Ansys / DYNARDO | presented at the 17th Weimar Optimization and Stochastic Days 2020 | Source: www.dynardo.de/en/library

HYDRO

# OPTISLANG: LAYOUT OF RADIAL FANS IN GENERATOR COOLING

D. LANGMAYR[1], G. KANDLER[2]

1: ANDRITZ HYDRO GmbH
2: DYNARDO Austria GmbH

25.6.2020

Europäische Union Investitionen in Wachstum & Beschäftigung. Österreich.

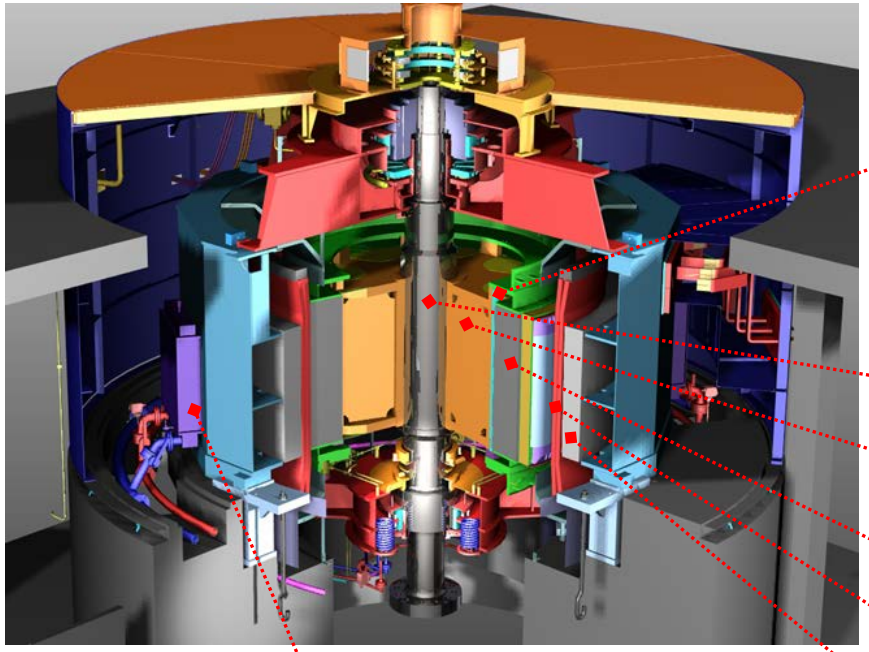
EFRE

ANDRITZ ENGINEERED SUCCESS

# OUTLINE

- Generator cooling
  - Air cooling of a hydro generator?
  - How much power needs to be dissipated?
- Design of radial fans
  - Current approach
  - Computation Fluid Dynamics (CFD) Simulation
- Metamodel of Optimal Prognosis MOP creation
  - Parametrization
  - MOP creation
  - Comparison executed projects

