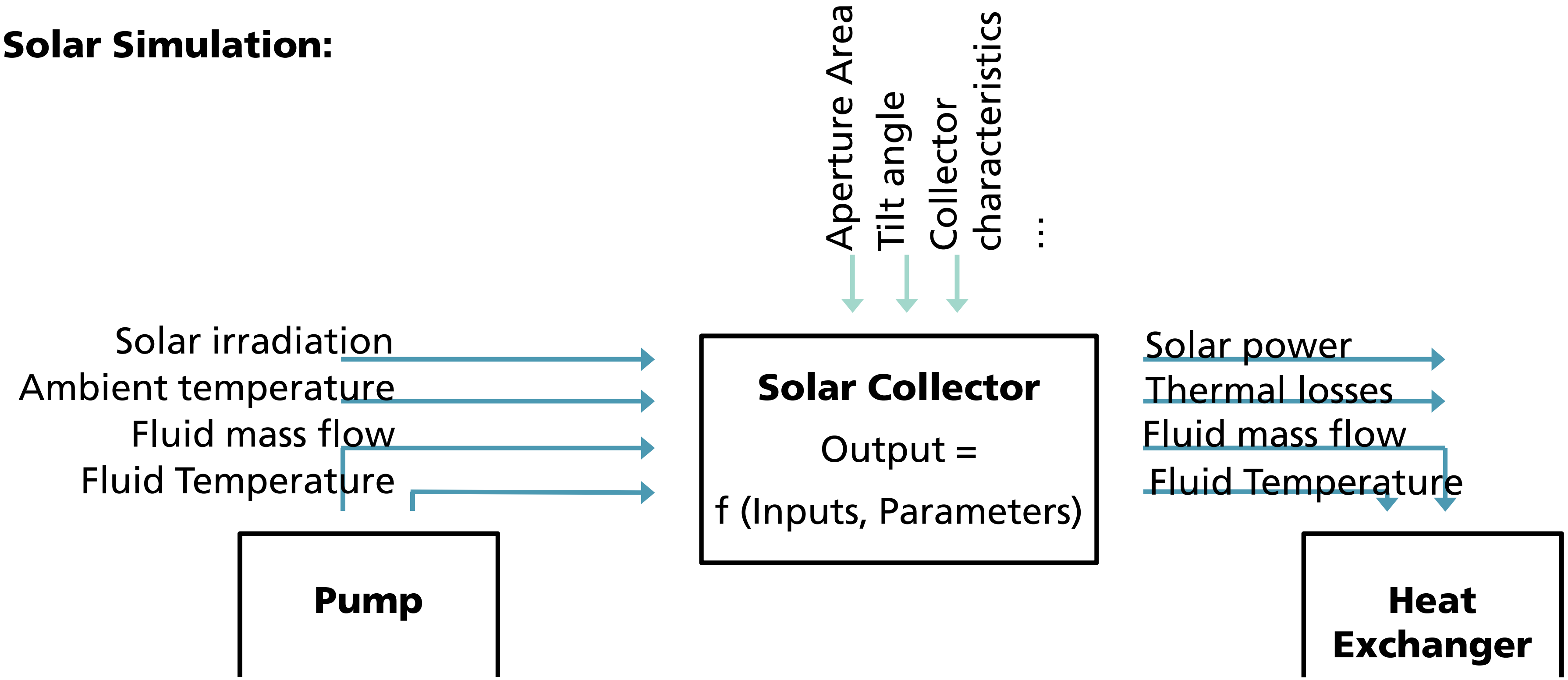
System Simulation

Inputs, Outputs and Parameters

Solar Simulation:



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System Simulation
Uncertainty of simulation results

- Uncertainty highly depends on
  - Simulation method
  - Complexity of system
  - Knowlege of system parameters
  - Accuracy of weather data

- Validation improves credibility
  - Comparison with measured data

- Possibilities to guarantee accuracy are limited!

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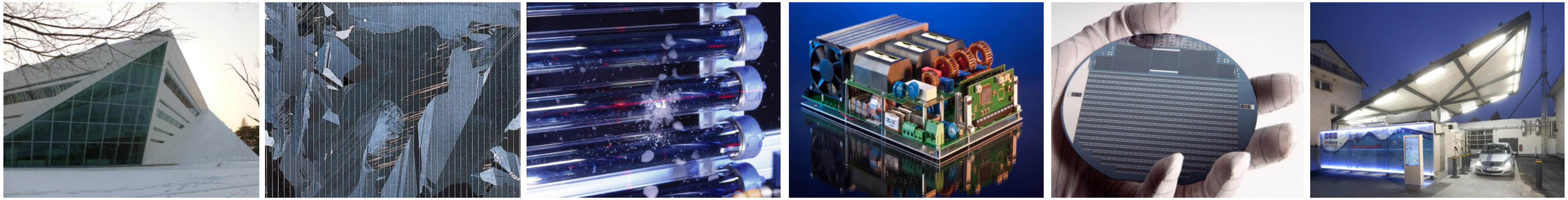
Thank you for your Attention!



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fanny.huebner@ise.fraunhofer.de

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