Method for evaluation of technology impact on subsea system lifetime costs and risks.

Sim@SL 2015

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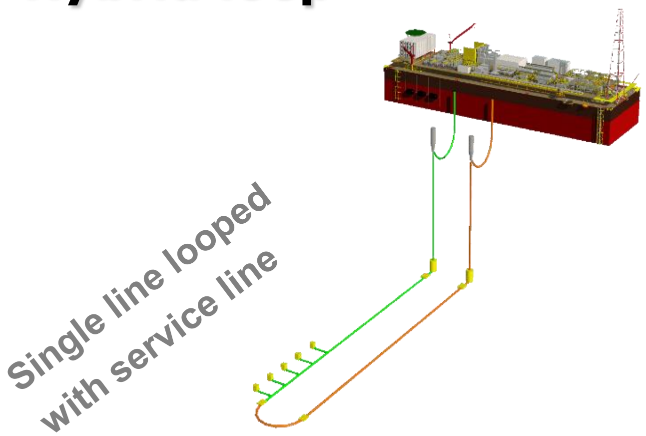
Example of Challenge: Subsea field architecture selection

Hybrid loop



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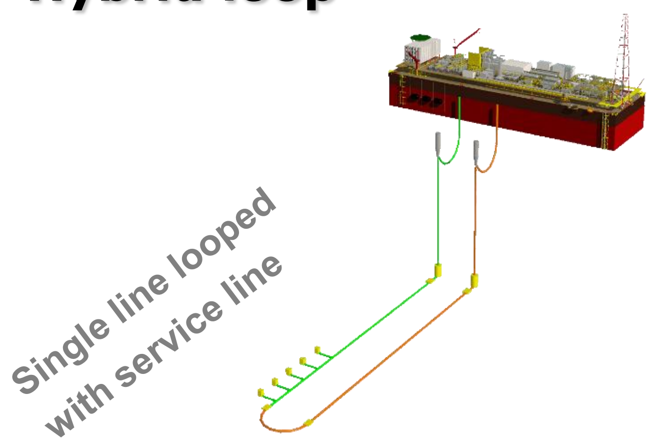
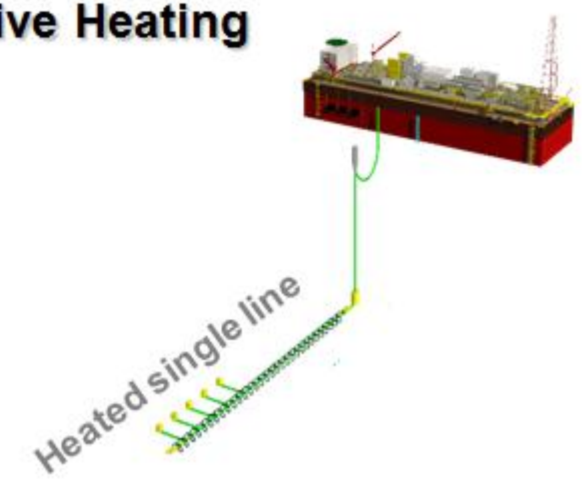


VS

Active Heating



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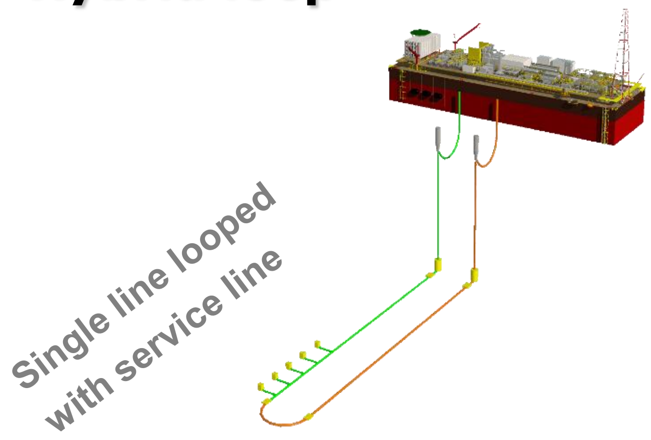

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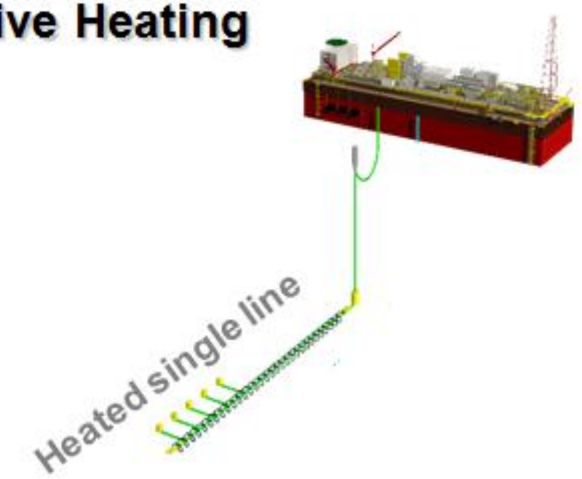

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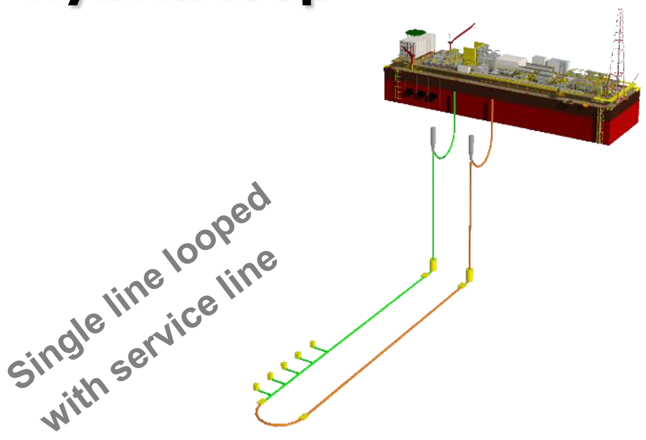

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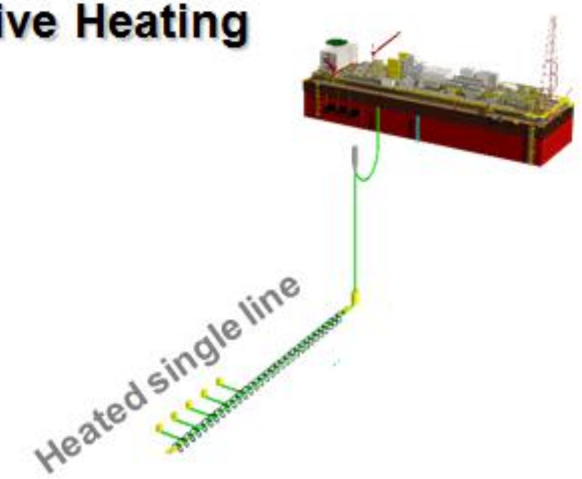

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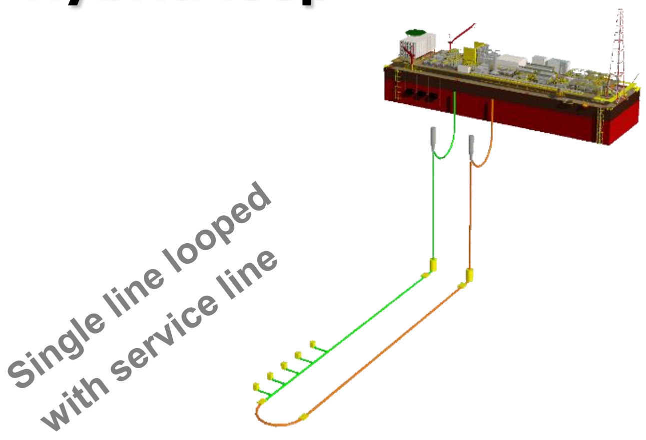

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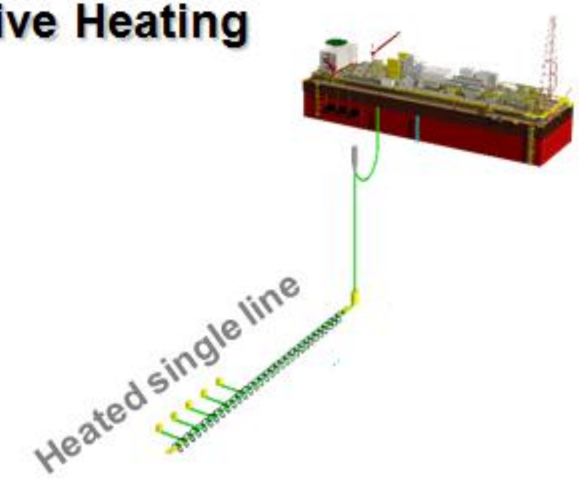

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- Proposal: Review engineering methodology…

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- But what kind of model?
  - We must be able to **exchange** our models and make them work together!