# RELEVANT COMPONENTS FOR AIR COOLING



Fan

Shaft

Rotor hub

Poles

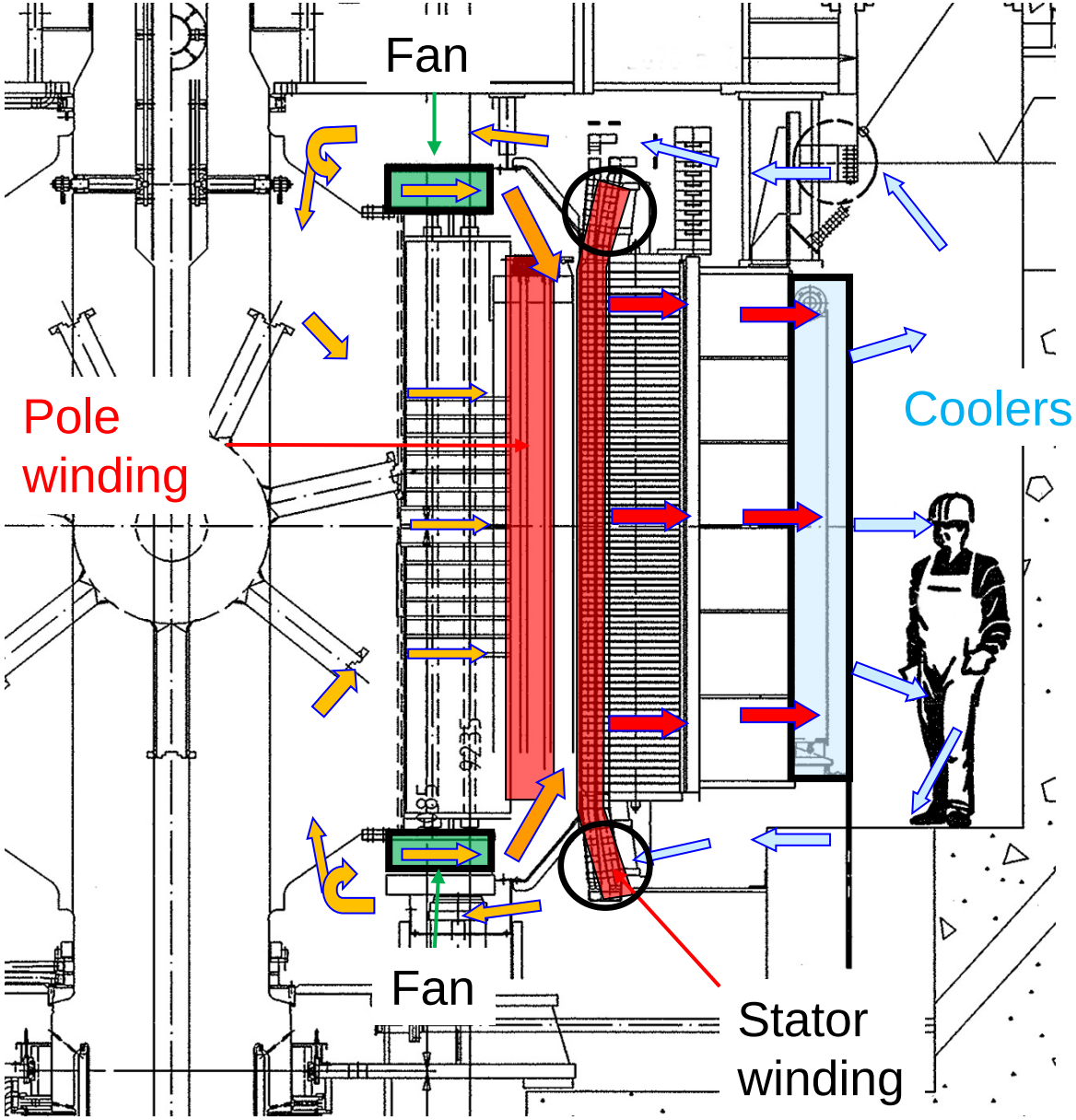
Stator winding

Stator core

Air-cooler


Generators can be very big …

# COOLING AIR FLOW




In a closed ventilation circuit cold air enters the generator, and passes in general

- the endwinding Zone,
- the fans,
- the rimducts (if present),
- the interpolar space,
- the stator ventilation ducts,
- the coolers,
- and enters the generator again.

