EERA-DTOC Software

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EERA DTOC
THE EUROPEAN ENERGY RESEARCH ALLIANCE
DESIGN TOOLS FOR OFFSHORE WIND FARM CLUSTER

Support by

SEVENTH FRAMEWORK PROGRAMME

DTOC software development: Goals

1. Definition of the end-user requirements for the software

2. Definition of the data and control interfaces to facilitate the coupling of existing models available with the partners

3. Design of the DTOC software

4. Development of the software to couple existing models at the various institutes to create integrated offshore wind farm design tools

Integration task

EERA-DTOC portfolio of models

Name	Partner	Status	Programs	Input/ output	Script/ GUI	Database interface	IPR	Com
CFDWake	CENER		Fluent, C++, OpenFOAM	ASCII	script	Yes		
CorWind	Risoe DTU	Ope	DOS exe Delphi	CSV files	no	no	+	+
CRES-farm	CRES	Ope	Linux/ Fortran77	ASCII	no	no	+	
CRES--flowNS	CRES	Ope	Linux/ Fortran77	ASCII	no	no		
DWM	Risoe DTU	Ope	Fortran, pc, pc-cluster	ASCII	script		+	
ECNS	ECN	Beta	Linux/ Fortran90	ASCII	No	No	+	
EeFarm	ECN	Alpha	Matlab	Matlab scripts	Script/ GUI	yes	+	+
Farm-farm interaction	ECN	Ope	Fortran	ASCII	No	no	+	
FarmFlow	ECN	Ope	Delphi	ASCII/ binary	GUI	Yes	+	+
FlowARSM	CRES	Alpha	Linux/ Fortran77	ASCII	no	no		
FUGA	Risoe DTU	Ope	Fortran, C, Delphi, pc	ASCII	Script/ GUI	No	+	
NET-OP	SINTEF	Proto type	Matlab	ASCII	script	No	+	
Skiron/WAM	CENER	Ope	Unix/ Fortran	GRIB	script	yes		
TOPFARM	Risoe DTU	Beta	Matlab/C/ Fortran	ASCII	script		+	
UAEP	Risoe DTU		Matlab, pc	ASCII/ binary	no	yes		
VENTOS	UPorto	Beta	Unix/ Fortran	ASCII	no	yes	+	+
WAsP	Risoe DTU	Ope	Windows pc	ASCII	Script/ GUI	No	+	+
WCMS	Fraunhofer	Ope	Matlab/JAVA	OracleDB		yes	+	
WRF	Risoe DTU	Ope	Unix, Linux, Fortran90	netCDF	Shell script	yes		
WRF/ROMS	CIEMAT	Ope	Linux/ Fortran	netCDF	script	yes	+	

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Farm-farm interaction	ECN	Ope	Fortran [illegible]	[illegible]	[illegible]	[illegible]	+	
FarmFlow	ECN	Ope	Delpl[illegible]	[illegible]	[illegible]	[illegible]	+	+
FlowARSM	CRES	Alpha	Linux/ [illegible]	[illegible]	[illegible]	[illegible]		
FUGA	Risoe DTU	Ope	Fortran, C, [illegible] pc	[illegible]	[illegible]	[illegible]	+	
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Run on Windows, on a single PC

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Runs on Cluster under UNIX/Linux

User Requirements

EERA-DTOC vision

- A **robust, efficient, easy to use** and flexible tool created to facilitate the **optimised design** of individual and clusters of offshore wind farms.

- A keystone of this optimisation is the precise prediction of the future **long term wind farm energy yield** and its associated uncertainty.

Users

Design and model selection guided by end-users

Two **main user groups** were identified:

- Strategic planners
- Developers of offshore wind farms

Associated users could be:

- Consultants
- Research institutions
- Manufacturers
- System Operators

Selected User Stories

- As a developer I can determine the wake effects of neighbouring wind farm clusters on a single wind farm.
- As a developer I can determine the optimum spacing, position, turbine model and hub height of turbines within an offshore wind farm.
- As a strategic planner I can determine the optimum strategic infrastructure to accommodate offshore wind farm clusters.
- *14 relevant user stories in total*

Optimisation process

- As a developer I can **determine the optimum** spacing, position, turbine model and hub height of turbines within an offshore wind farm.

*Software supports the **comparison** of many design scenarios.*

***Comparative** reporting enables selection of optimised configurations.*

Score for comparison: Levelised Cost of Energy

Optimisation Process

1. Generate Design Options

- Scenario 1
- Scenario 2
- Scenario 3
- Scenario 4
- Scenario 5
- Scenario 6
- Scenario 7