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- How does it work in a system prospective?

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- Citing Prof. Box:
  - "The most that can be expected from any model is that it can supply a useful approximation to reality: **All models are wrong; some models are useful**"

Photo: http://en.wikipedia.org/wiki/George_E._P._Box

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- With other words: It becomes possible to assess **“Resilience of design”.**

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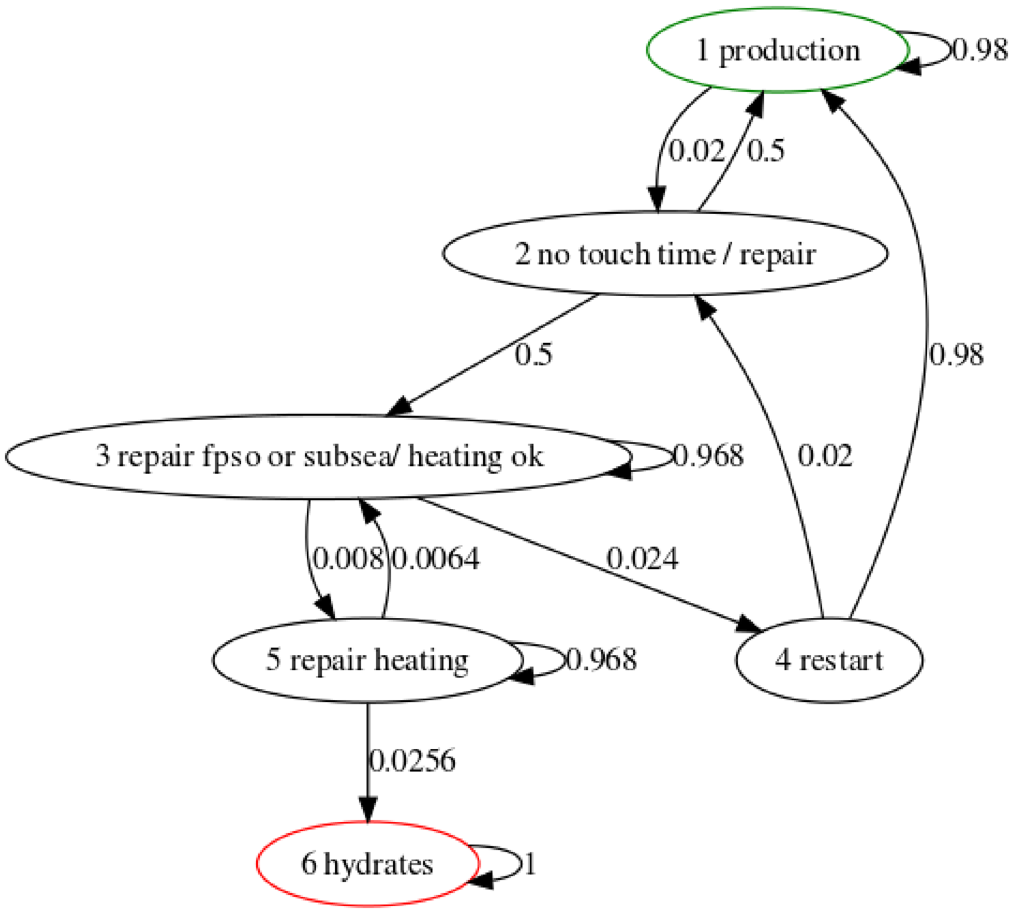
- How it is modelled currently
  - Markov-Chain Monte-Carlo simulation
  - A random process which transits from state to state
  - These event-stories are **"Scenarios"**



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- A suitable multi-physics tool: Modelica…

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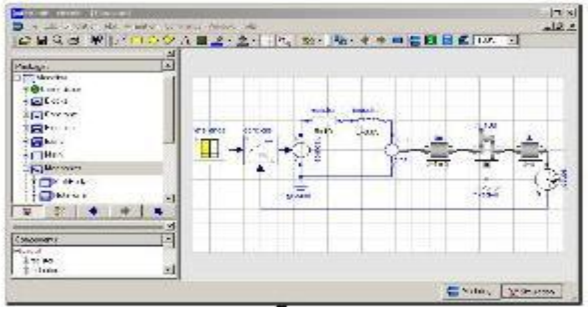
- Graphical editor mode – Build system selecting components and connecting them:



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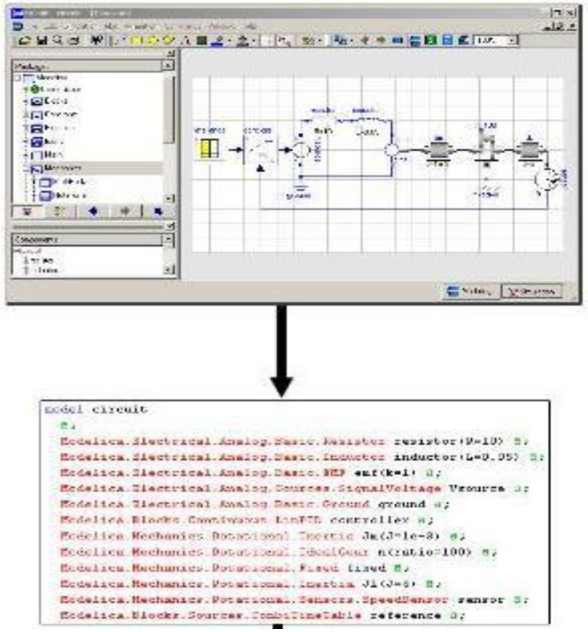

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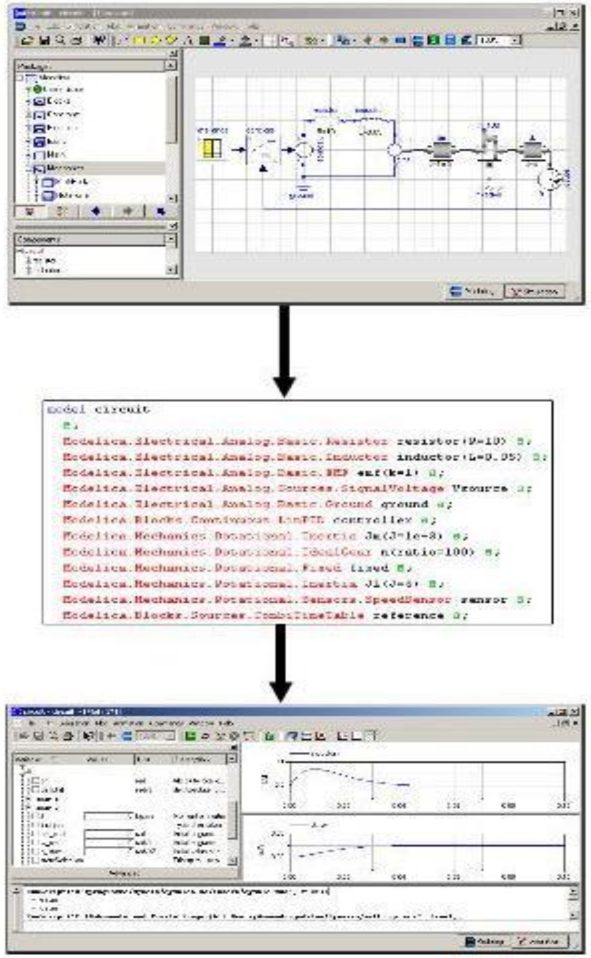
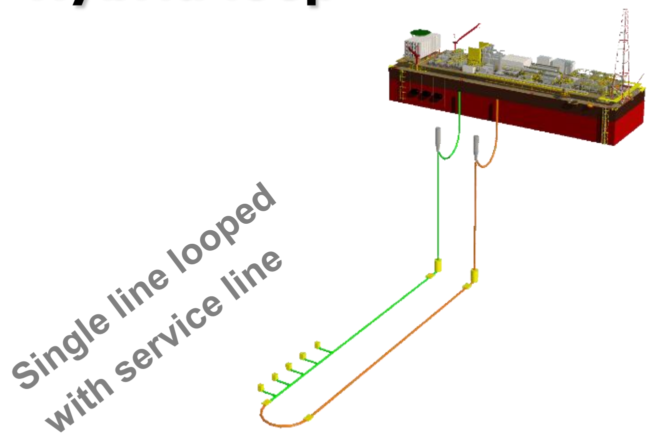
- Running the modelling system…
- Post processing of data, plots of variables, export of data to other tools…