# DISSIPATED POWER

~2 Million mobile phones

21000 refrigerators

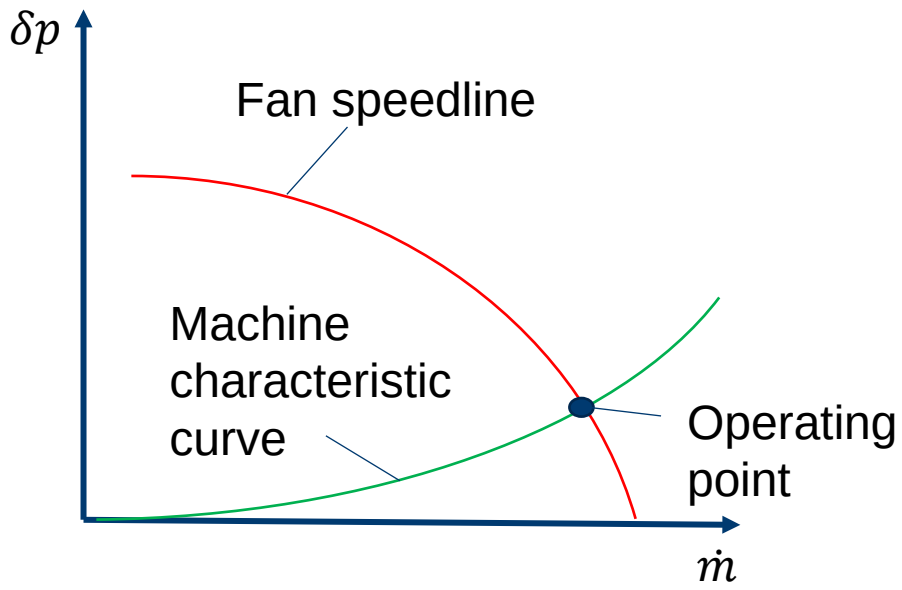
For large projects, cooling air has to dissipate a power loss of about 3 MW

30 cars


1 steam locomotive

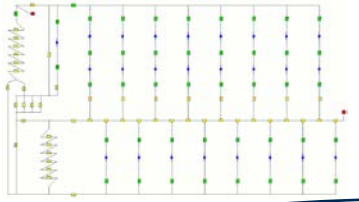
# DESIGN OF RADIAL FANS

Cooling layout




How to get the required profiles?

