

TOPFARM2 - Wind Farm Optimization Framework

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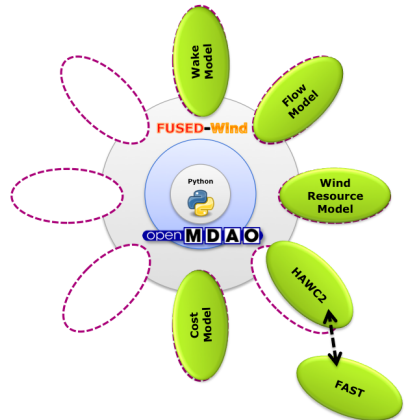
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Outline

- 1 FUSED-Wind
- 2 FUSED-Wake
- 3 TOPFARM
- 4 Application

Connecting All Wind Energy Models in a Workflow

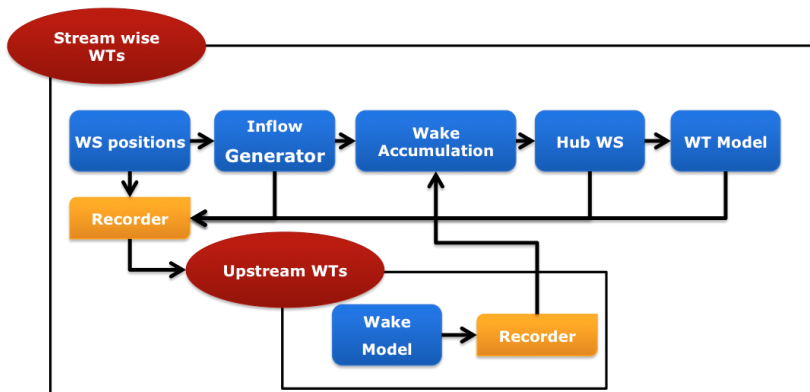
- ◆ Collaborative effort between DTU and NREL to create a **F**ramework for **U**nified **S**ystem **E**ngineering and **D**esign of **W**ind energy plants.
- ◆ Based on OpenMDAO, a python based Open source framework for **M**ulti-**D**isciplinary **A**nalysis and **O**ptimization.
- ◆ FUSED-Wind will offer built in capabilities for Uncertainty Quantification, Machine Learning and Optimization



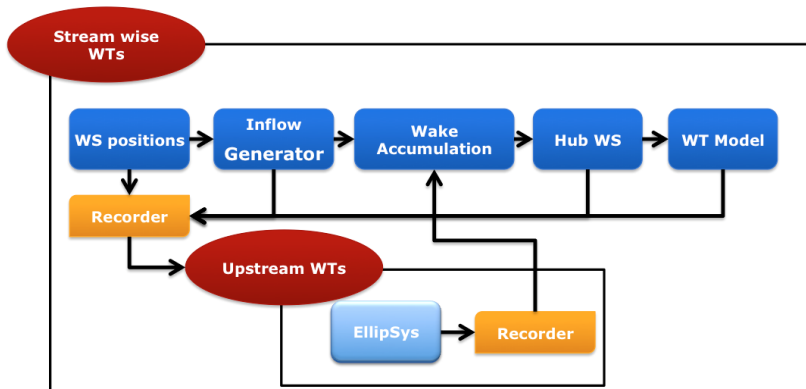


- ◆ Collaborative open source tool developed by DTU
- ◆ General purpose (AEP, Loads, Optimization, steady/unsteady)
- ◆ Modular (workflow divided in sub components)
- ◆ Each component is "swappable"
- ◆ Each component have multiple fidelity levels
- ◆ Derivatives friendly (faster Uncertainty Quantification & Optimization)
- ◆ Open Source framework + Closed source subcomponents
- ◆ Alpha version is ready for testing