Back to initial example: FPSO and 40 km tieback

Hybrid loop



VS

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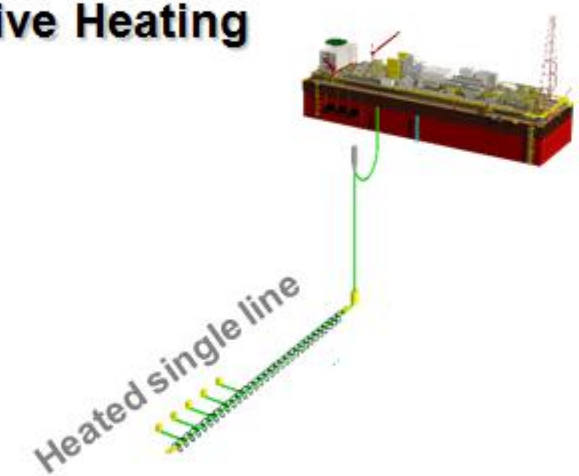

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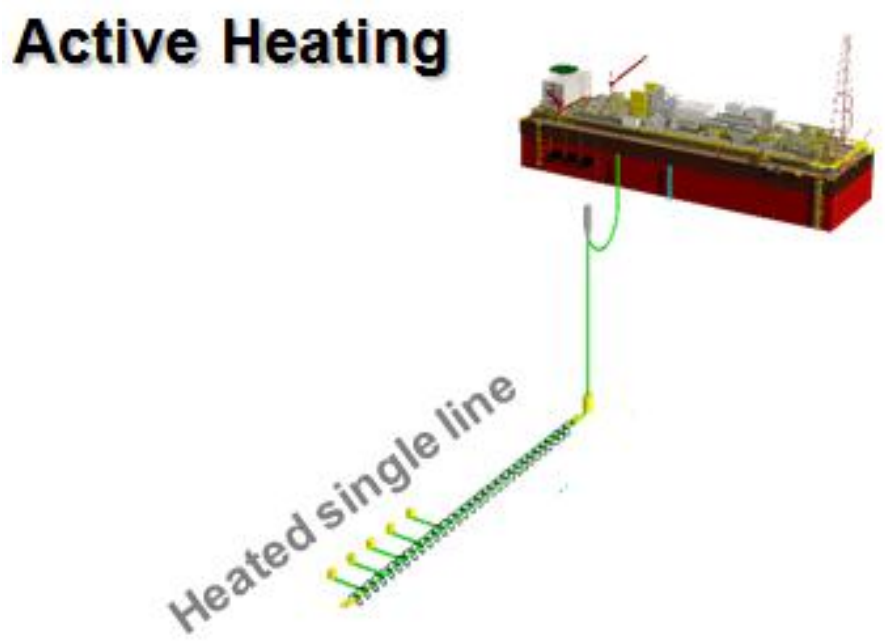

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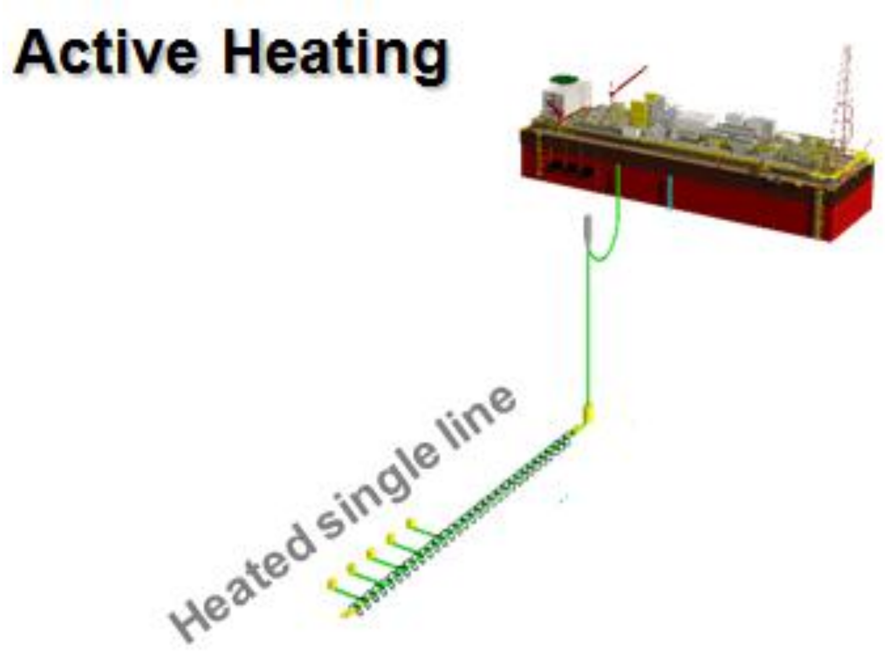

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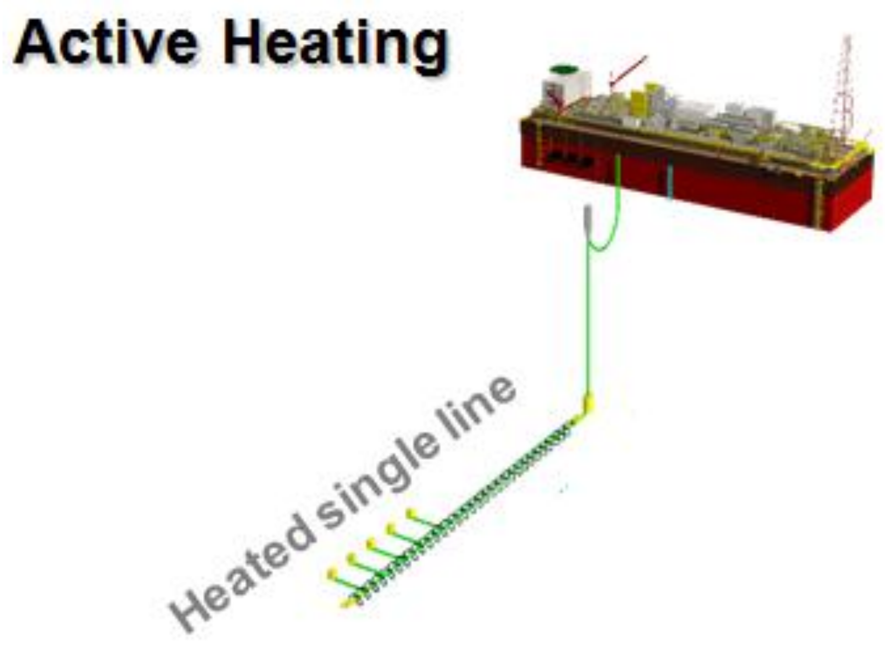
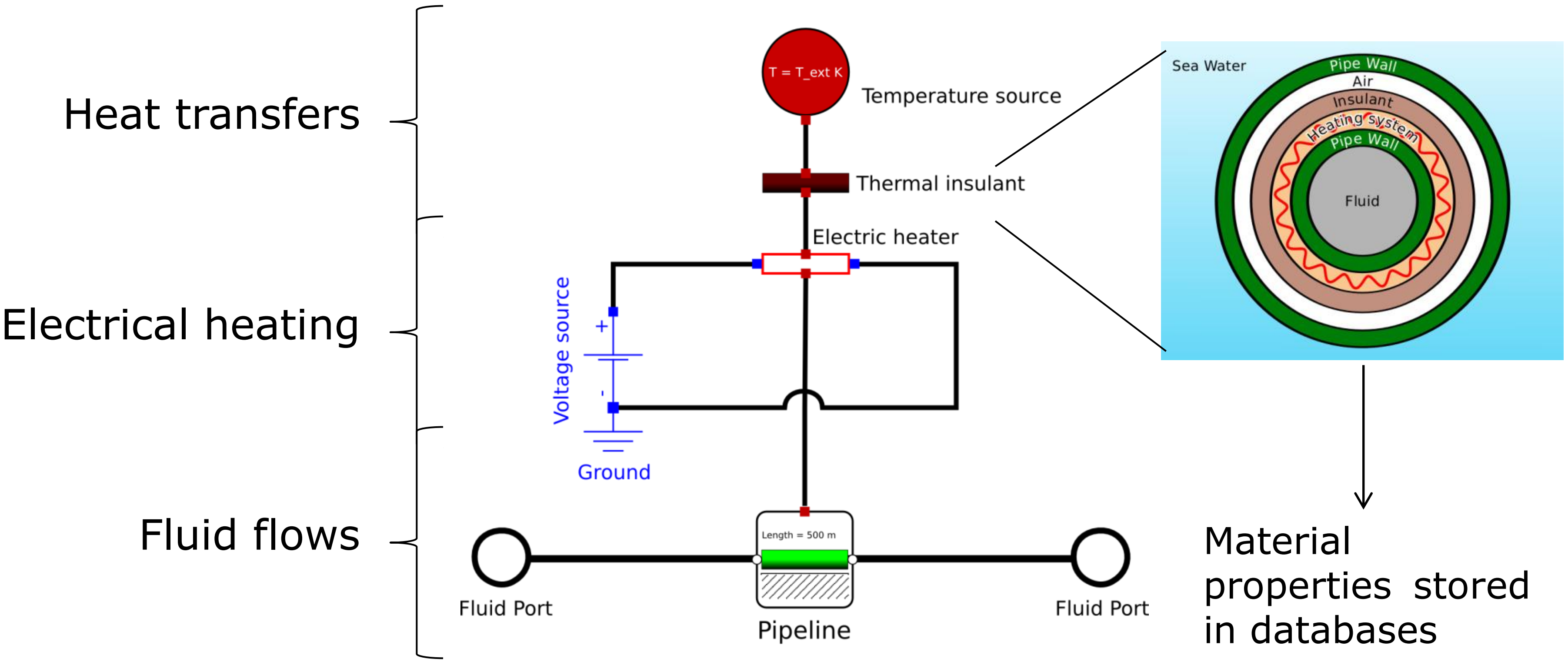