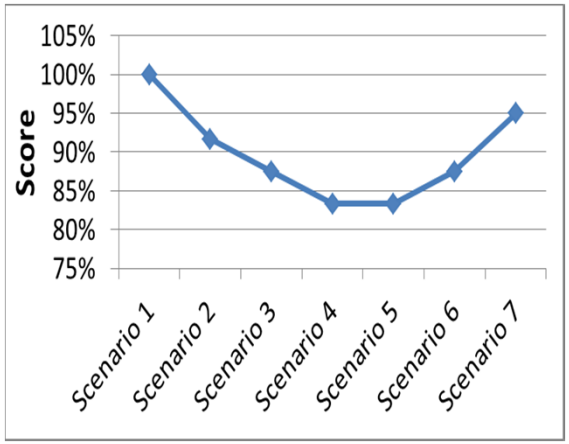
2. Evaluate Design Options

Wake Model

Electrical Model

Energy model

3. Compare Design Options



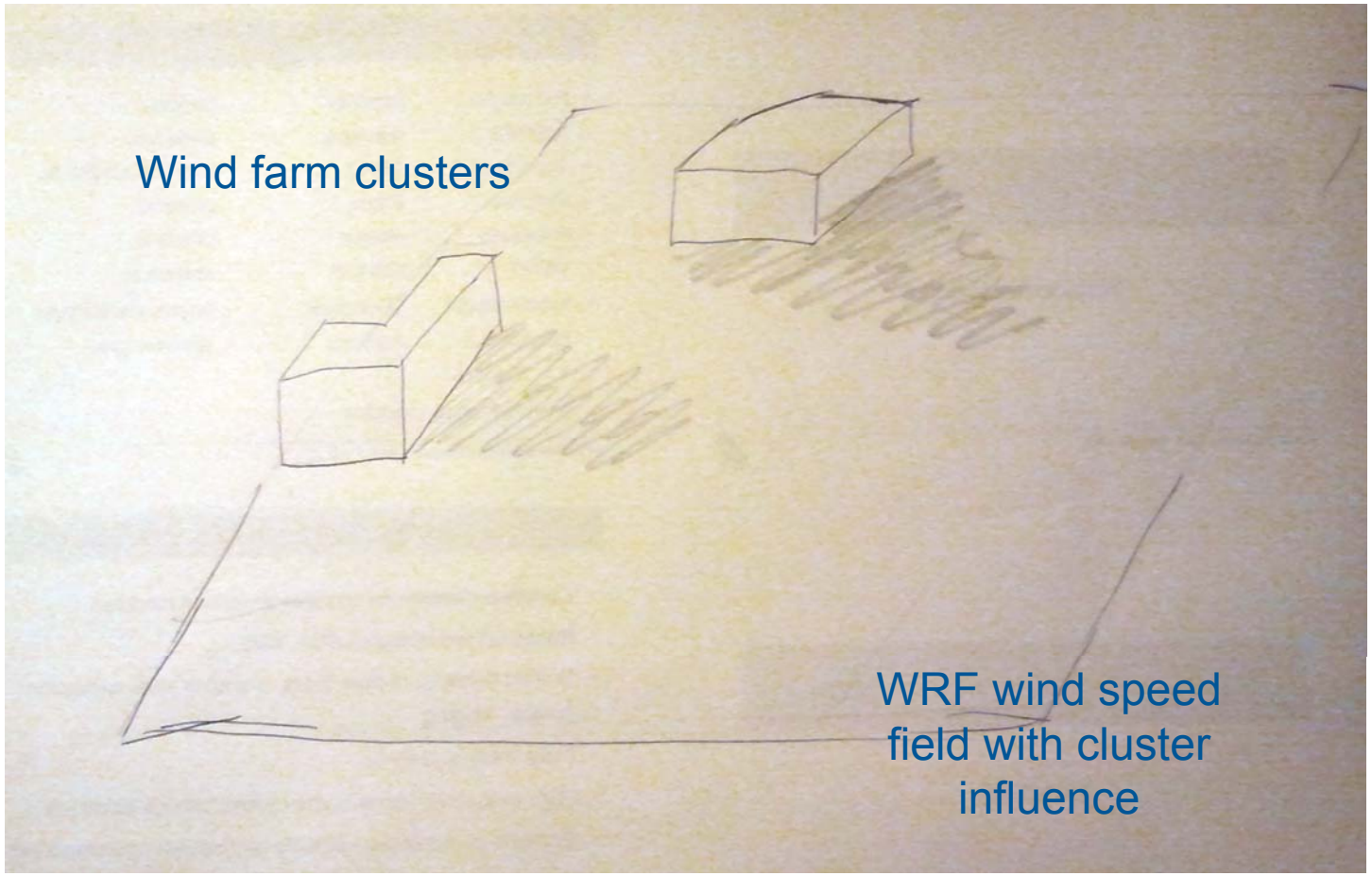
4. Iterate steps 1 to 3

Score: Levelized cost of energy

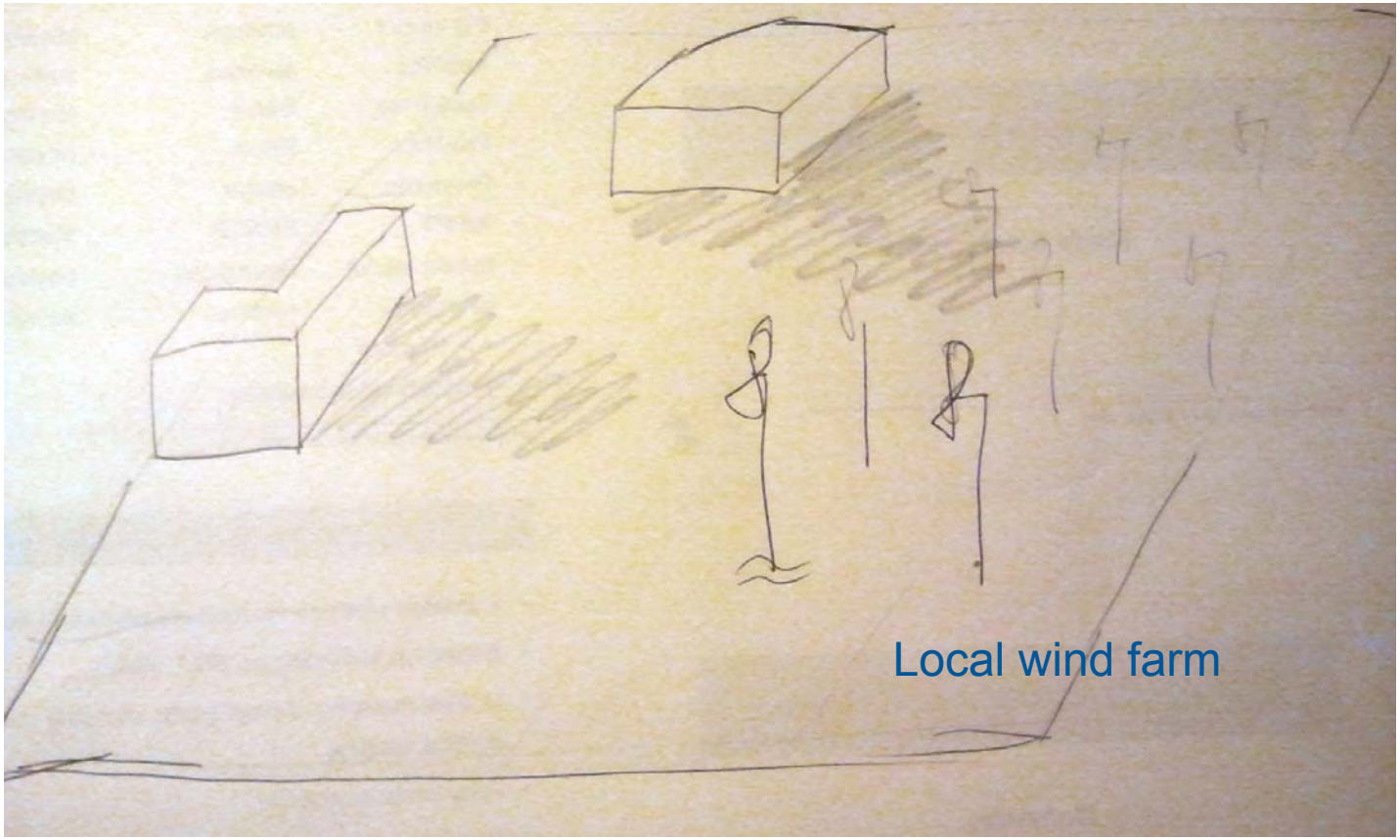
What decision parameter can we use to compare design options?