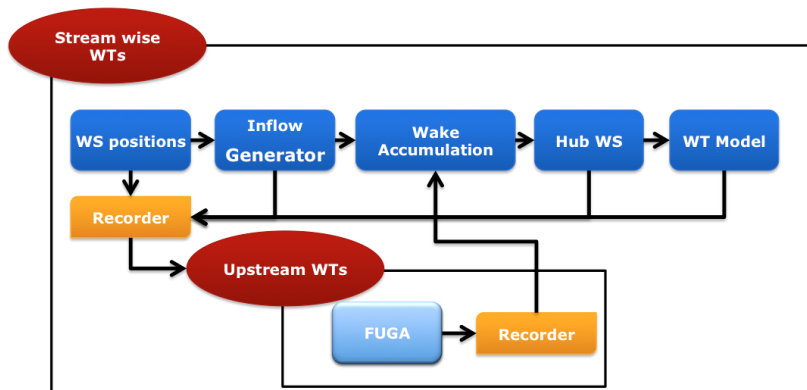
FUSED-Wake



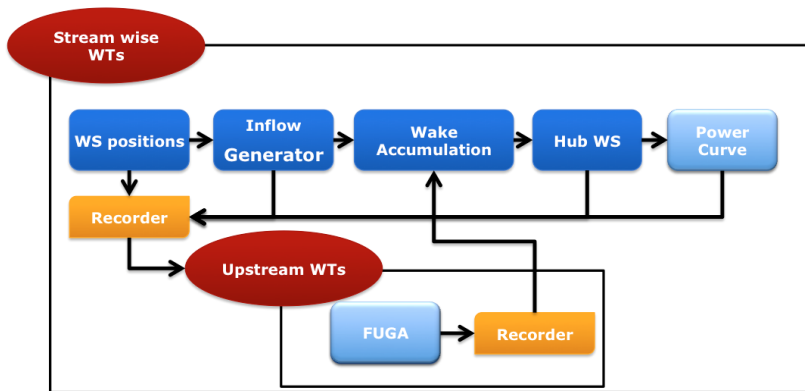
FUSED-Wake



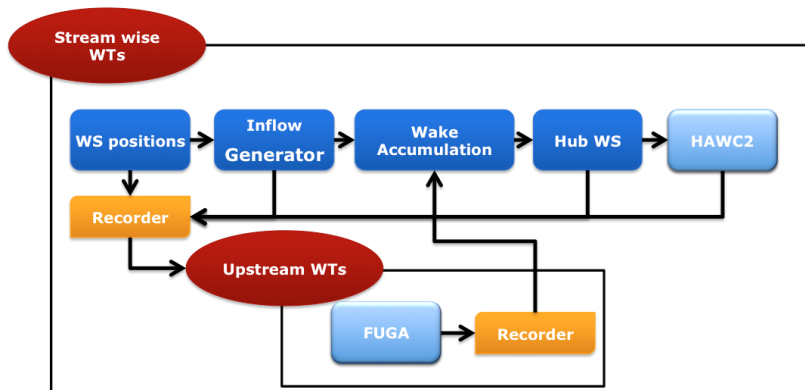
FUSED-Wake



FUSED-Wake



FUSED-Wake



FUSED-Wake

Stream wise

FUGA

FUSED-Wake

Stream wise

EllipSys
AL/LES

TOPFARM

- ◆ TOPFARM = Topology OPTimization of wind FARM
- ◆ EU-FP6 Funded project 2006-2010
- ◆ Multi-fidelity framework for wind farm layout optimization
- ◆ Optimization from the wind farm developer perspective
- ◆ Objective function is the wind farm lifetime financial balance
- ◆ The cost models take into account:
 - ◆ Wake effects on power production
 - ◆ Wake effects on wind turbines components fatigue
 - ◆ Offshore foundation costs
 - ◆ Electrical grid cabling
 - ◆ Financial parameters

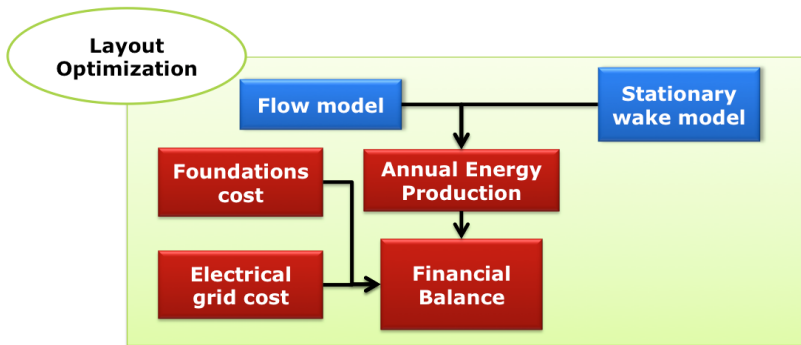
TOPFARM II

- ◆ Framework based on FUSED-Wind
- ◆ Use WAsP & WRF engine to calculate accurate local wind resources
- ◆ Multi-fidelity wake model based on FUSED-Wake
- ◆ 3rd level of fidelity: running the whole wind farm with dynamic wake models (DWM & AL/LES)
- ◆ More advanced multi-fidelity optimization strategy
- ◆ Higher degree of parallelization
- ◆ Expert driven iterative design process
- ◆ GUI connected to WAsP