Some components are made of several components, eg. Heated pipe model



The heated pipe is **multi-physics system built in a multi-level approach**

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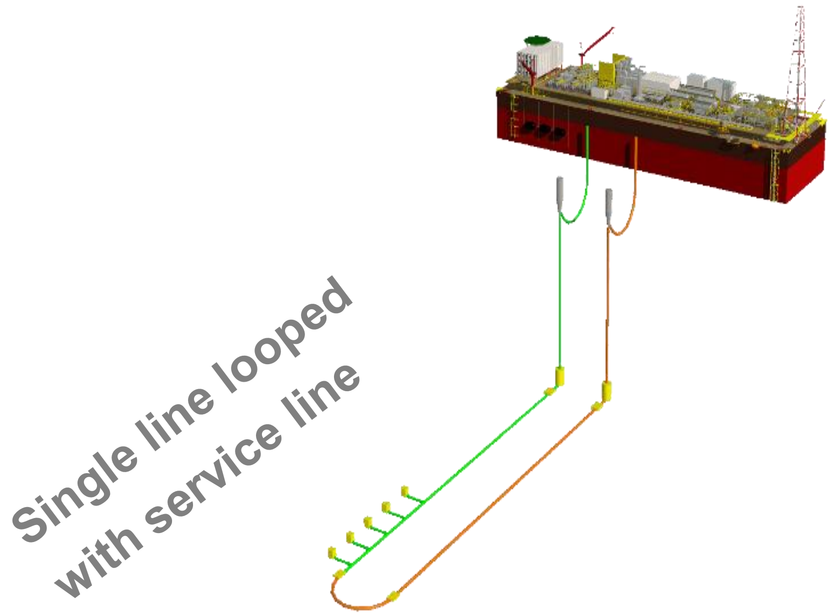

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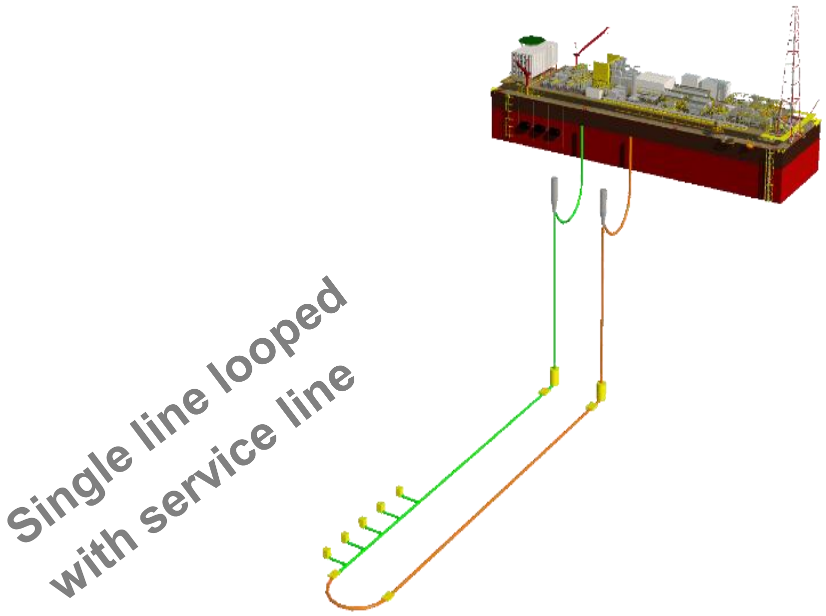

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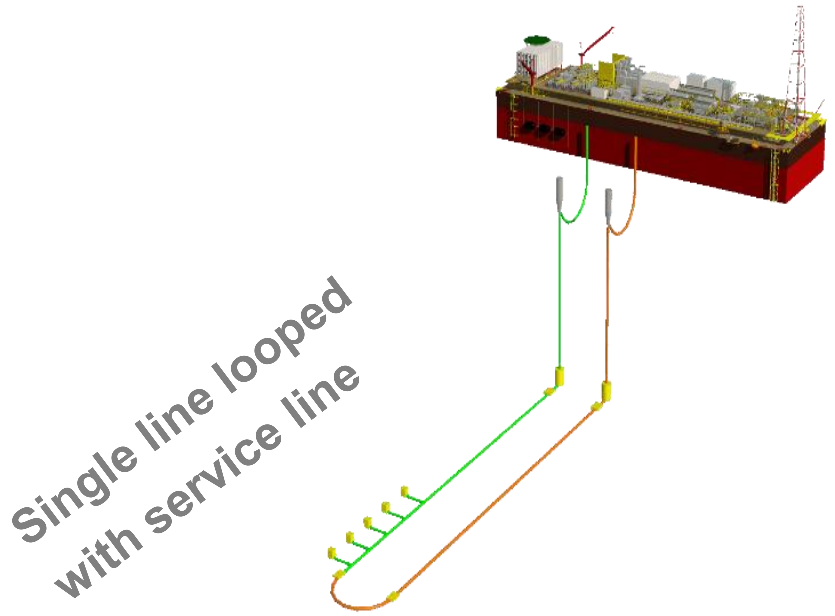
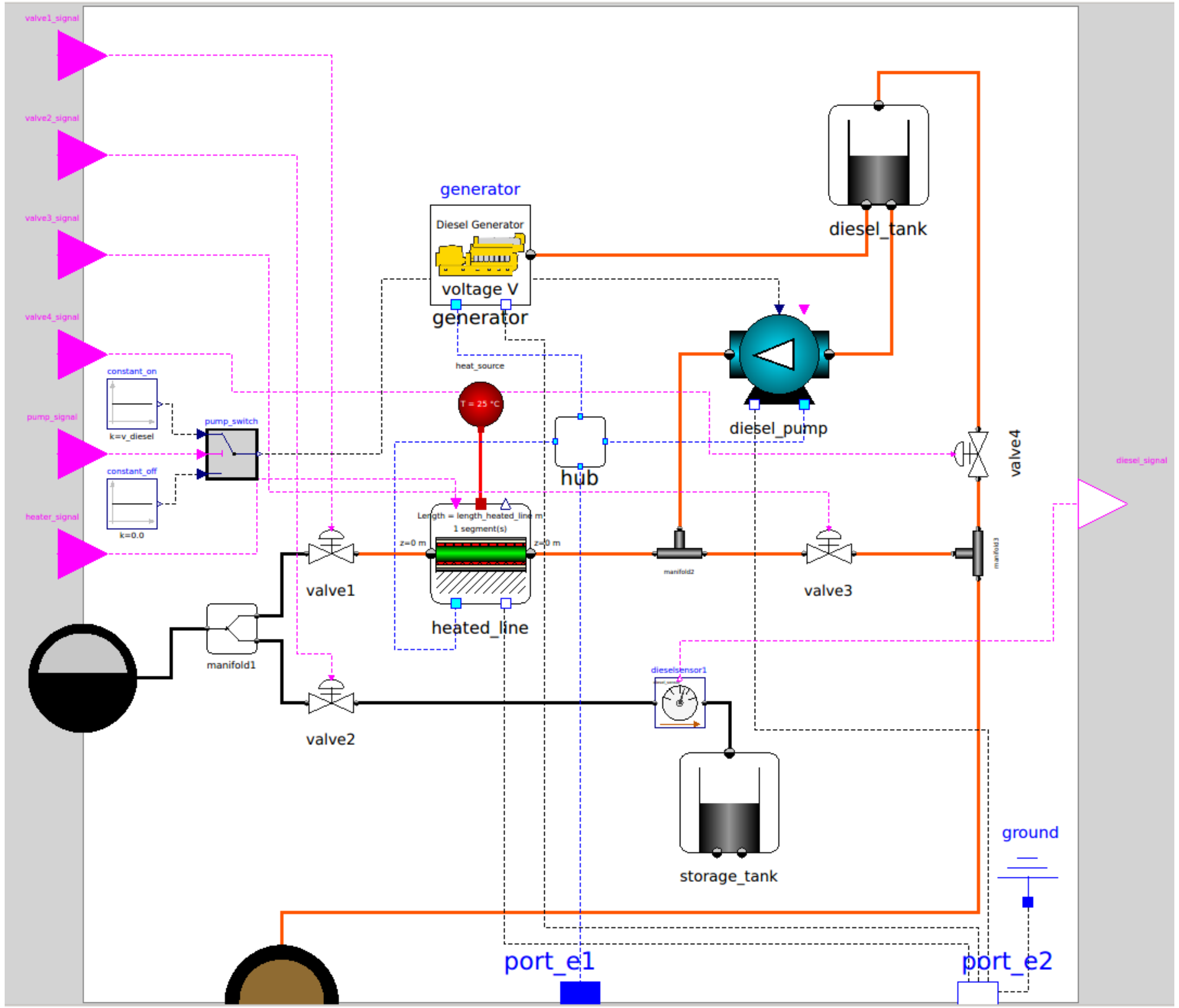


