DNV·GL

OIL & GAS

HiPerCap WP4

Methodology for Benchmarking

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HiPerCap CO_2

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What is benchmarking?

One of the first Benchmarks

The origin of the term **bench mark**, or **benchmark**,

- Chiselled horizontal marks made by surveyors in stone structures,
- Used to place an angle-iron in to form a “bench” for a levelling rod
- So this levelling rod could be replaced on the exact same level

Source: Wikipedia

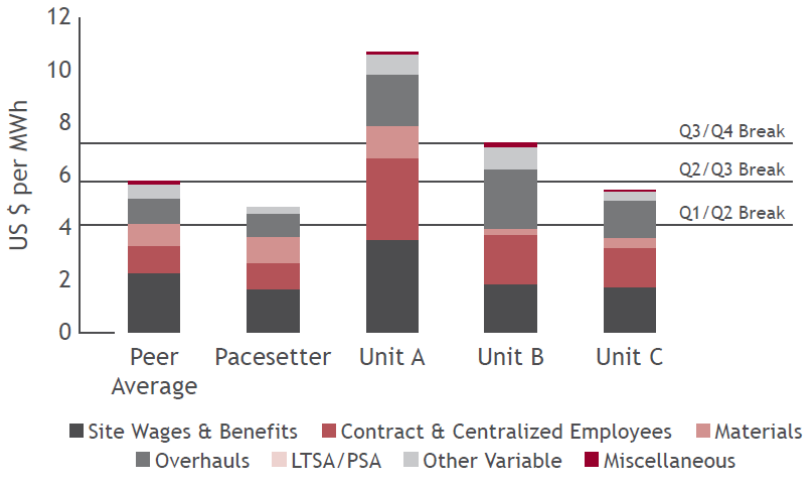
Source: http://www.waymarking.com

Goal of benchmarking

Two types of goals

1. Metrics Benchmarking
   (to determine (relative)
   position in own sector)

Learn *were you are, compared to others*



Source: http://www.solomononline.com

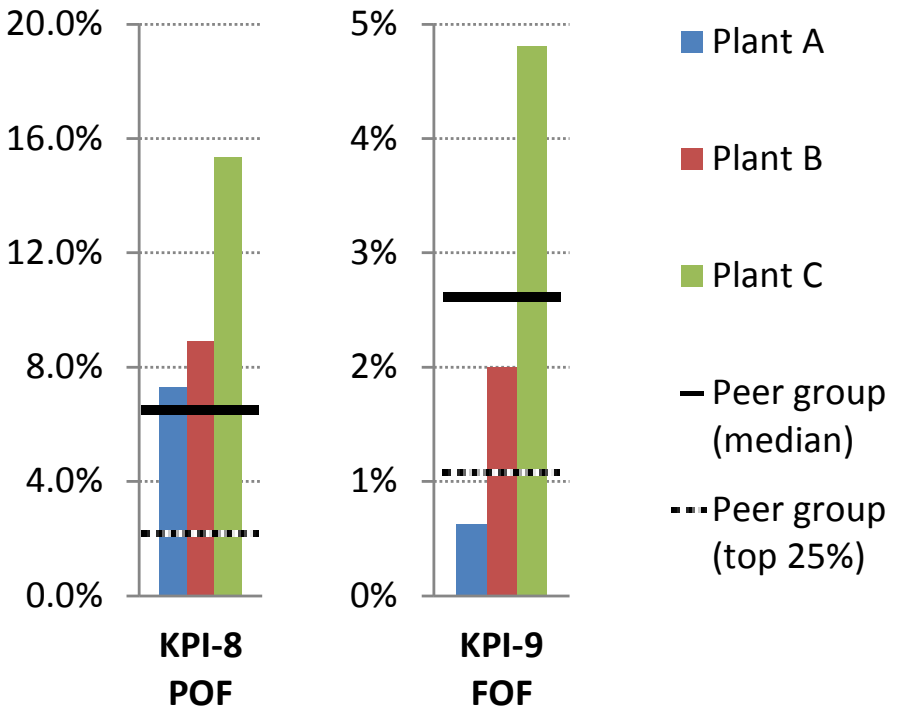
2. Activity Benchmarking (find & implement 'Best Practices')

According to the European Benchmarking Code of conduct "Benchmarking is about the process of identifying and ***learning*** *from best practices in other organizations "*

Benchmarking is about learning

Example results

Power plant maintenance performance



POF = Planned Outage Factor

FOF = Forced Outage Factor

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HiPerCap Objectives

1. To develop high-potential novel and environmentally benign technologies and processes for post-combustion CO_2 capture leading to real breakthroughs.