Model Chains

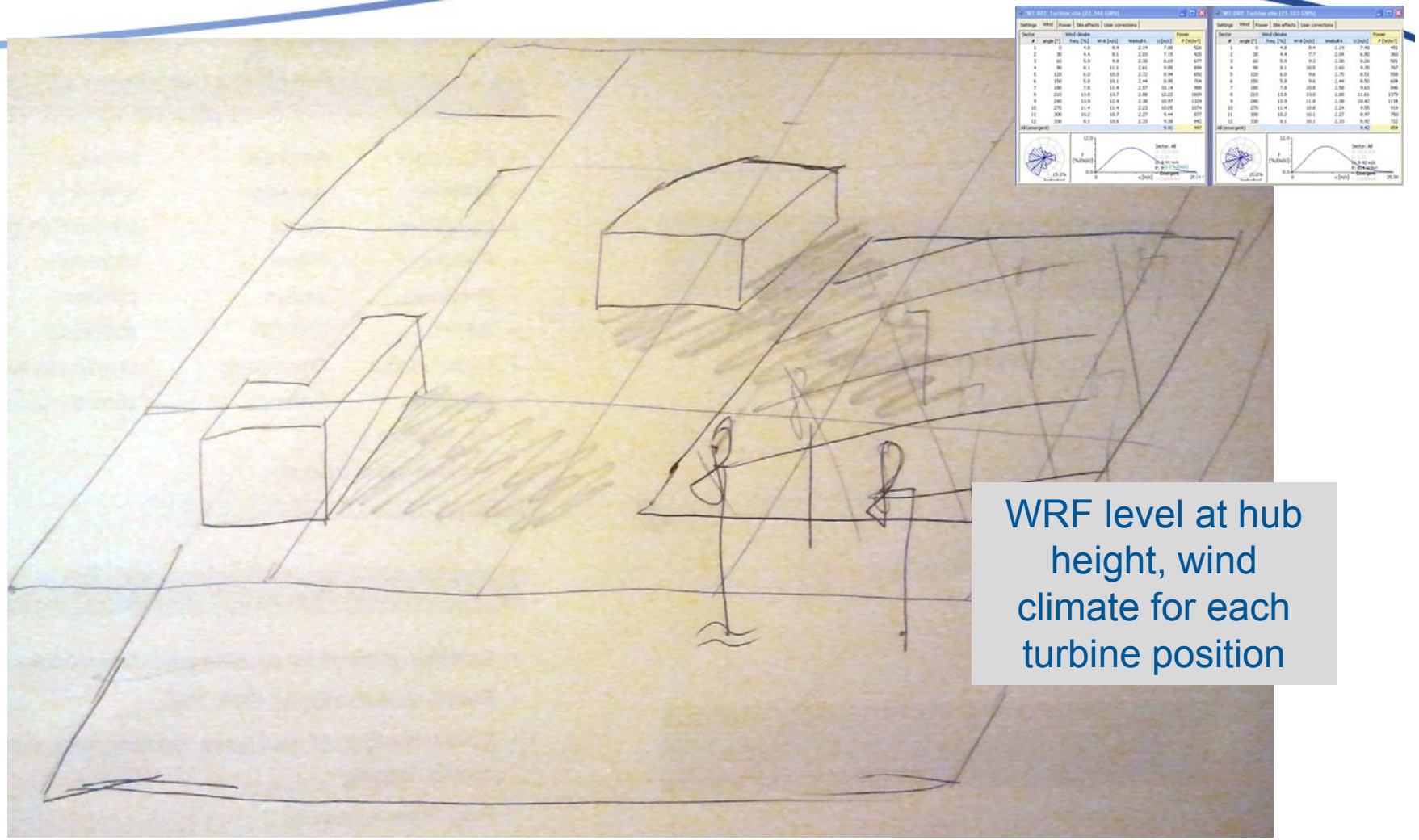
Wind climate/Wind farm model coupling



Wind climate/Wind farm model coupling

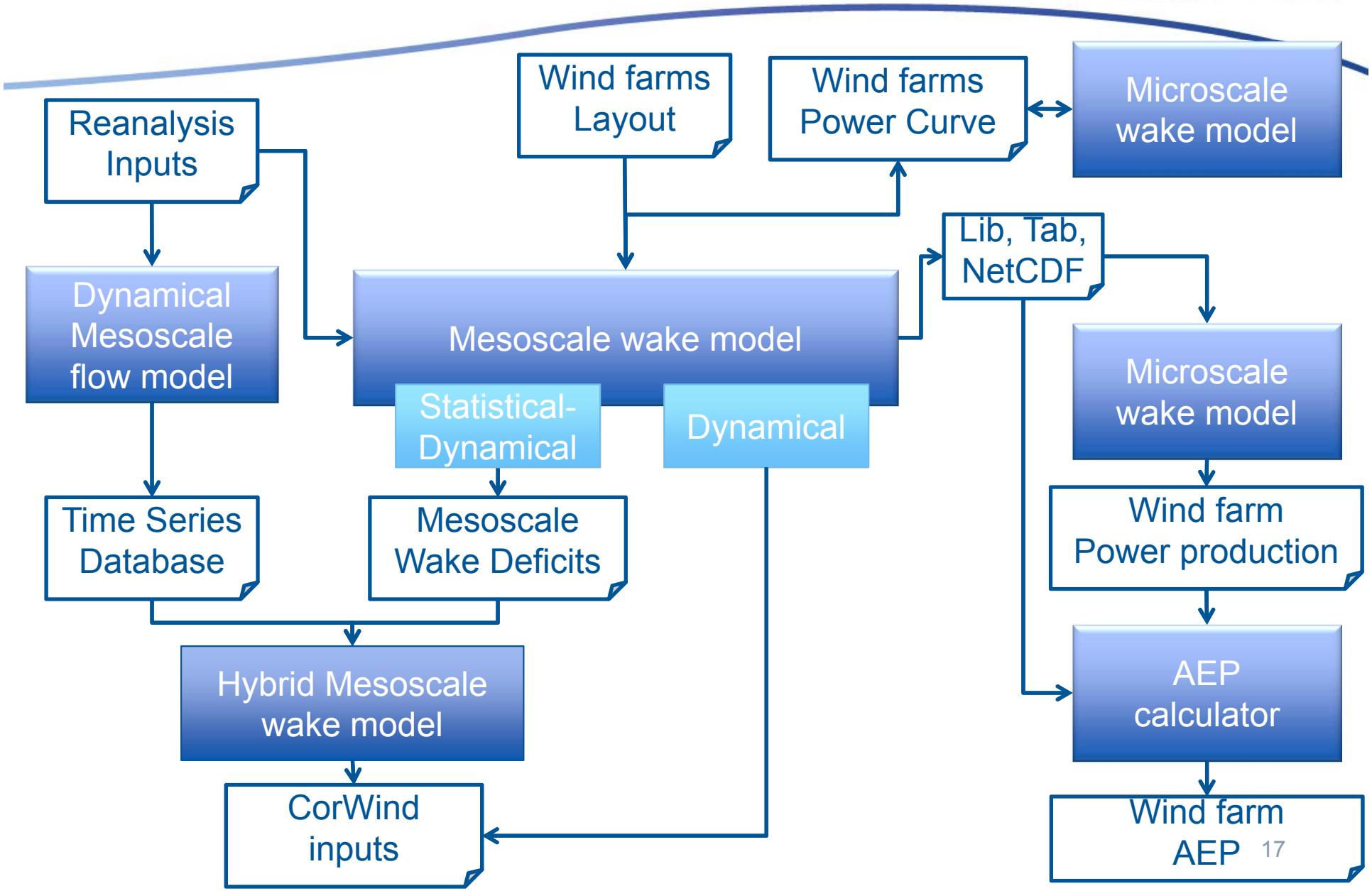


Wind climate/Wind farm model coupling ctd.