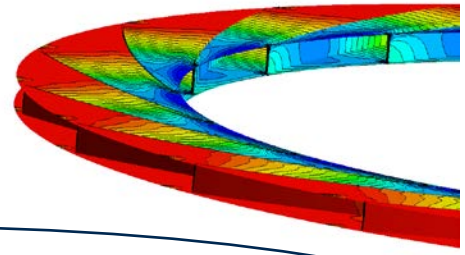
Layout Tools



Pro‘s:
- Quick turnaround times
- Early in the design process

Con‘s:
- No accurate geometry representation
- Limited accuracy

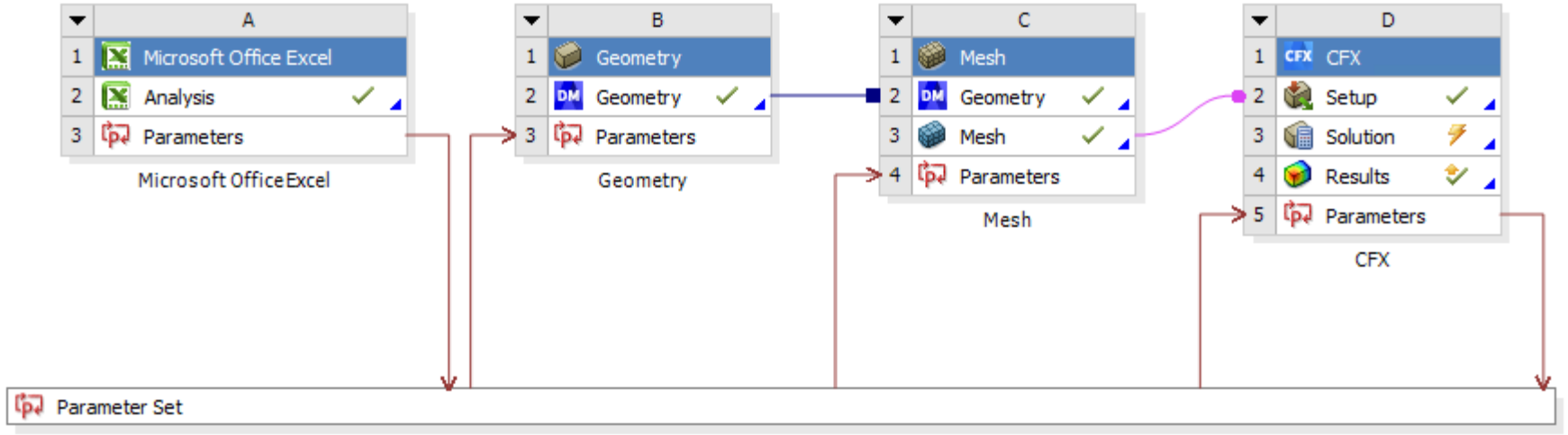
CFD

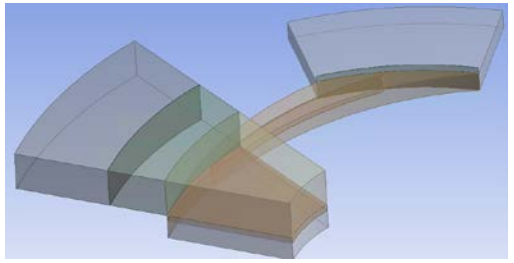


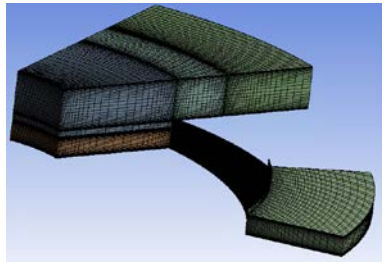
Pro‘s:
- High accuracy
- Special designs possible

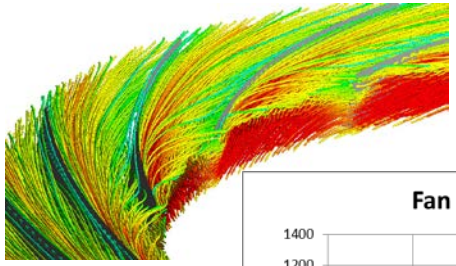
Con‘s:
- License cost
- Simulation time
- Expert knowledge

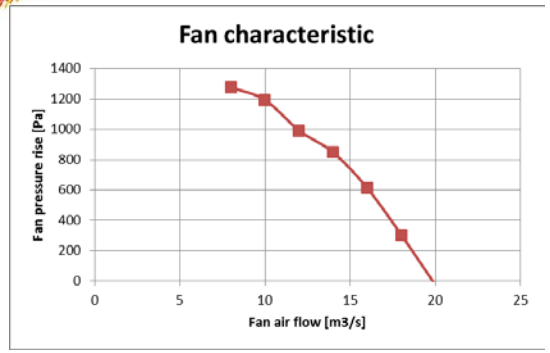
# CFD SIMULATION









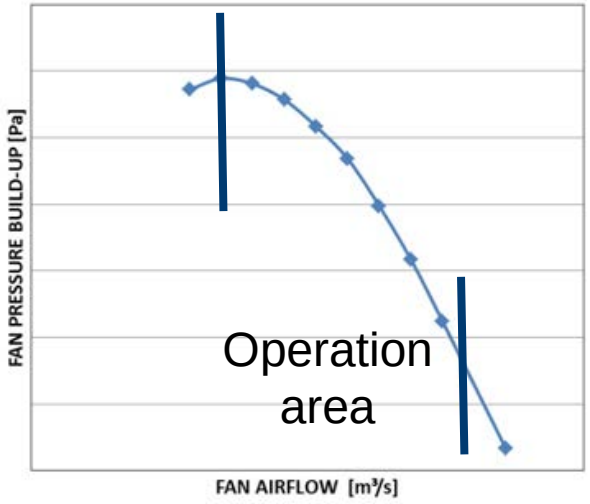

User input ⟵ | ⟶ Fully automated

# PARAMETRIZATION

- There are two types of input parameters
  - Geometric parameter: Blade radius, blade angle, …
    Thresholds are defined by database containing all executed projects up to now
    Relative parameter definition to avoid constraint equation, e.g.,

$$R_o = R_i + \delta R$$

  - Operation parameter: volume flow rate, speed
    Critical and tricky to define proper ranges for the operational parameters