Hybrid line – System-of-Systems

The FPSO model is an example of system-of-systems:

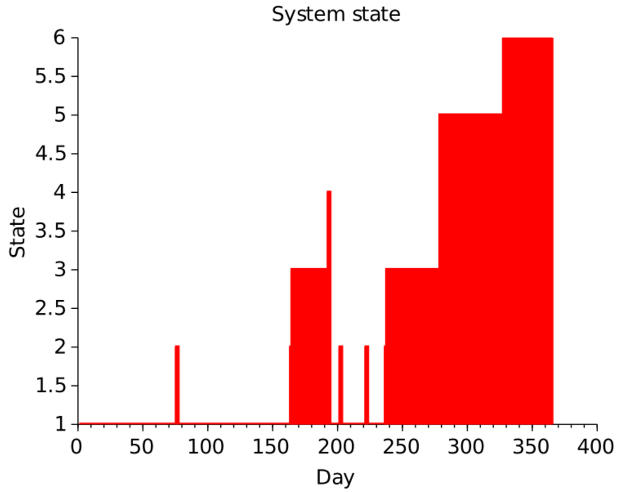
- Various components are involved

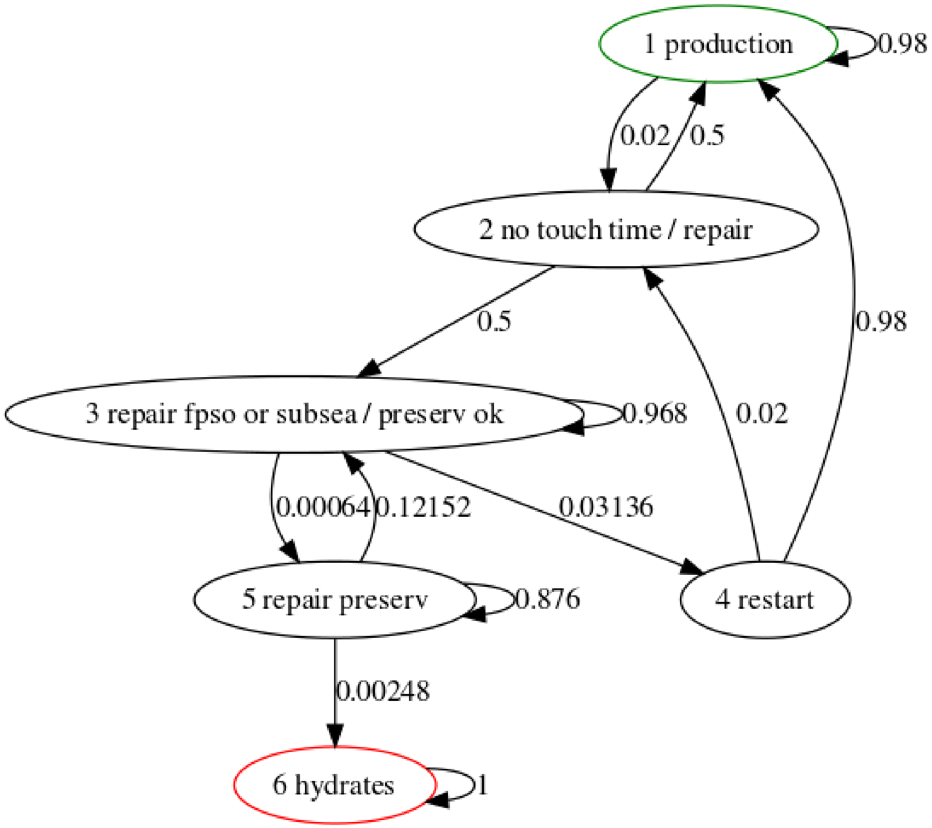
- Many physical phenomena are simulated



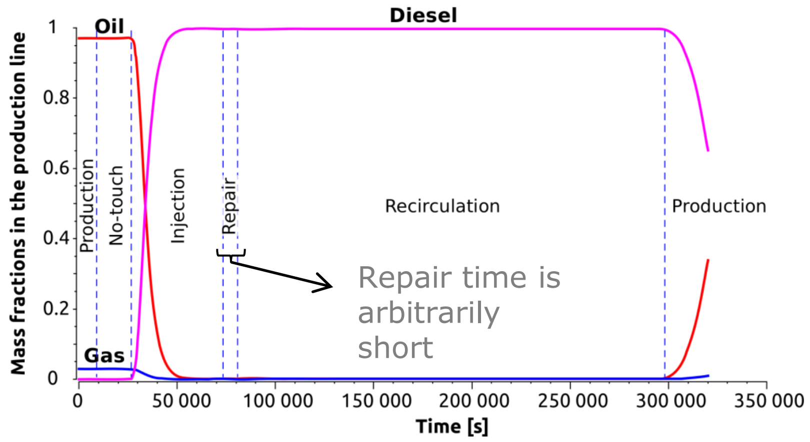
Hybrid loop state simulation

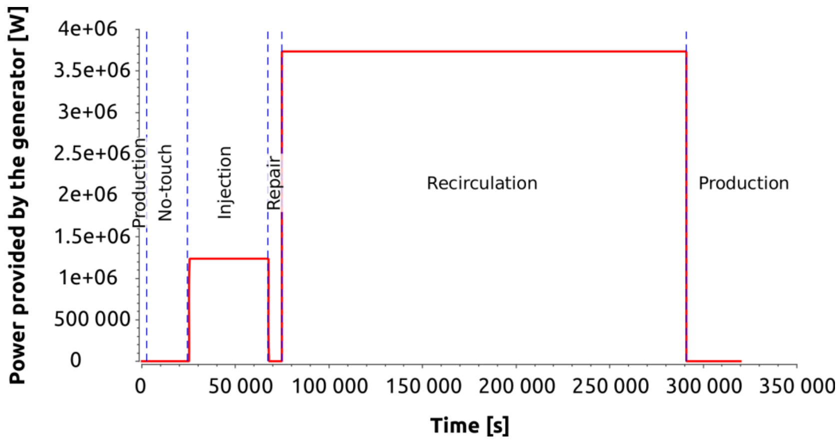
State over 1 year,
Hybrid loop
(1 simulation)