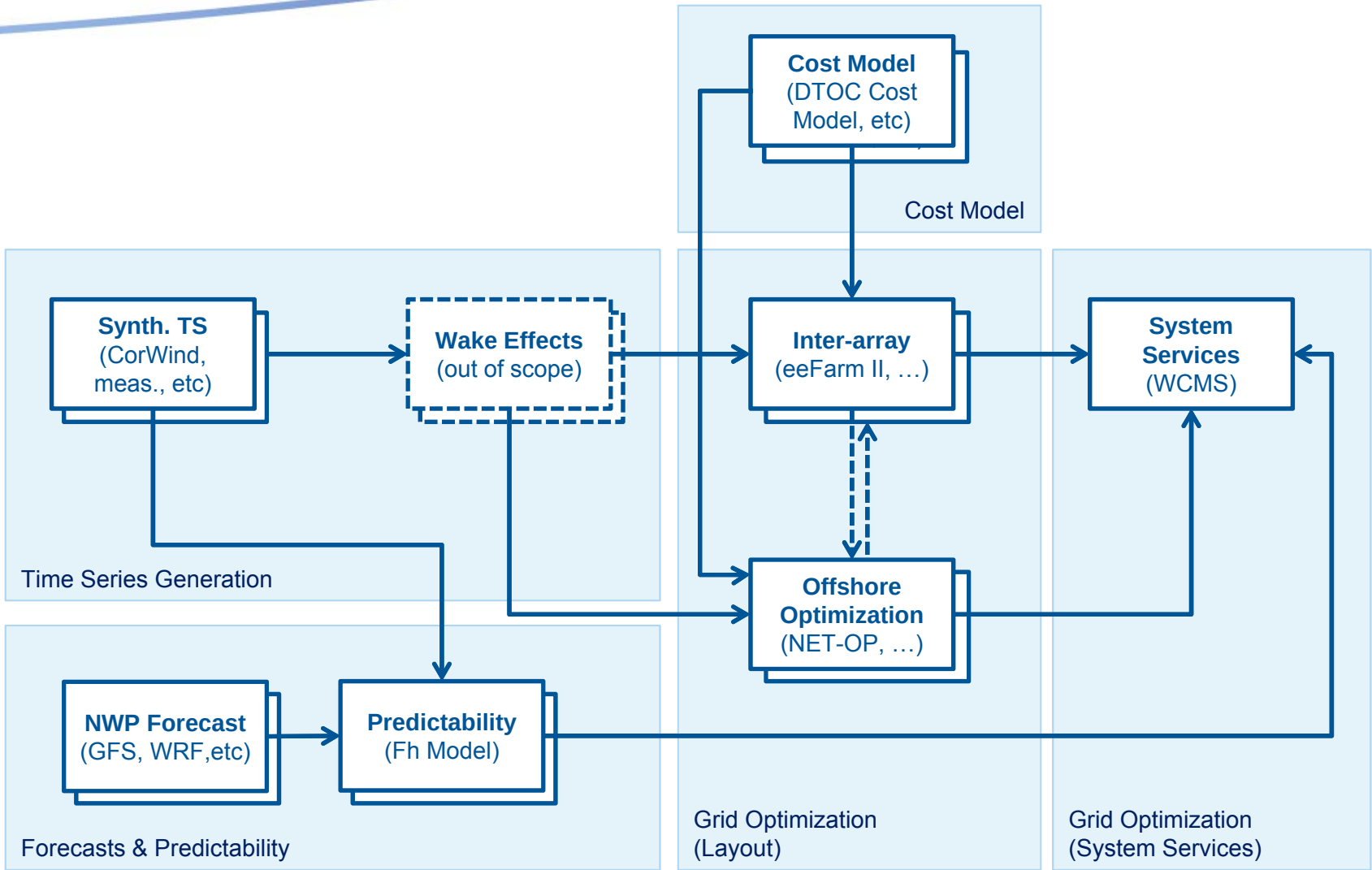


WRF level at hub height, wind climate for each turbine position

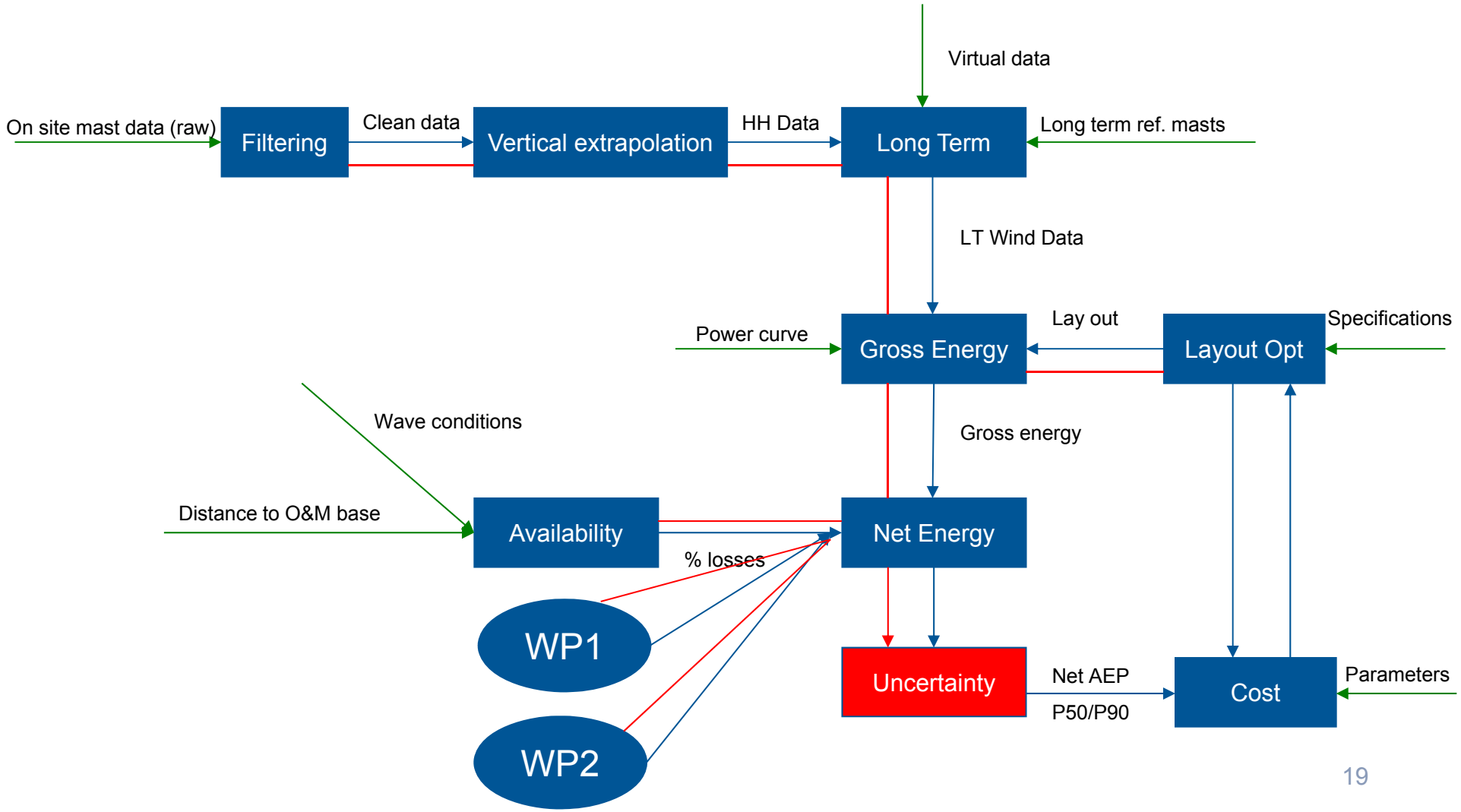
Model Workflow WP1



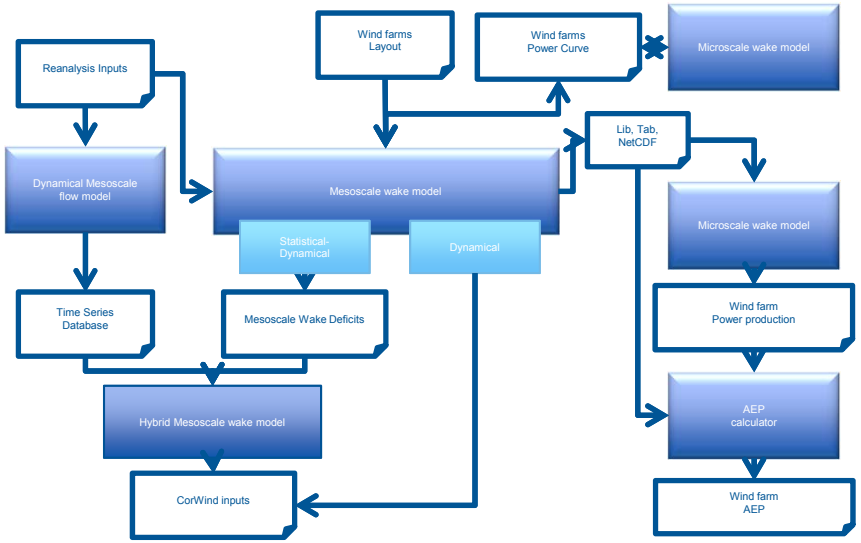
Model Workflow “Electrical”