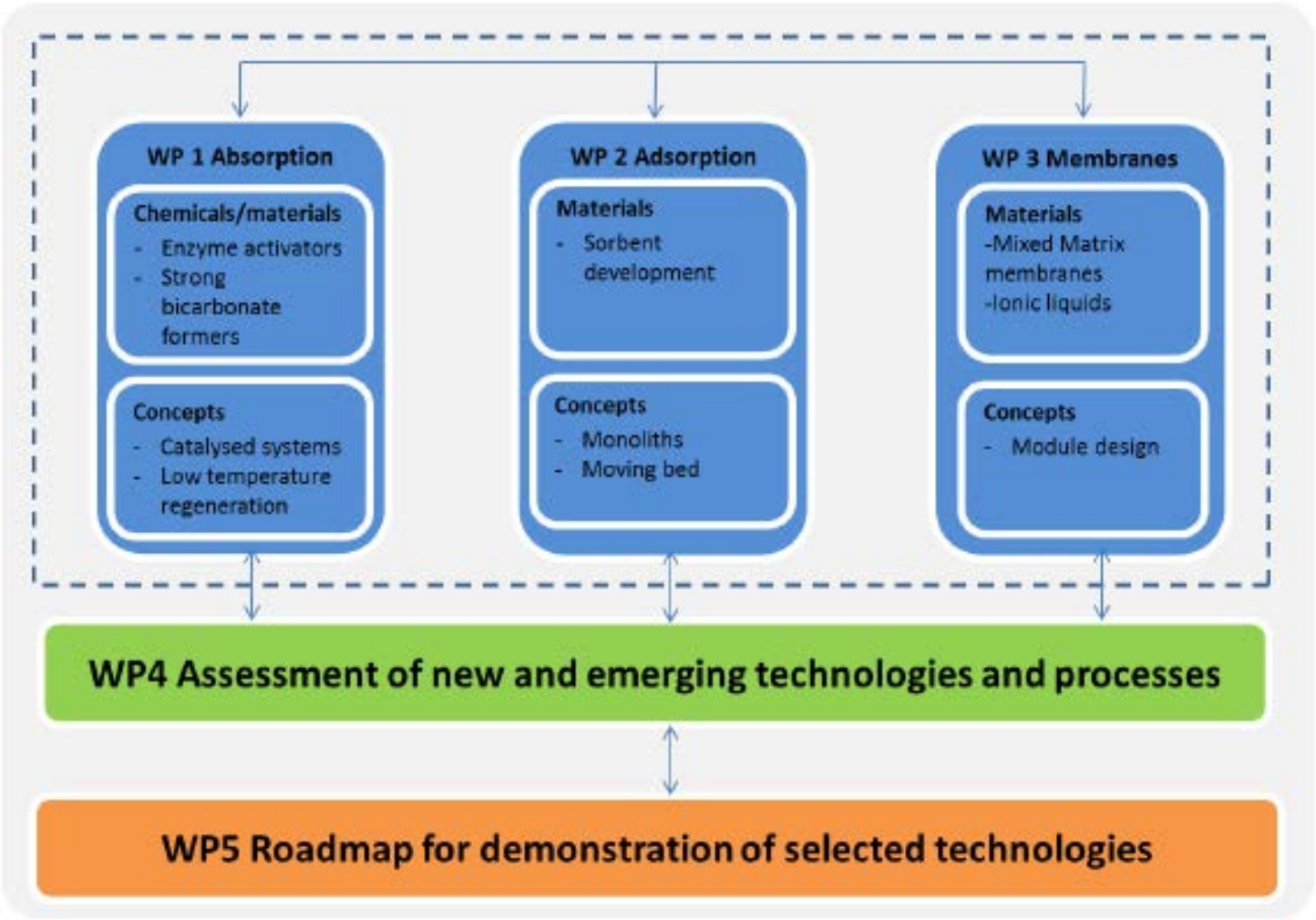
2. To achieve 25% reduction in efficiency penalty compared to a demonstrated state-of-the-art capture process