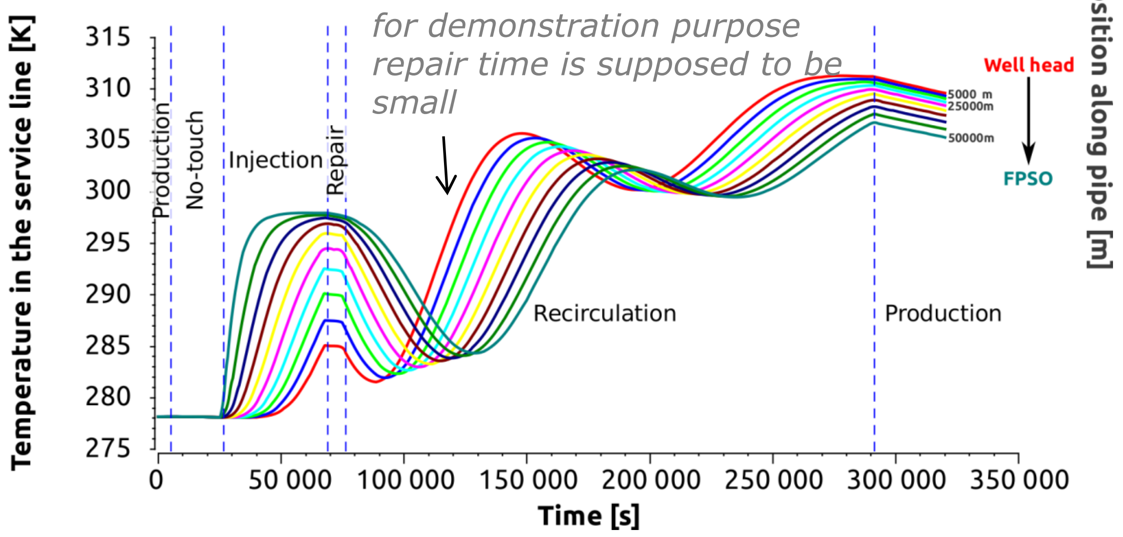


Hybrid loop simulation results

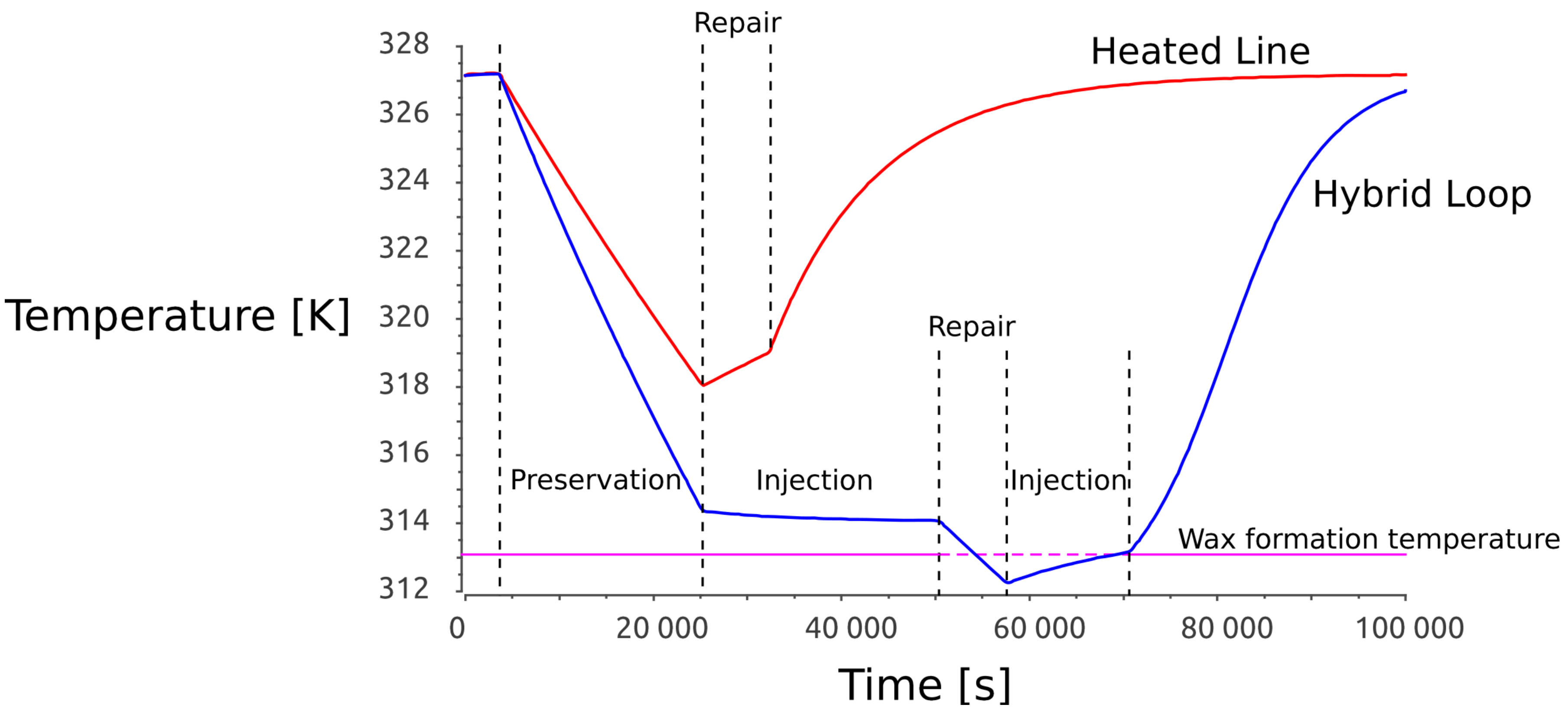




Hybrid loop architecture results: physical simulation



Comparison of results: Hybrid- VS Heated-line



Fluid temperature comparison in the line at the sea bottom (active heating and hybrid loop architectures)

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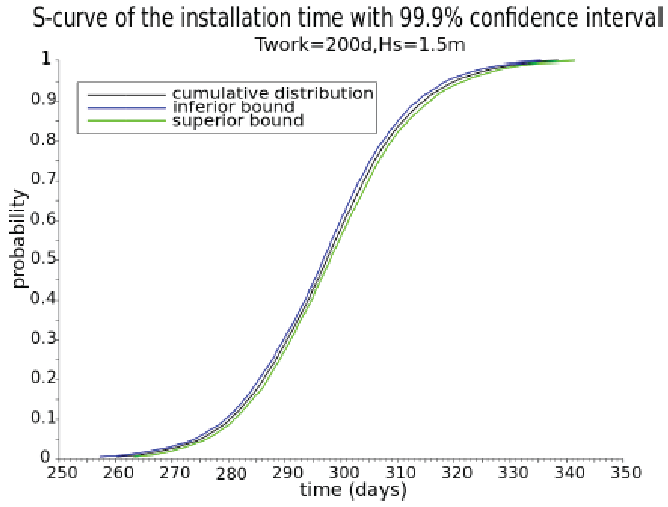