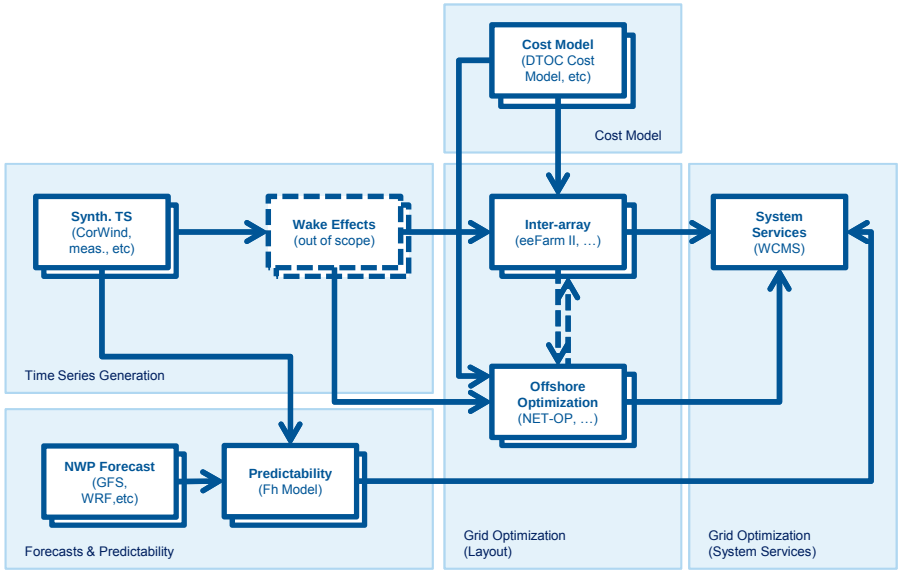


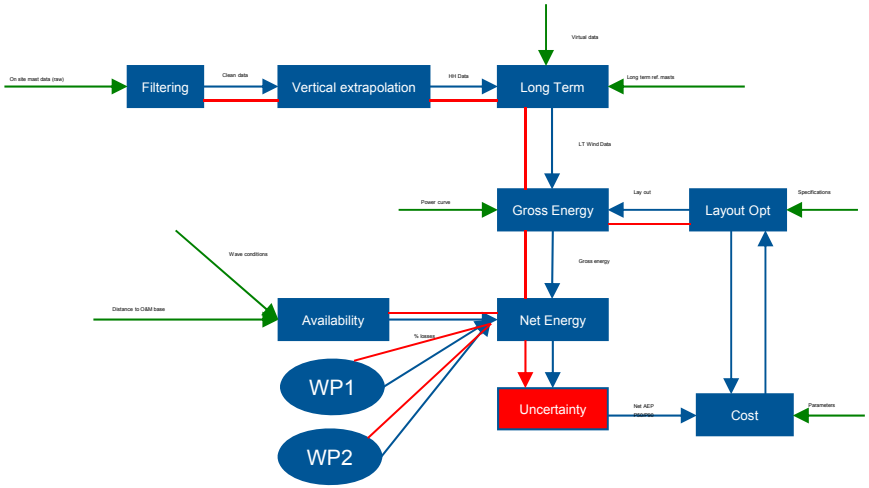
Yield modelling



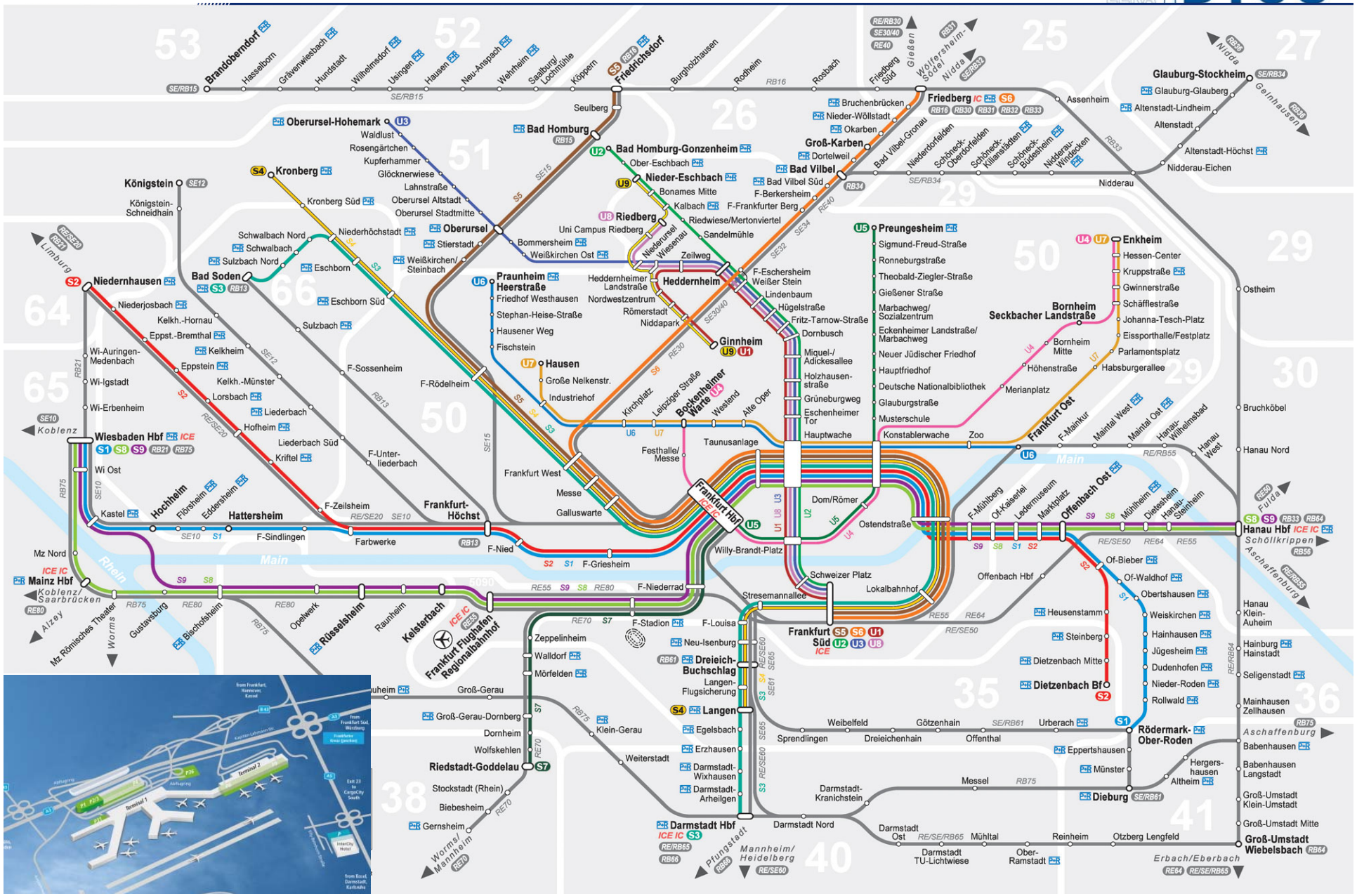
Total tool overview







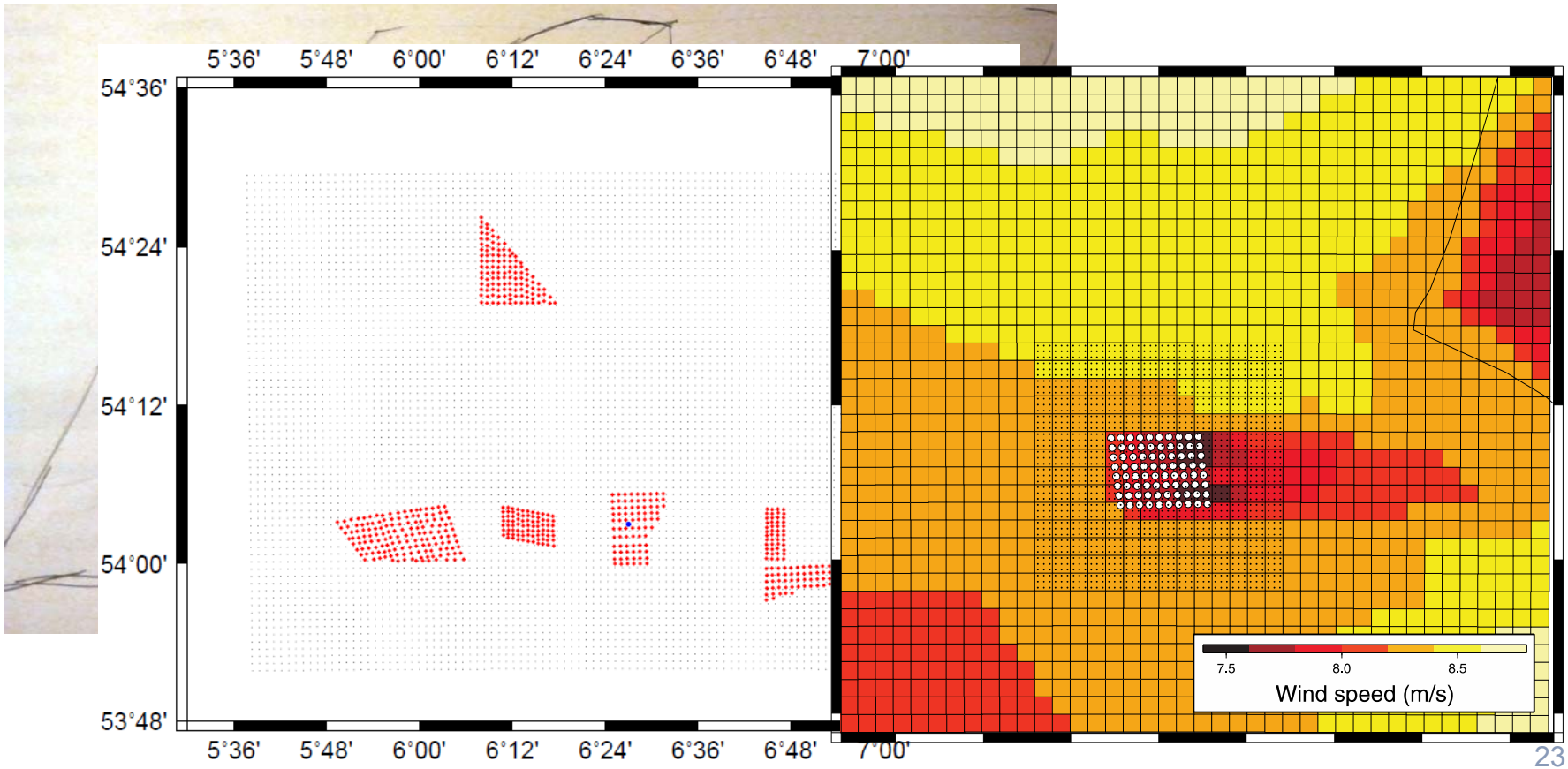
Total tool overview – very complex!



Applications

Example User Story

As a developer, I can determine the wake effects of neighbouring wind farm clusters on a single wind farm.



Ex: Energy prod. of single farm in cluster

Wind farm clusters/meso-scale effects

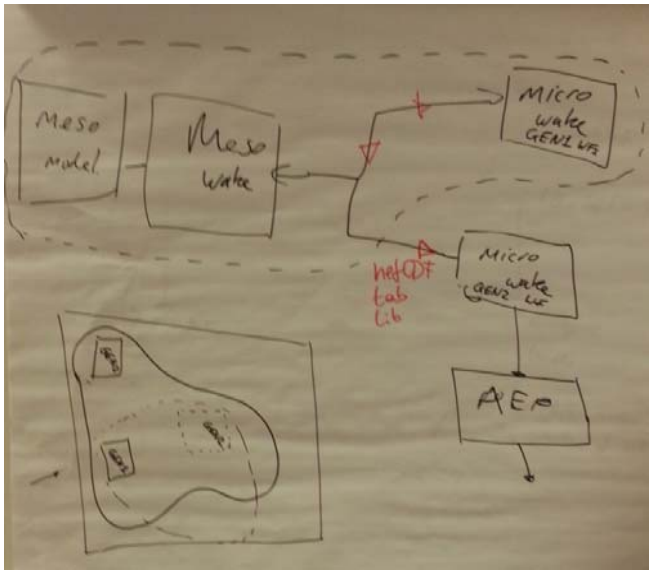
Wind speed field with wind farm cluster influence