3. Deliver proof of concept for technologies

4. Develop a fair methodology for comparing capture technologies

5. Develop technology roadmaps for the two most promising technologies

HiPerCap Project



Assessment Methodology

The Final Assessment

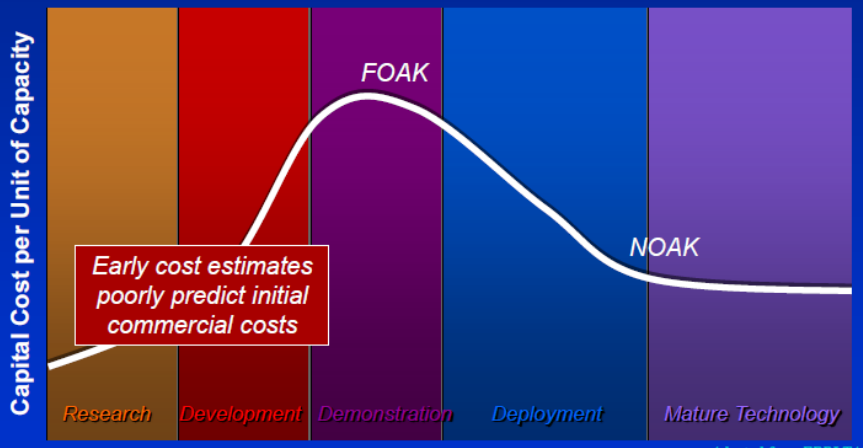
- Ultimately the impact of CCS on the COST of the product produced will be how future CCS investment decisions are made

Avoid Cost Estimates a Earliest Stages of Develo

- Don't ask about cost for new capture techno or process concepts. Instead ….
- Use performance metrics and other non-eco criteria to evaluate and screen novel materia components and early-stage concepts (low T e.g.

E.S. Rubin, Carnegie Mellon

Typical Cost Trend of a New Technology



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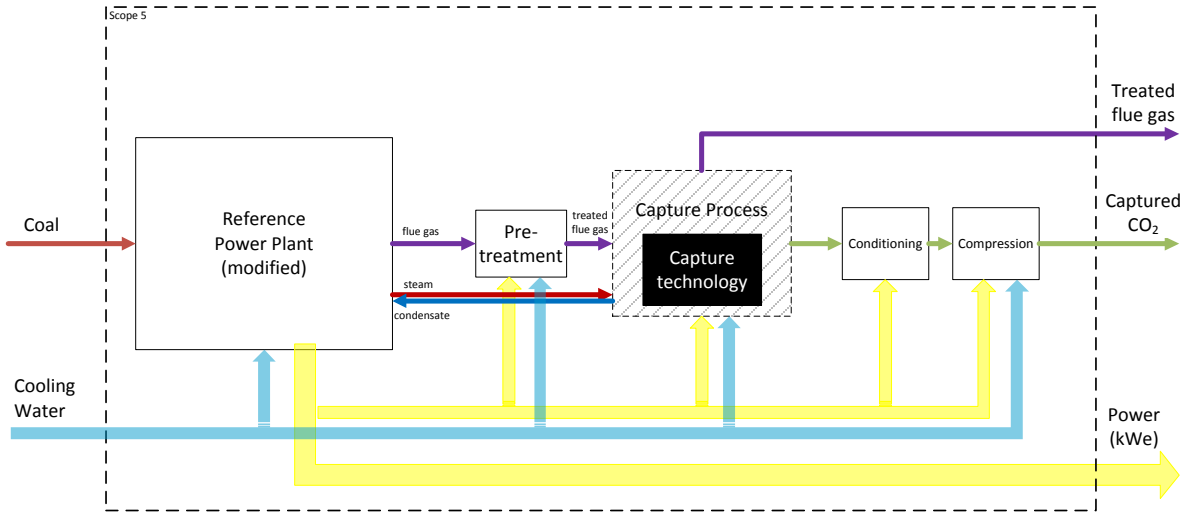
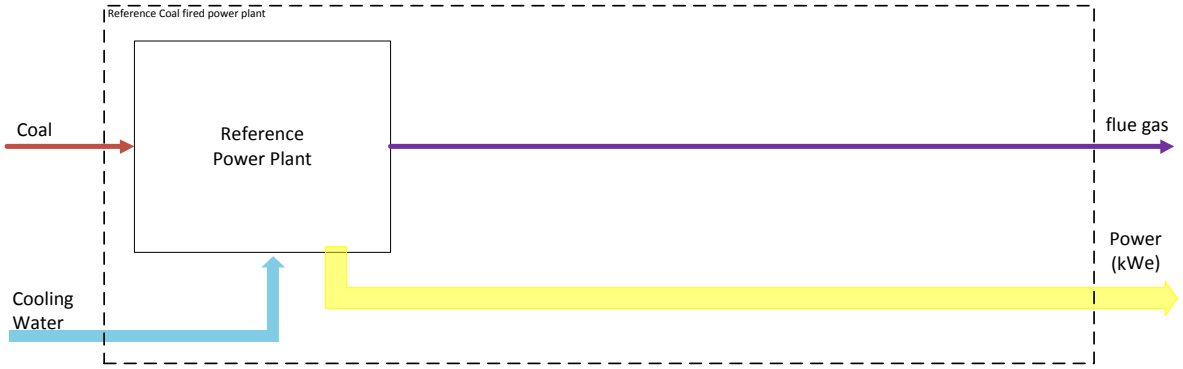
Scope of the assessment