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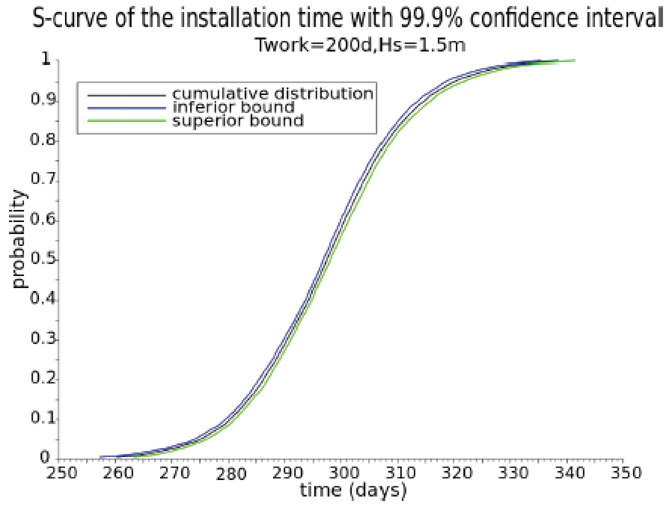
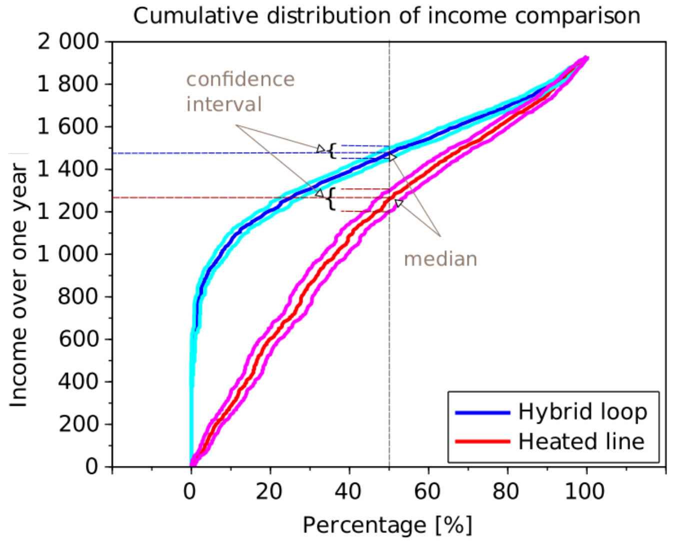


- Economy - Plot of cumulative distribution of income for two designs:
  - Elaboration based on array of scenarios and relative Monte Carlo simulation.



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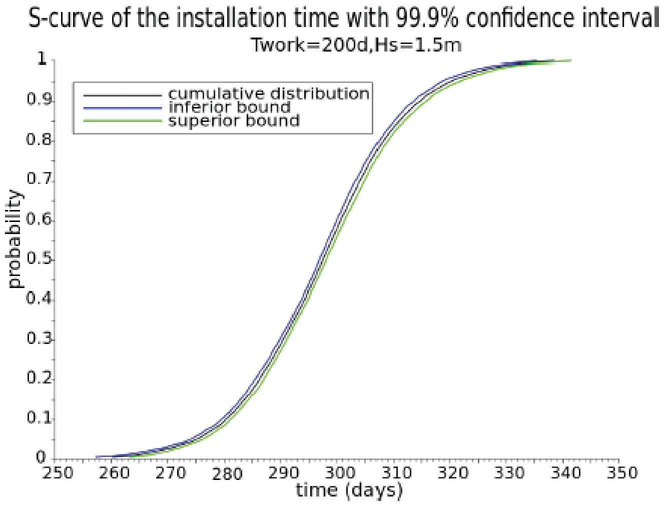
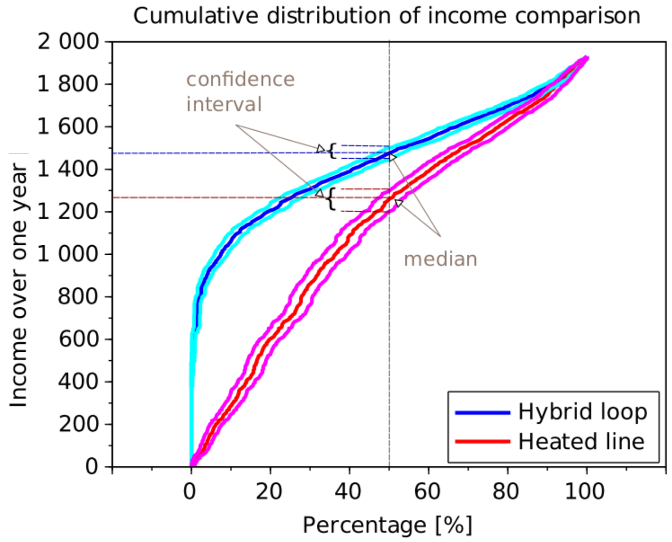


- Economy - Plot of cumulative distribution of income for two designs:
  - Elaboration based on array of scenarios and relative Monte Carlo simulation.



- **Interpretation of cumulative plot:**
  - At about 0% unlikely or rare outcome.
  - At 50% average of course…
  - At e.g. 90% outcome high but unlikely
  - NB: Based on given data and scenarios

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  - Enabling migration from document based workflow
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- Future collaborations
  - Build and continue EU-programmes of Modelica development
  - Promote collaborations on Modelica modelling to Oil & Gas Industry

Conclusion

- Enable a holistic evaluation of design validity
  - Construction and Installation
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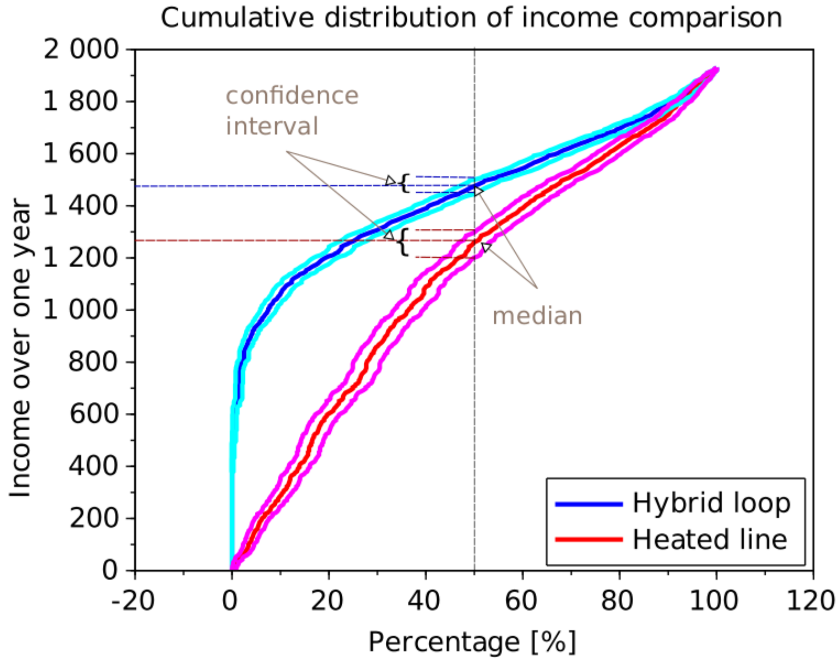

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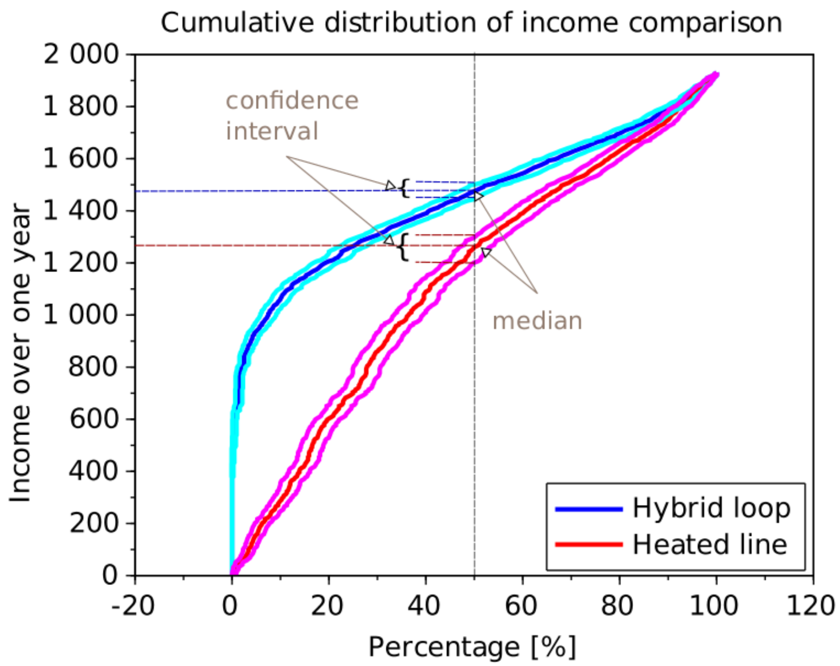
- Mandatory: Shorten development time