Single wind farm model

Wind farm AEP with consideration of cluster influence

WRF with wind farm extension:
WRF @ Risoe DTU
WRF @ Ciemat

WAsP/Park
FarmFlow
Jensen model

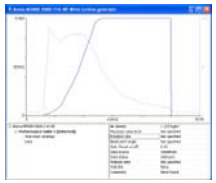


WRF/Farm model coupling

DTOC XML

Turbine clusters

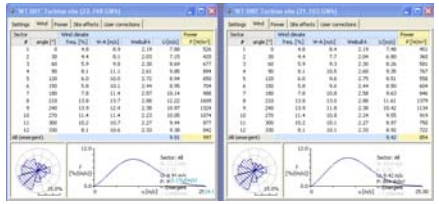
Turbine types



Turbine types

Turbine positions single farm

Representative meteo



Turbine positions

Turbine types

WRF

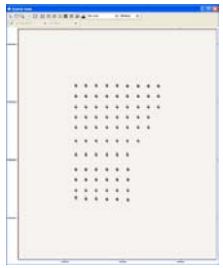
WRF netCDF

Tab for each wturbine site

WAsP

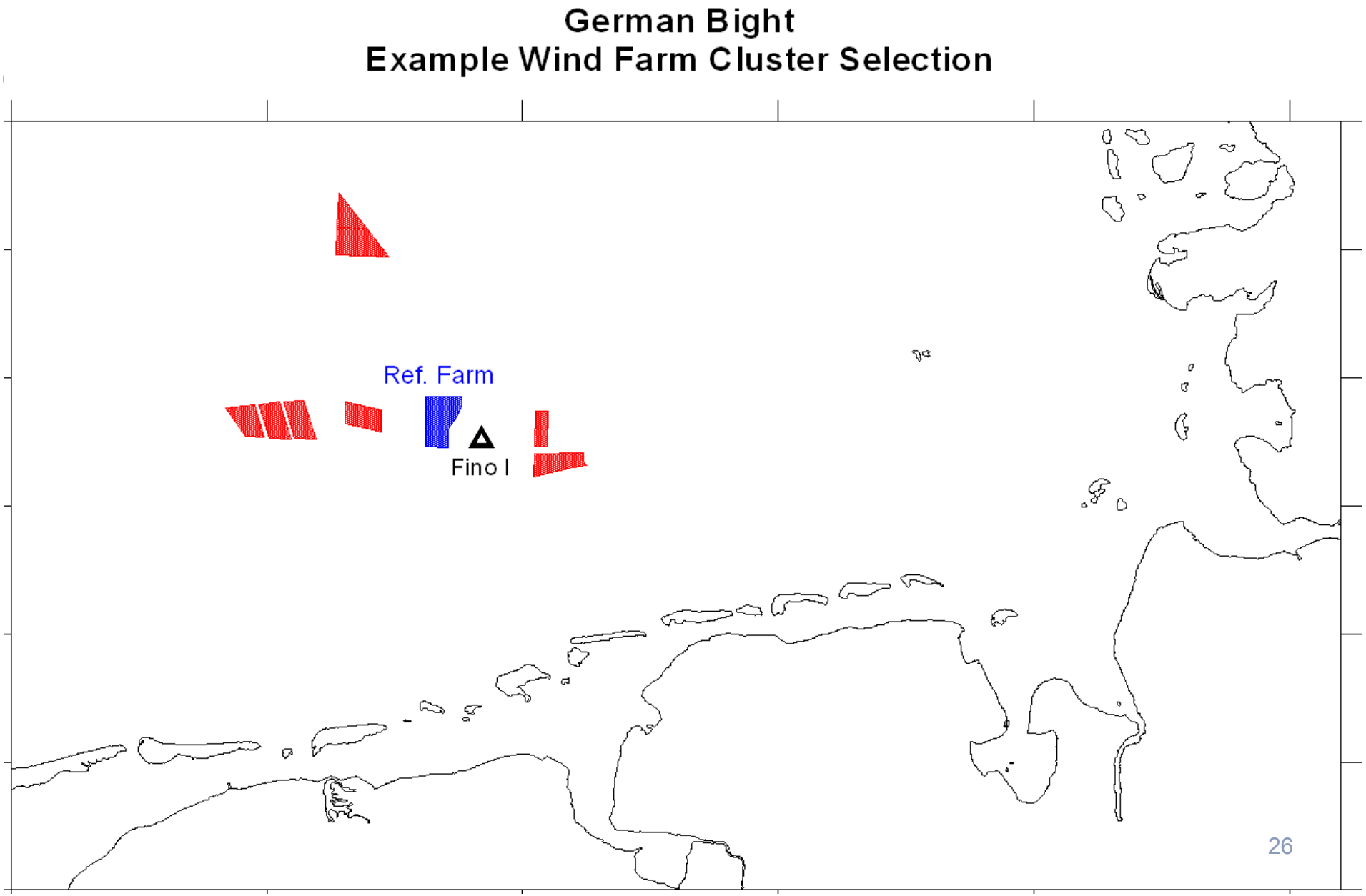
Park

AEP

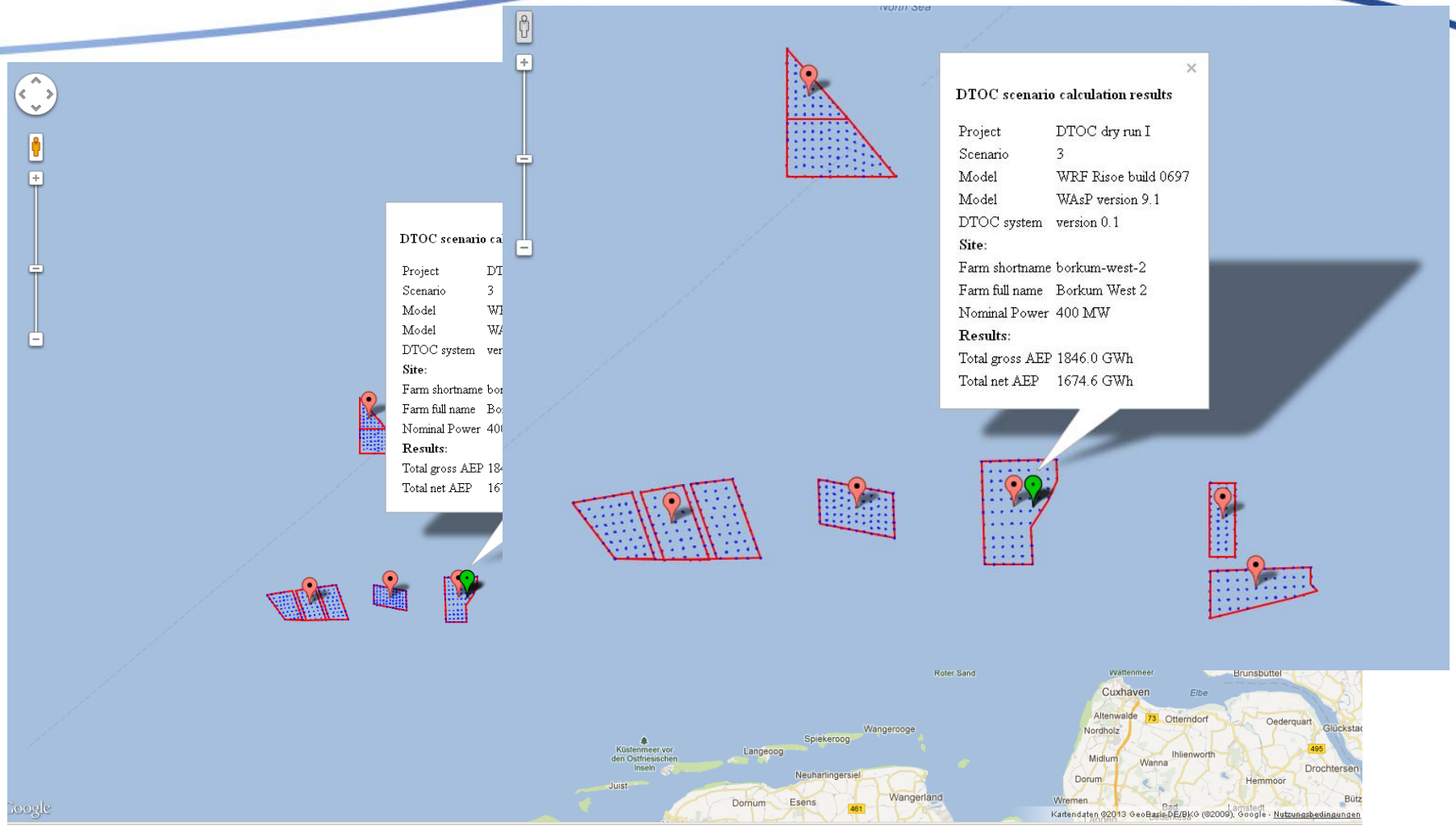


Google maps

Ex: Calculate one farm in presence of Cluster



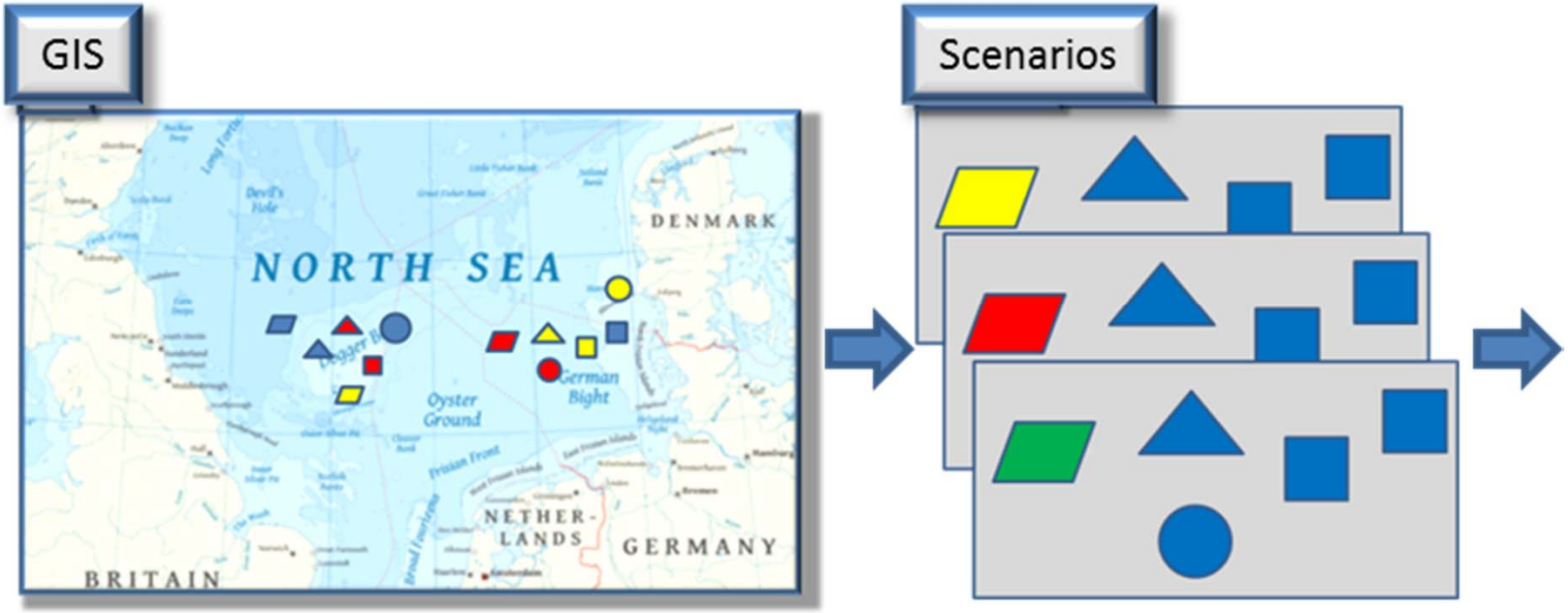
WRF/Farm model coupling Google maps



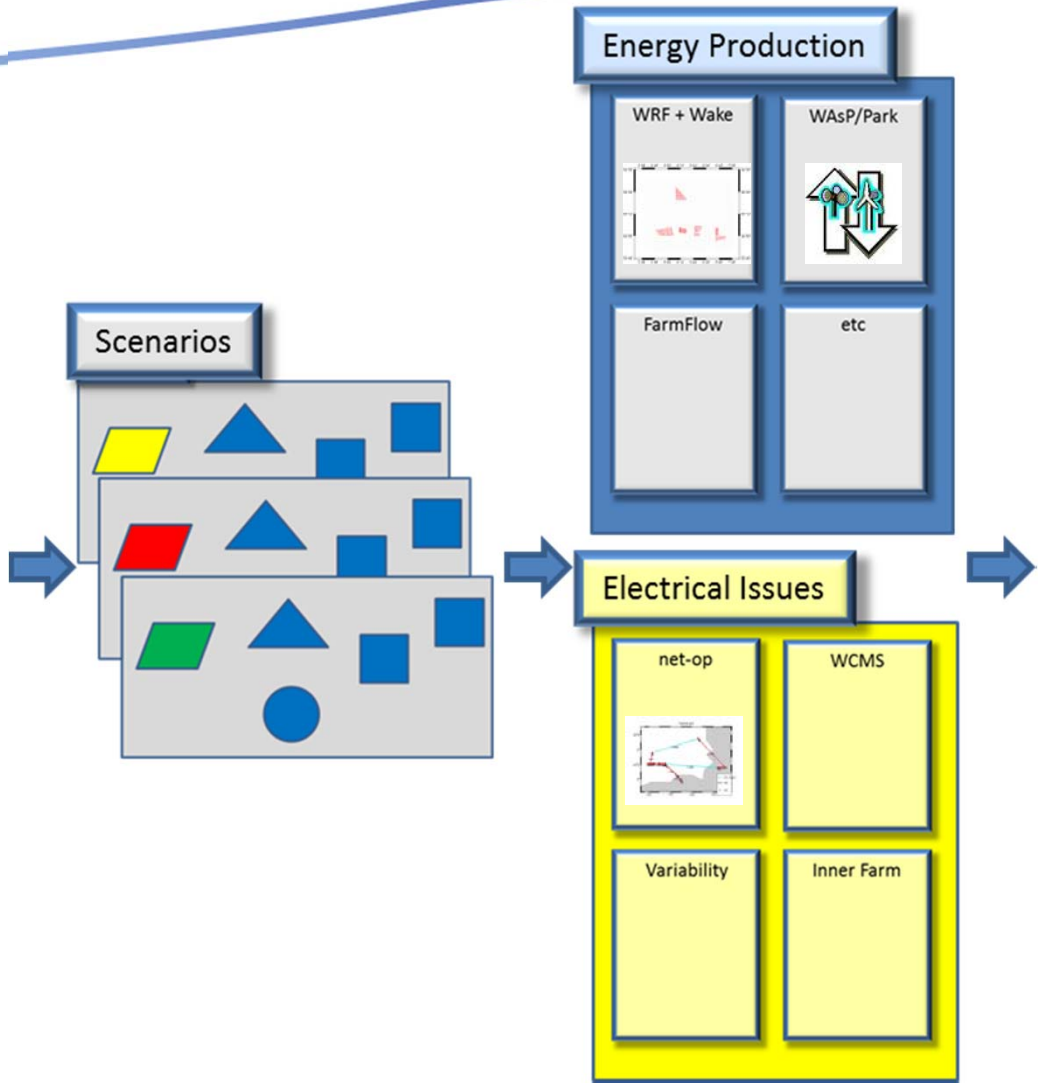
One transp. From IWES power plant behaviour of cluster