TOPFARM II

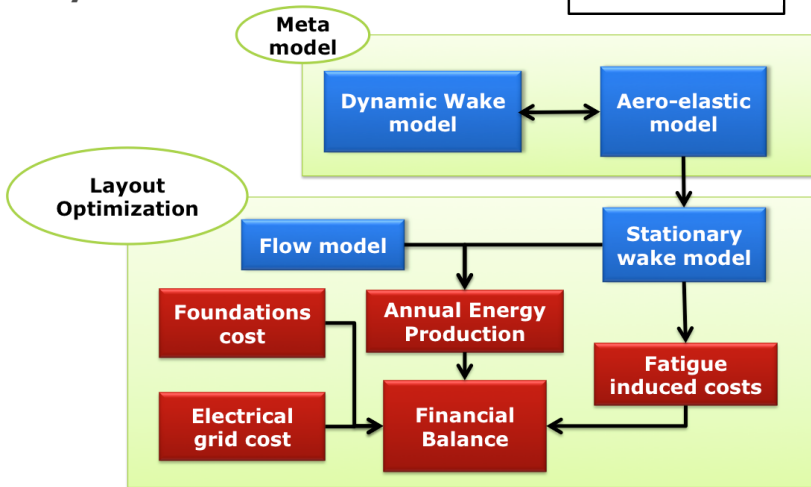
System Overview

Multi-fidelity:
1st Level



TOPFARM II System Overview

Multi-fidelity:
2nd Level



TOPFARM II System Overview

**Multi-fidelity:
2nd Level**

Meta
model

Dynan
model

FUSED-Wake

Elastic
model

Layout
Optimization

Flow model

Stationary
wake model

Foundations
cost

Annual Energy
Production

Fatigue
induced costs

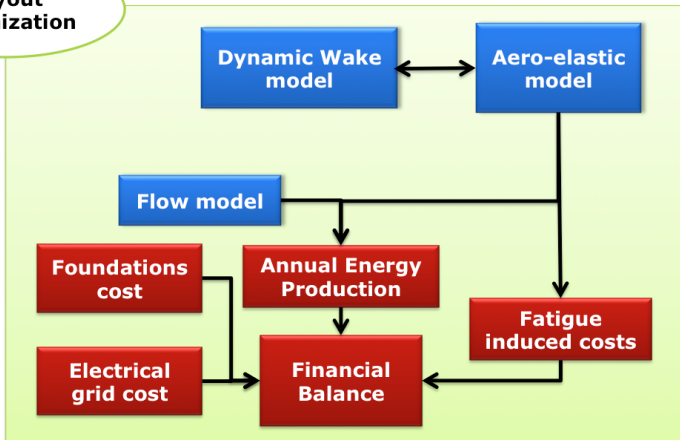
Electrical
grid cost

Financial
Balance

TOPFARM II System Overview

Multi-fidelity:
3rd Level

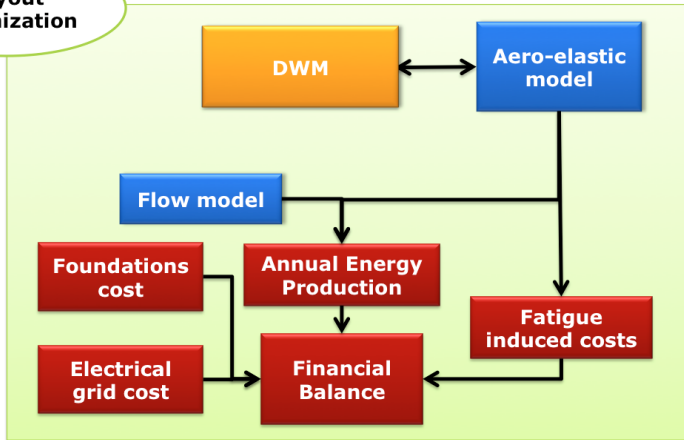
Layout
Optimization



TOPFARM II System Overview