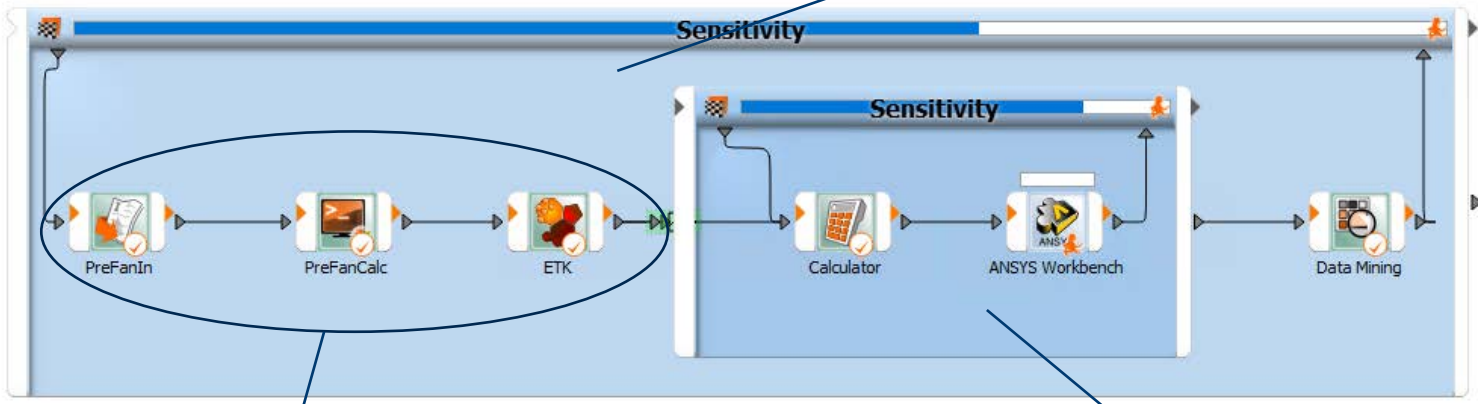




Layout tool is used to determine limits for the air flow through the fan

# OPTISLANG SCHEMATIC

- Nested approach

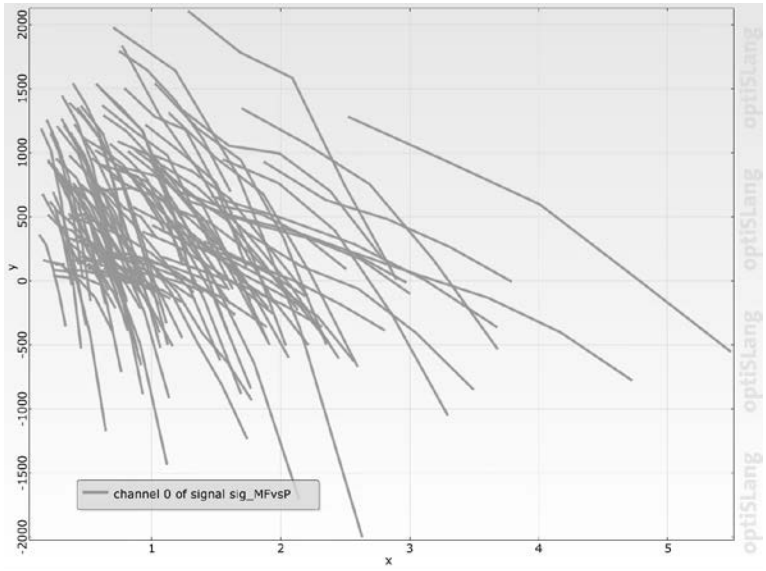
Geometry parameters are varied in the outer sensitivity container