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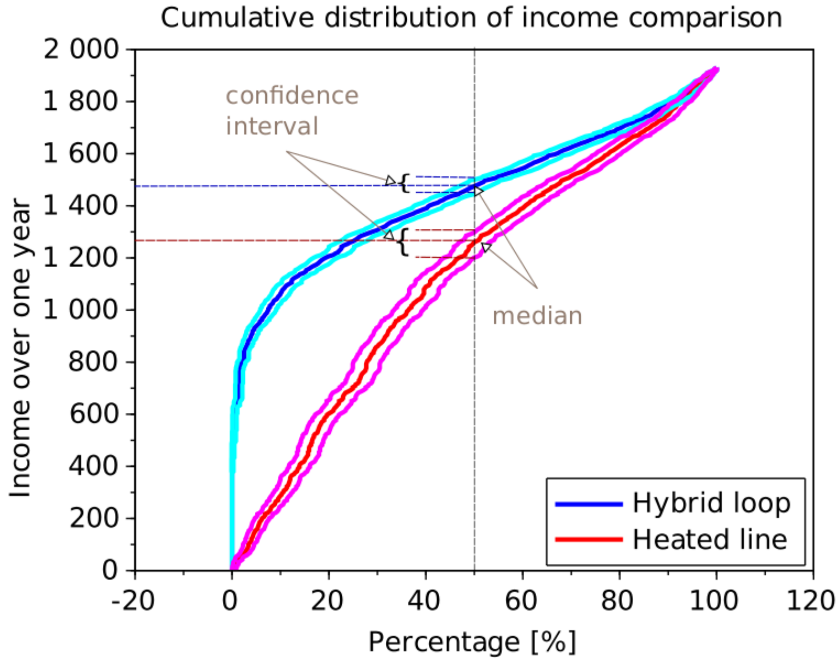


- Compare design alternatives
- Mandatory: Shorten development time

- Proposal:
  - Move from document- to **Model-Based engineering**
  - Select an **"open" platform for exchange of models** – should we start with **Modelica**?

eni

End of presentation

Questions?

Extras!

Multi-level modeling

- Principle of incremental building of models
  - First level: conceptual models
  - Second level: feasibility
  - Third level: FEED or basic design

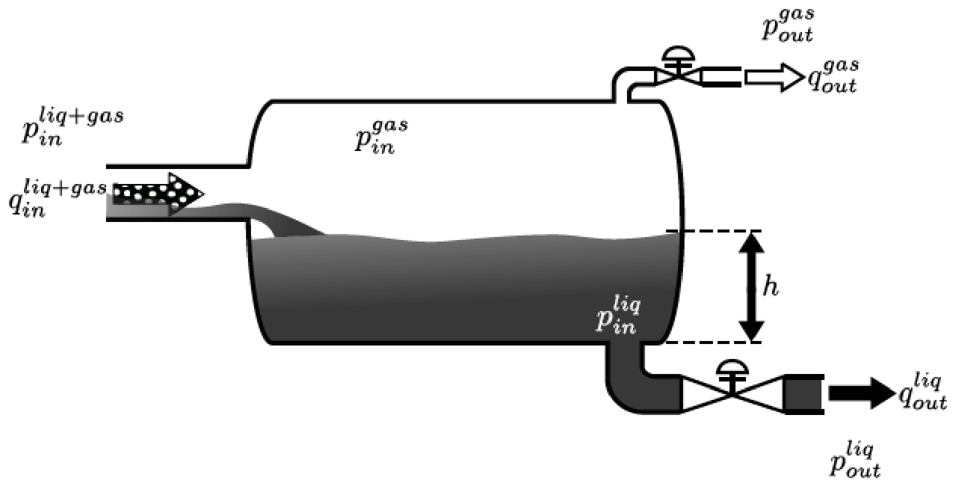
Increasing details in the data

- Best practice
  - Re-use most of previous designs
  - Strong capitalization on previous projects
  - Incremental V&V on new designs

  => Time-saving in project development

Level of detail – example 1

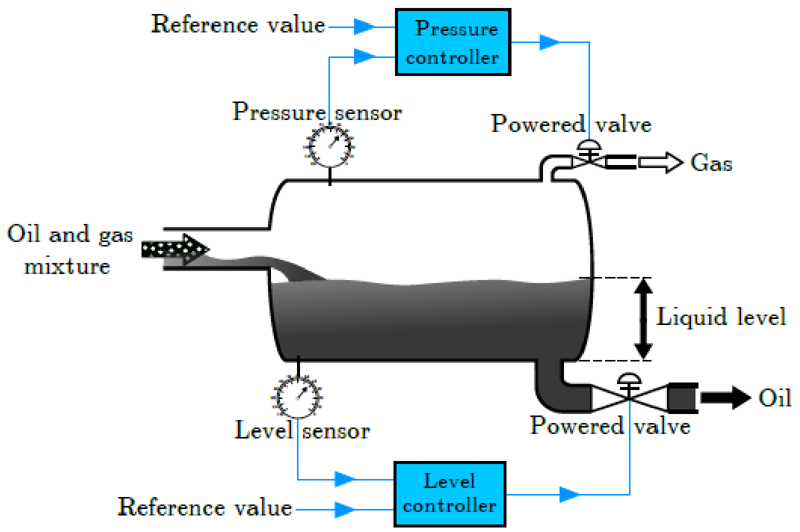
- A tank with inlet and outlet



- Modelica assessment of liquid level
  - Level may be calculated from tank geometry and mass of liquid

Level of detail – example 2

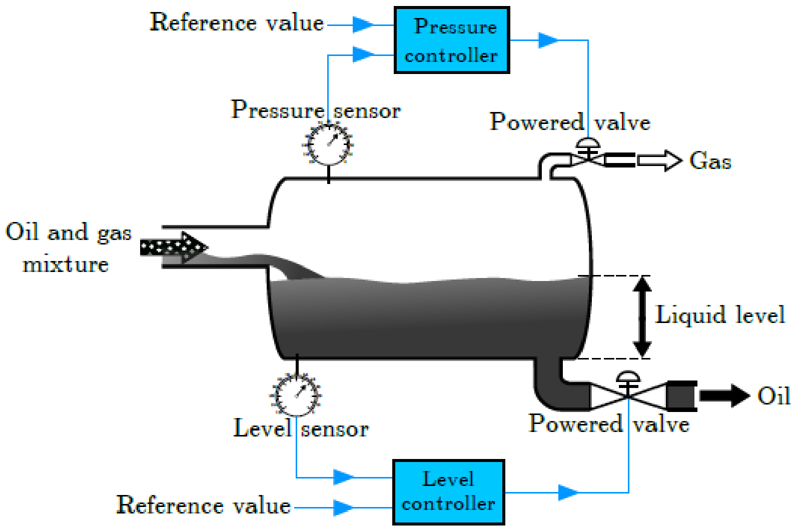
- A tank with inlet, outlet and level detection

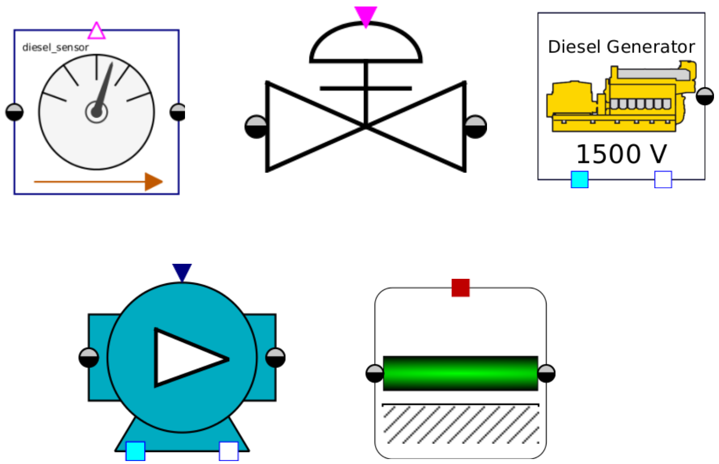


- Modelica assessment…
  - Level measurement depend on sensor, electricity, connectors and cables etc…

Level of detail – example 3

- A tank with…
- Depends on other components
  - Electrical system
  - Diesel power generator
  - Control system
  - Hydraulics
  - Compressed air actuators
  - Fire fighting equipment
  - …
- Constraints are
  - Weight limits on structure
  - Space limits
  - …





Future topics: Bifurcations and constraints

The problem is to remain within boundaries of given constraints

- Relevant for control systems design
  - Sensor ranges
  - Feedback loops and control parameters
- How to know if we can exclude other solutions or bifurcations?

Example

- Multiphase pipe-flow in pipeline/riser
  - For particular valve settings
  - Outflow unstable at FPSO

Goal:

  - Find suitable method for bifurcation detection – e.g. analysis of eigen-values of Jacobian