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Overall comparison

On level of key indicators the following performance can be determined:

Indicator Energy

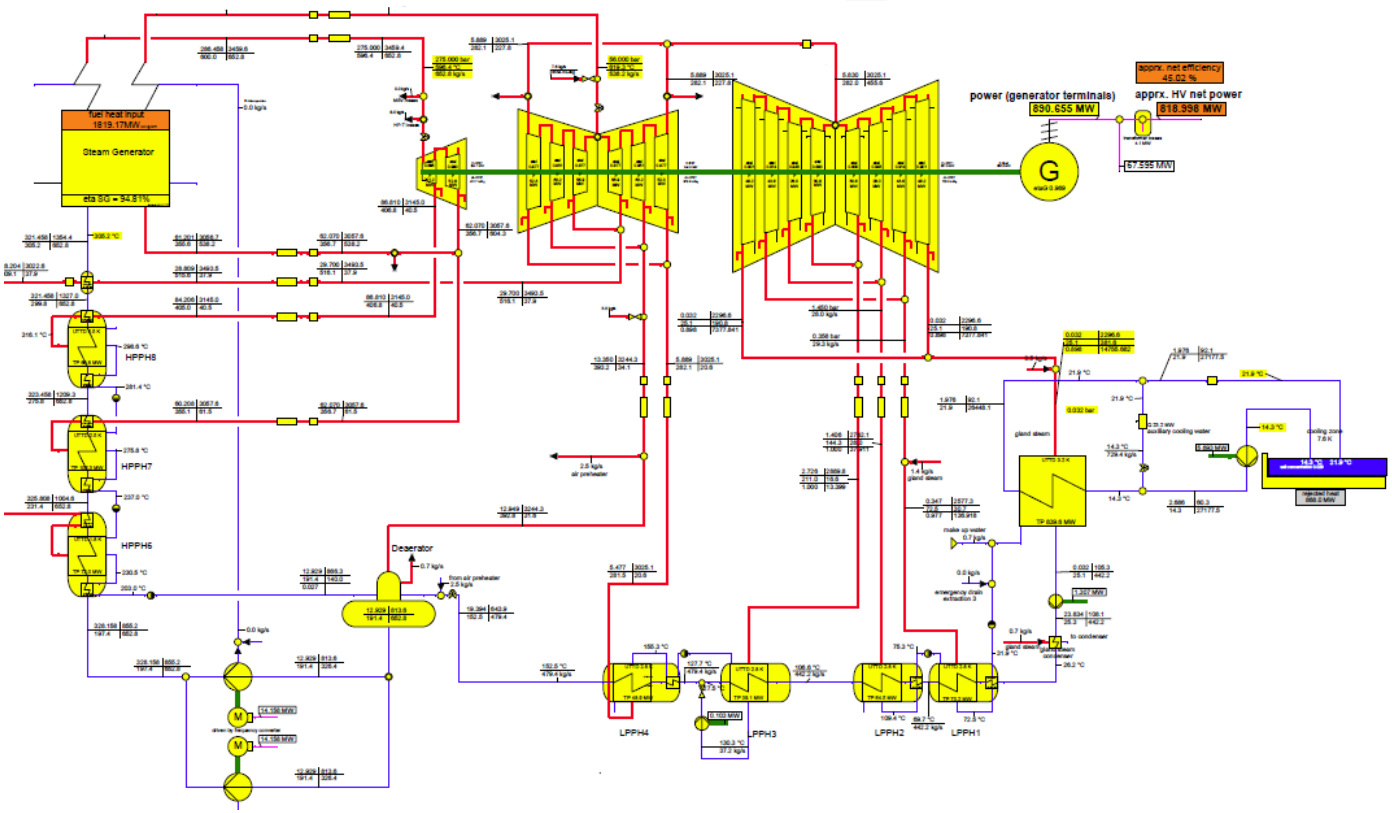
Indicator Environmental

Indicator Cost

Reference Coal Fired Power Plant and State of the Art Capture

Reference Coal fired Power Plant

- Updated EBTF Case
- 820MW Advanced supercritical (ASC) pulverised coal (approx. 600 °C/280 bar)