Determination of appropriate volume flow rates

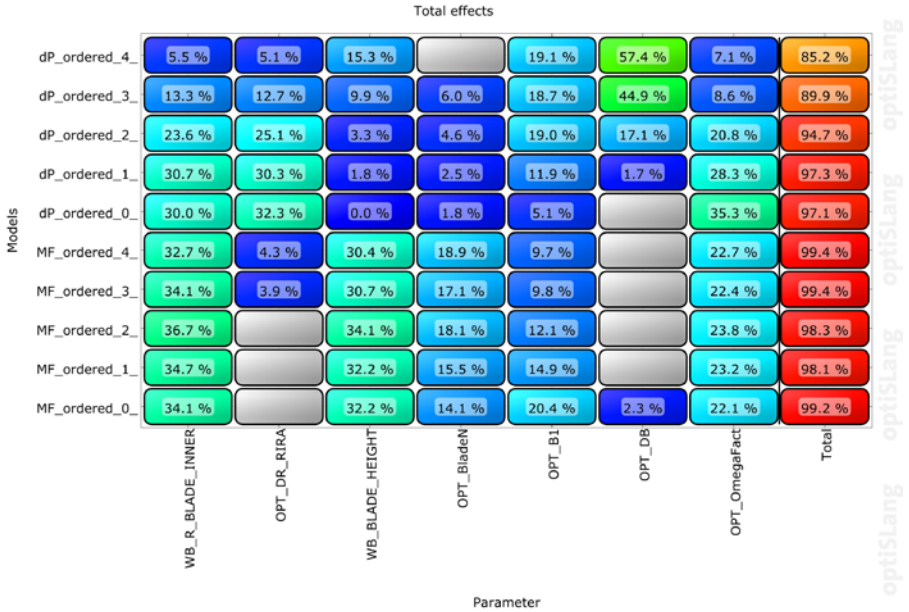
Operation parameters are varied in the inner sensitivity container → Speed line