The Software Product

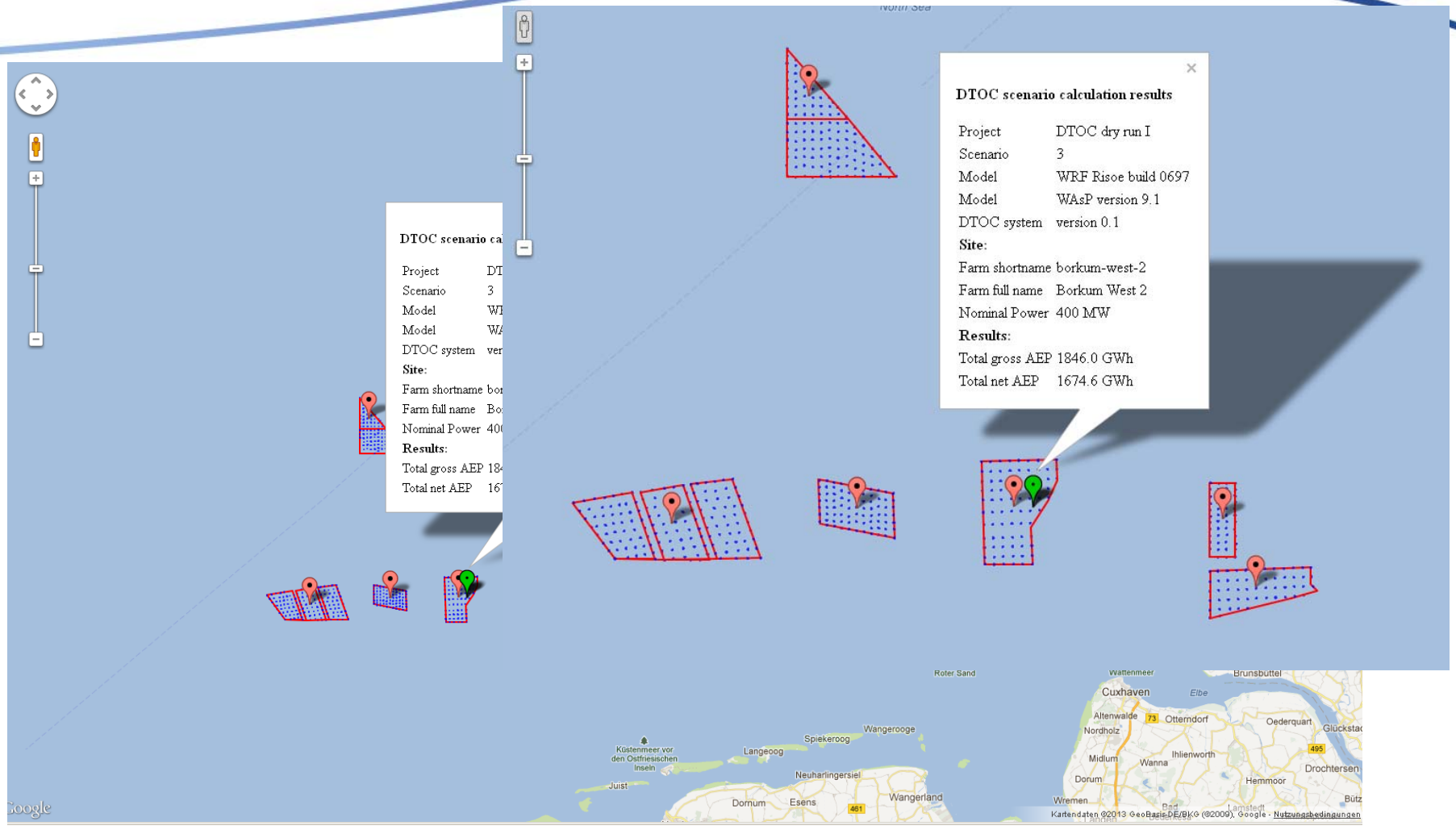
Handling and Comparing Scenarios



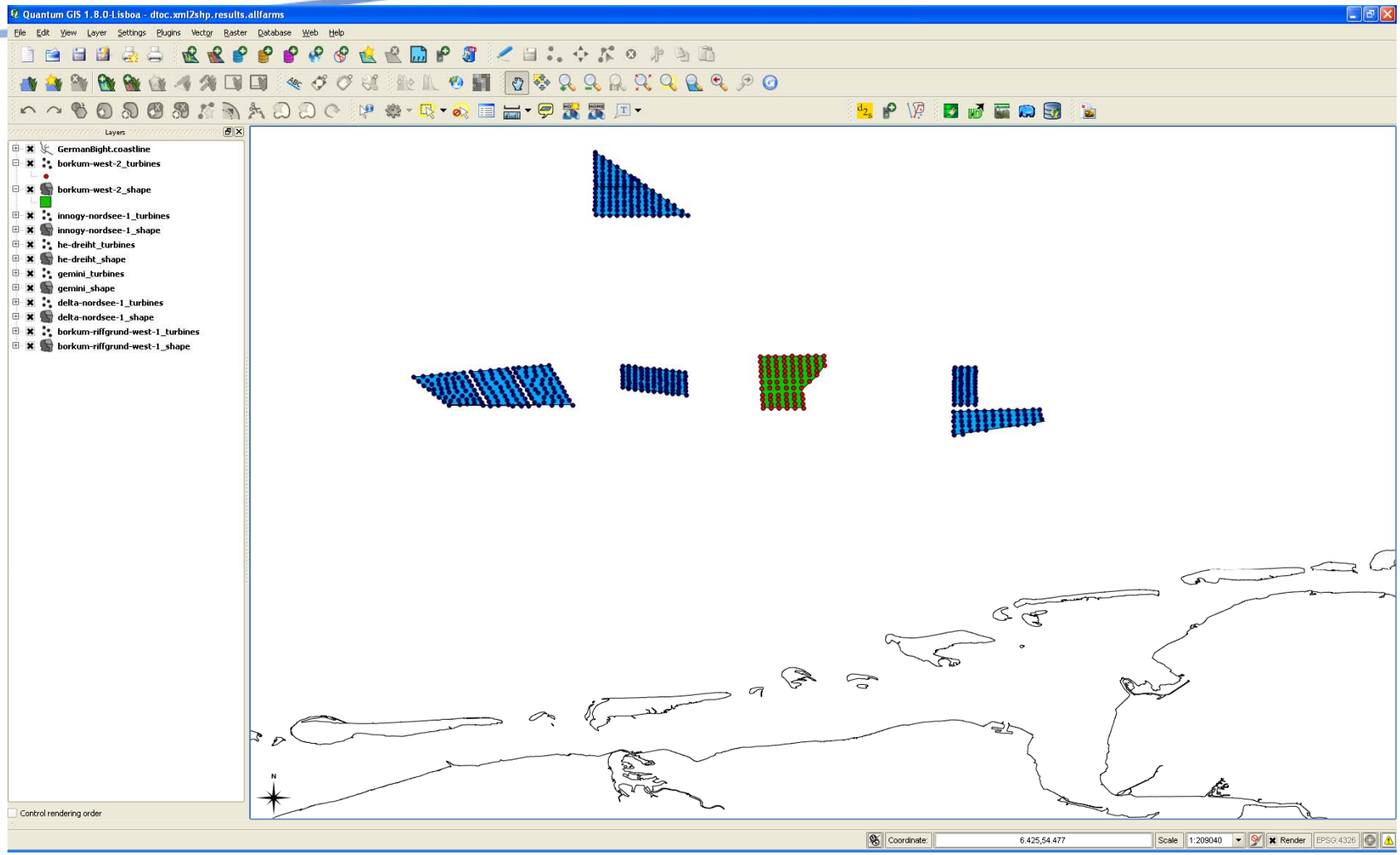
Modelling: Energy and Electrical Part



Graphical and tabular reporting



GIS integration



Converts DTOC XML ↔ ESRI Shapefiles *(industry standard)*

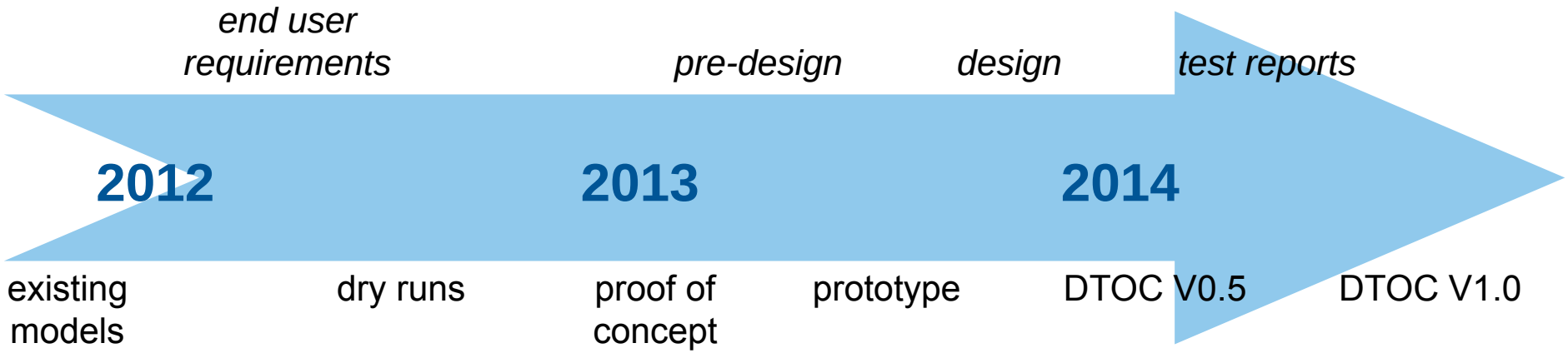
Open interfaces

- The sub-models are protected by IPR…
- …but the interfaces in the model chain are going to be open

- File formats for data exchange are based on existing industry standard formats, e.g. the WAsP types based on XML

Conclusion

DTOC software development timeline



DTOC: From concepts to product