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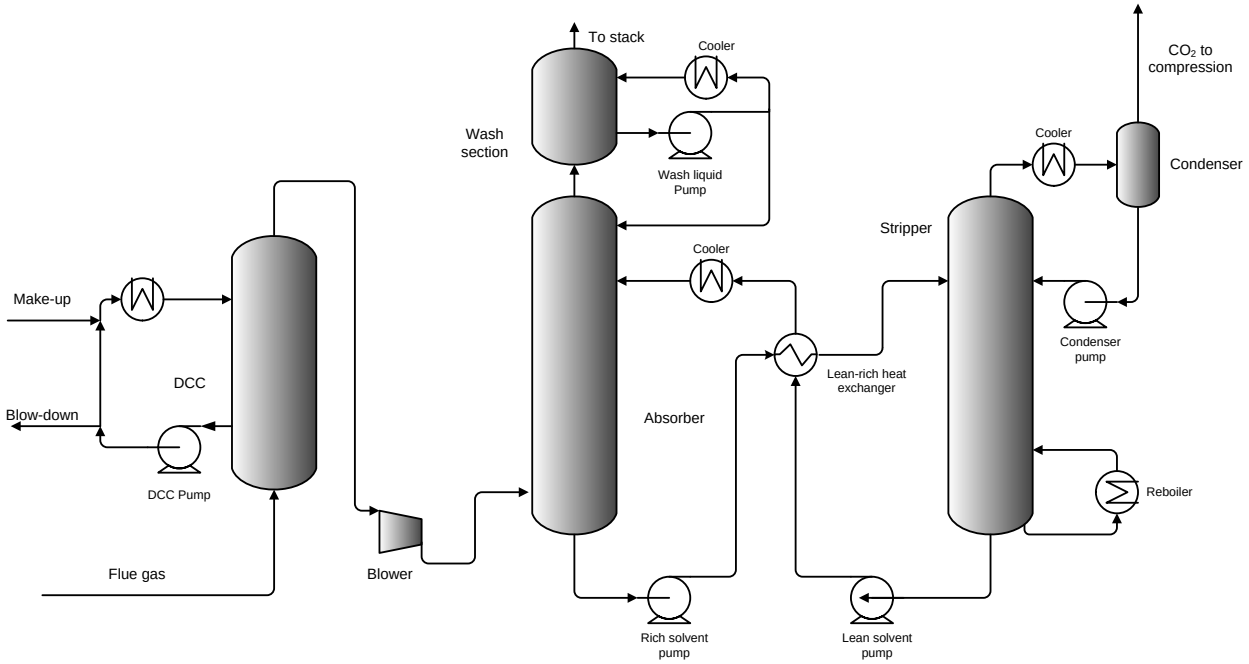
State of the Art Capture Technology

- Criteria
  - Technology needs to be installed on coal power plant
  - Full set of data and details need to be publicly available
  - The largest available reference should be used
  - CESAR 1 case



Energy KPI

Background

- Objective:
  - Show that capture processes have reached goal of a reduction in energy penalty by 25% compared to current state of the art technology.