# RESULTS



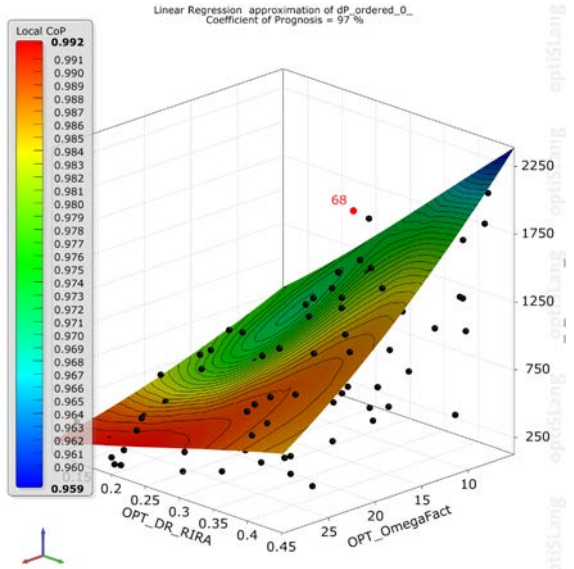

Advanced Latin hypercube sampling→ speed lines

→ Split results of sampling in x- and y-components




Coefficient of Prognosis Matrix

→ Compute sensitivities for operation points

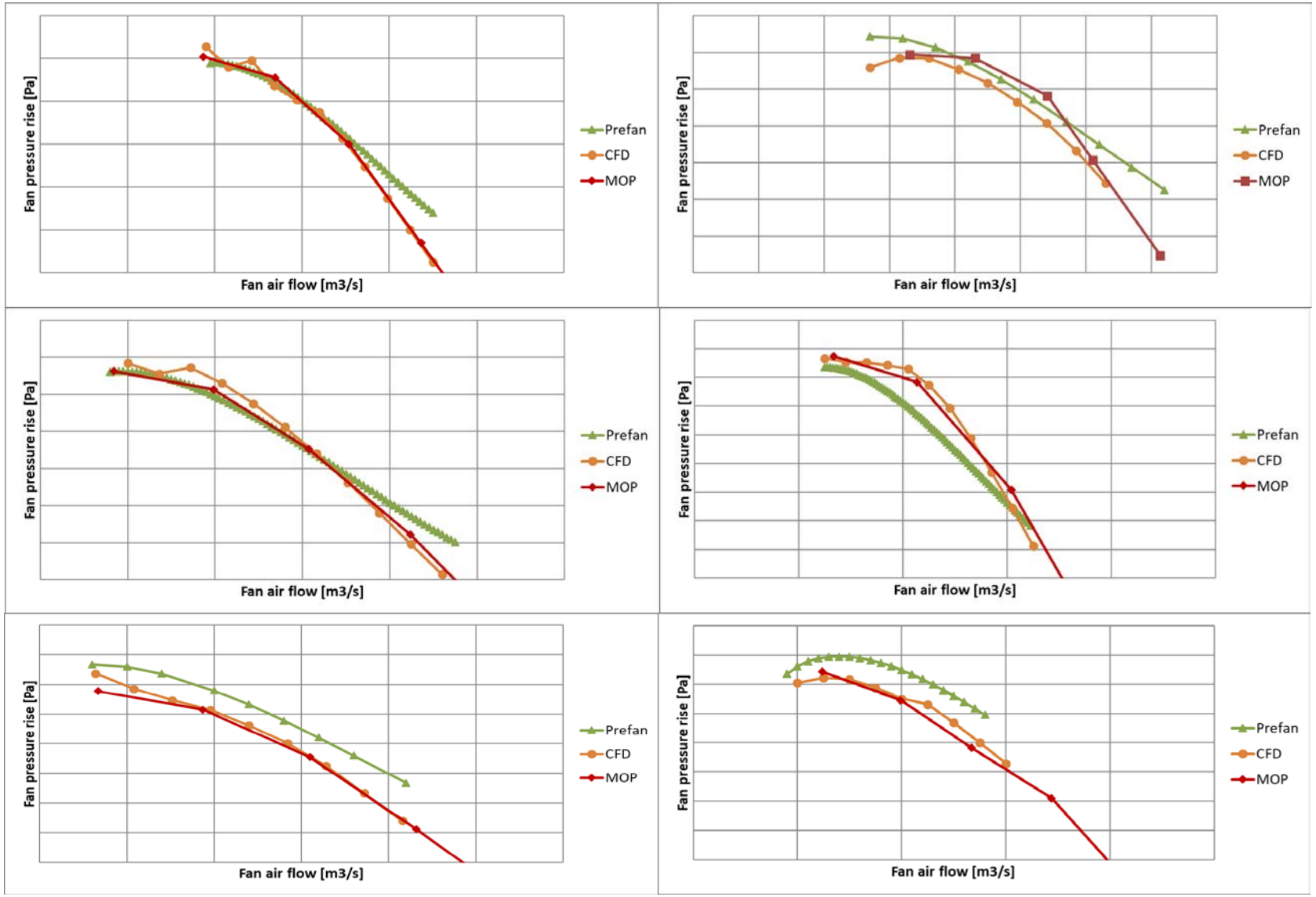



Response surface

→ Compute MOP for operation points

# VALIDATION

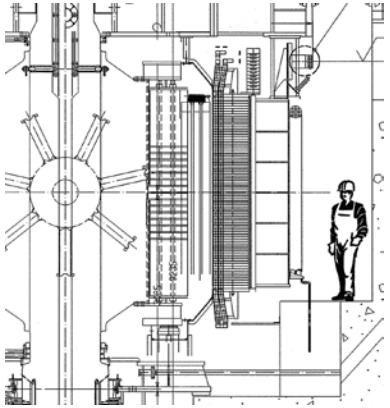
- Comparison
  - Actual standard design tool
  - MOP
  - CFD
- Six executed projects