Multi-fidelity:
3rd Level

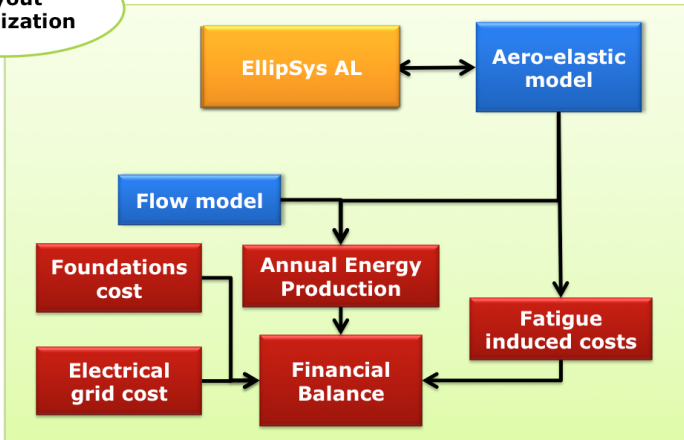
Layout
Optimization



TOPFARM II System Overview

Multi-fidelity:
3rd Level

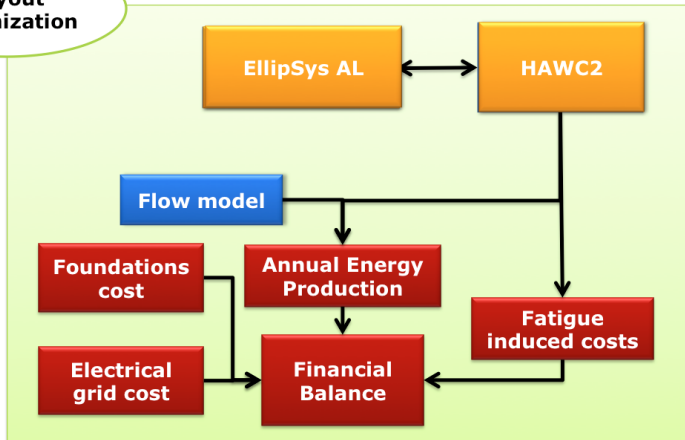
Layout
Optimization



TOPFARM II System Overview

Multi-fidelity:
3rd Level

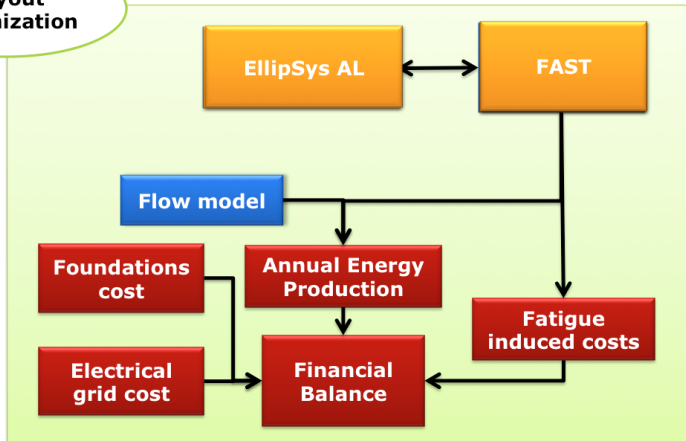
**Layout
Optimization**



TOPFARM II System Overview

Multi-fidelity:
3rd Level

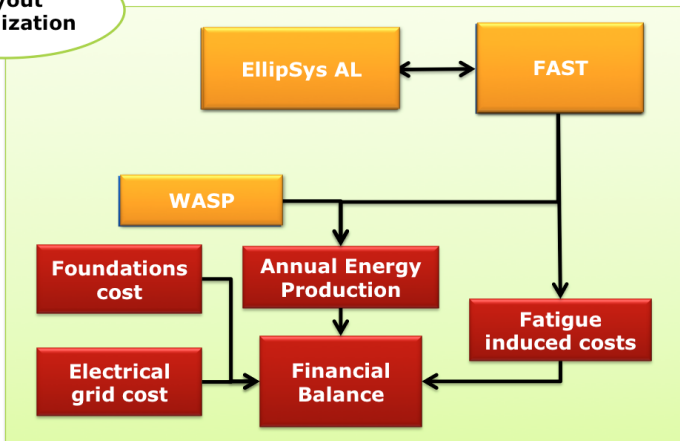
**Layout
Optimization**



TOPFARM II System Overview

Multi-fidelity:
3rd Level

**Layout
Optimization**



TOPFARM II System Overview

Multi-fidelity:
3rd Level

**Layout
Optimization**