- Boundary conditions
  - Minimal capture rate 85%

- What to benchmark
  - Impact of capture processes on the reference power plant output

Preferred energy KPI

Specific energy penalty of avoided CO_2 (SEPAC) [MJ_e/kg CO_2]

- $$SEPAC = \frac{P_{ref} - P}{\phi_{CO_2,ref} - \phi_{CO_2}}$$
  - P = net electric output of the power plant in MW_e
  - φ_{CO2} = the emitted flow of CO_2 in kg_{CO_2}/s

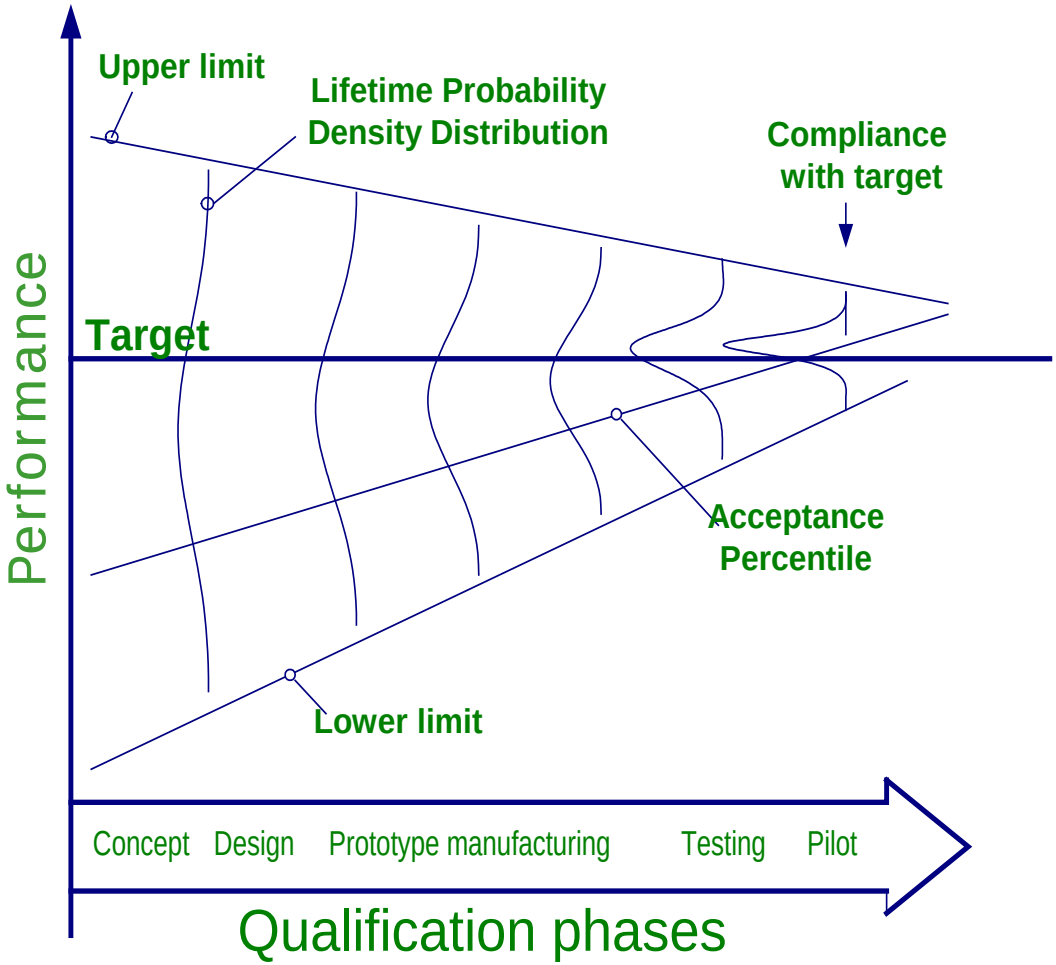
Uncertainty and Data Quality

Uncertainty

- Two types of uncertainty:

- Parameter Uncertainty
  - Uncertainty in experimental measurements made
- Model Uncertainty
  - Uncertainty related to assumptions in model and physics behind the models
  - Want to understand which assumptions the model is most sensitive to
  - Aim to reduce the influence of assumptions made

Uncertainty – A double edged sword



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