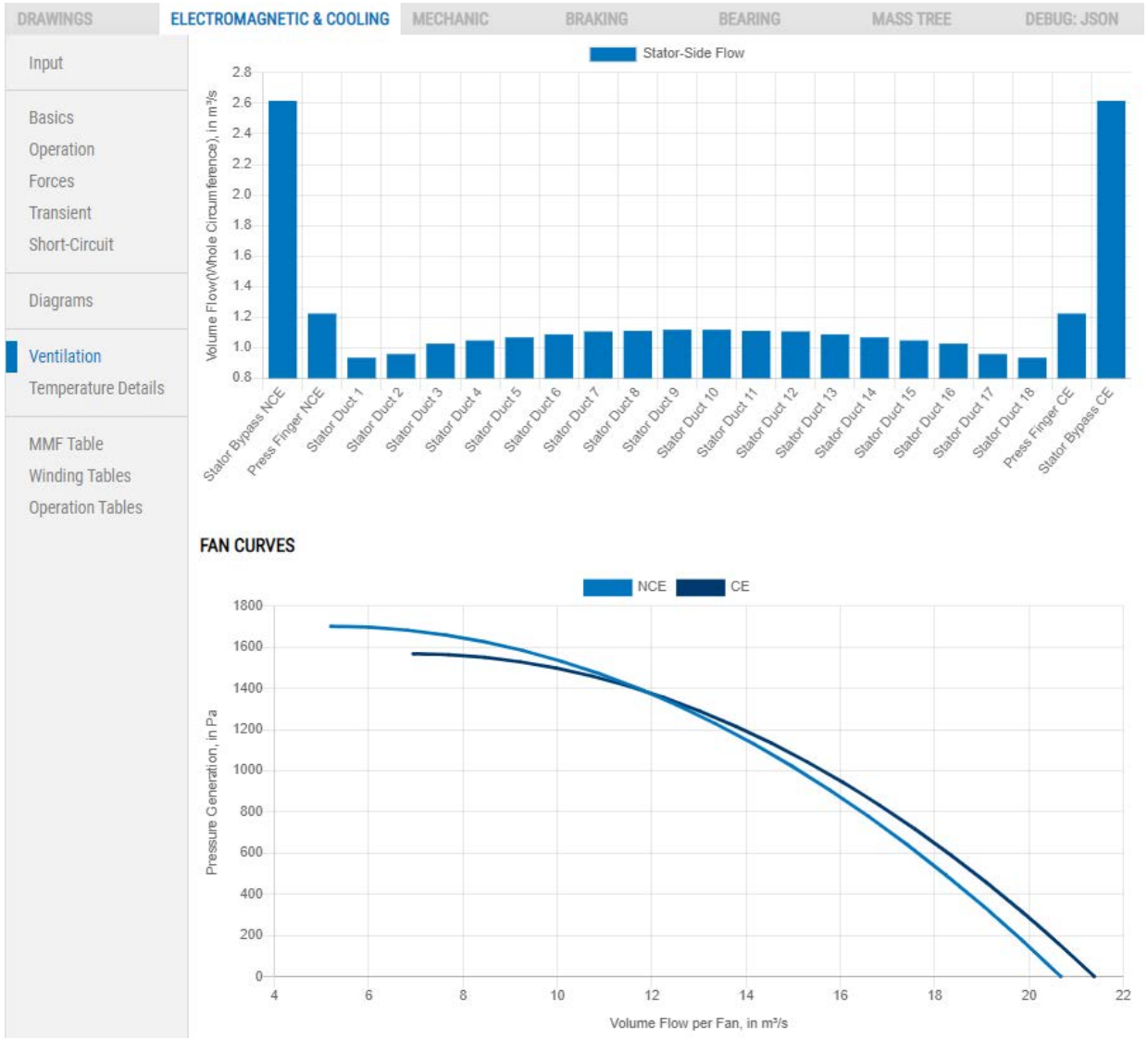
# WORKFLOW IMPLEMENTATION

- Implementation of the MOP in a general generator layout tool via .dll library.
- Fan layout is fully compatible and coupled with the electromagnetic and thermal simulation.

CE-Side



NCE-Side



# SUMMARY

- Fully parametric CFD model for the simulation of radial fans for generator cooling was generated
- Appropriate parameters, their dependencies and thresholds have been defined
- A MOP is generated based on the automated CFD workflow with a nested approach.
- Prognosis quality of the MOP is guaranteed by appropriate CoP’s and comparison to executed real life projects.
- The MOP is implemented in a general generator layout tool via .dll library