



ClusterDesign

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Cluster Design Toolbox for integrated Cluster design (WP5)

ERA DTOC workshop June 2013

FP7-ENERGY-2011
283145 / ClusterDesign





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Presentation Outline

- WP5 objectives & toolbox overview
- Design/ Operation and use in real-life applications
- IT infrastructure

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Presentation Outline

- **Objectives/ Overview**
- Use
- IT infrastructure

Objectives

- Toolbox specification (functionality)
- Integration of models
 - IT platform
 - Models interaction
 - Measurements and simulations DB
- User interface
 - Data import/export
 - User summary view
 - Farm/cluster layout(s)



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Presentation Outline

- **Objectives/ Overview**
- Use
- IT infrastructure

Product specifications/ user needs



**Imperial College
London**



- Wind farms interaction within a cluster (Wakes)
- Farm topology (Yield vs loads & control)
- Grid connection (topology & losses)
- Operations (Control)

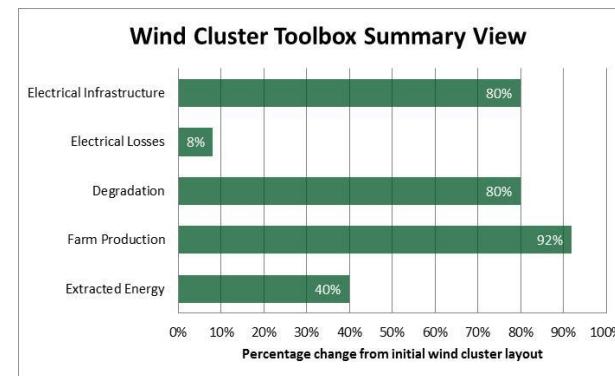
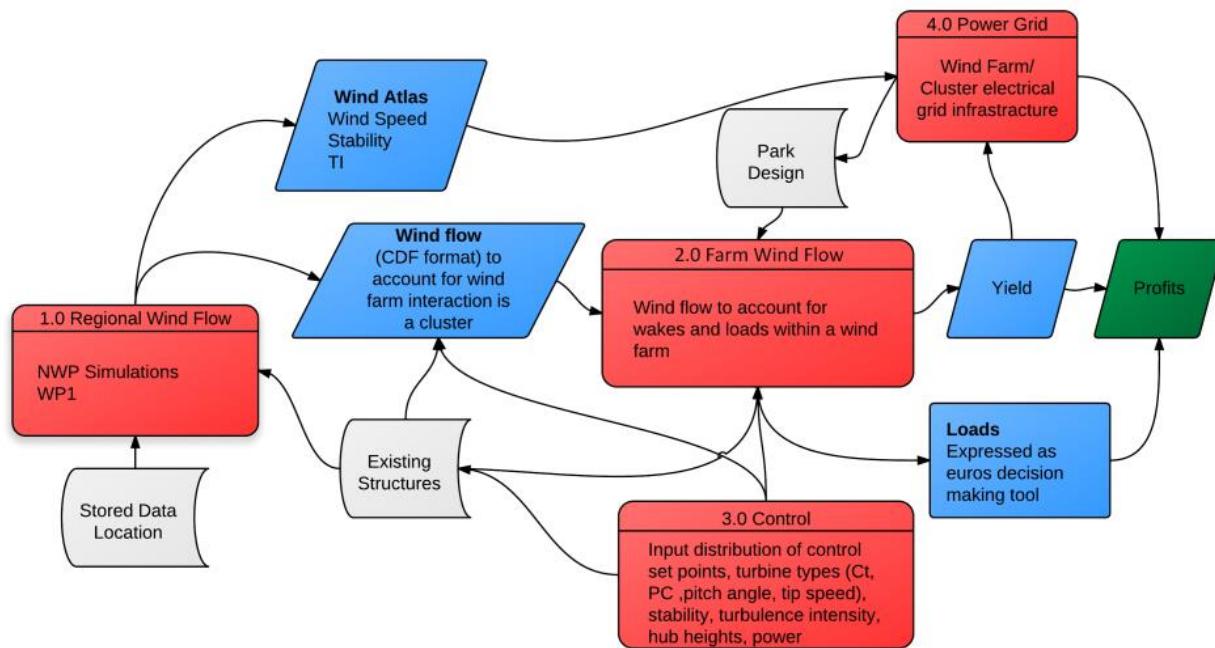
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Cluster design toolbox

Presentation Outline

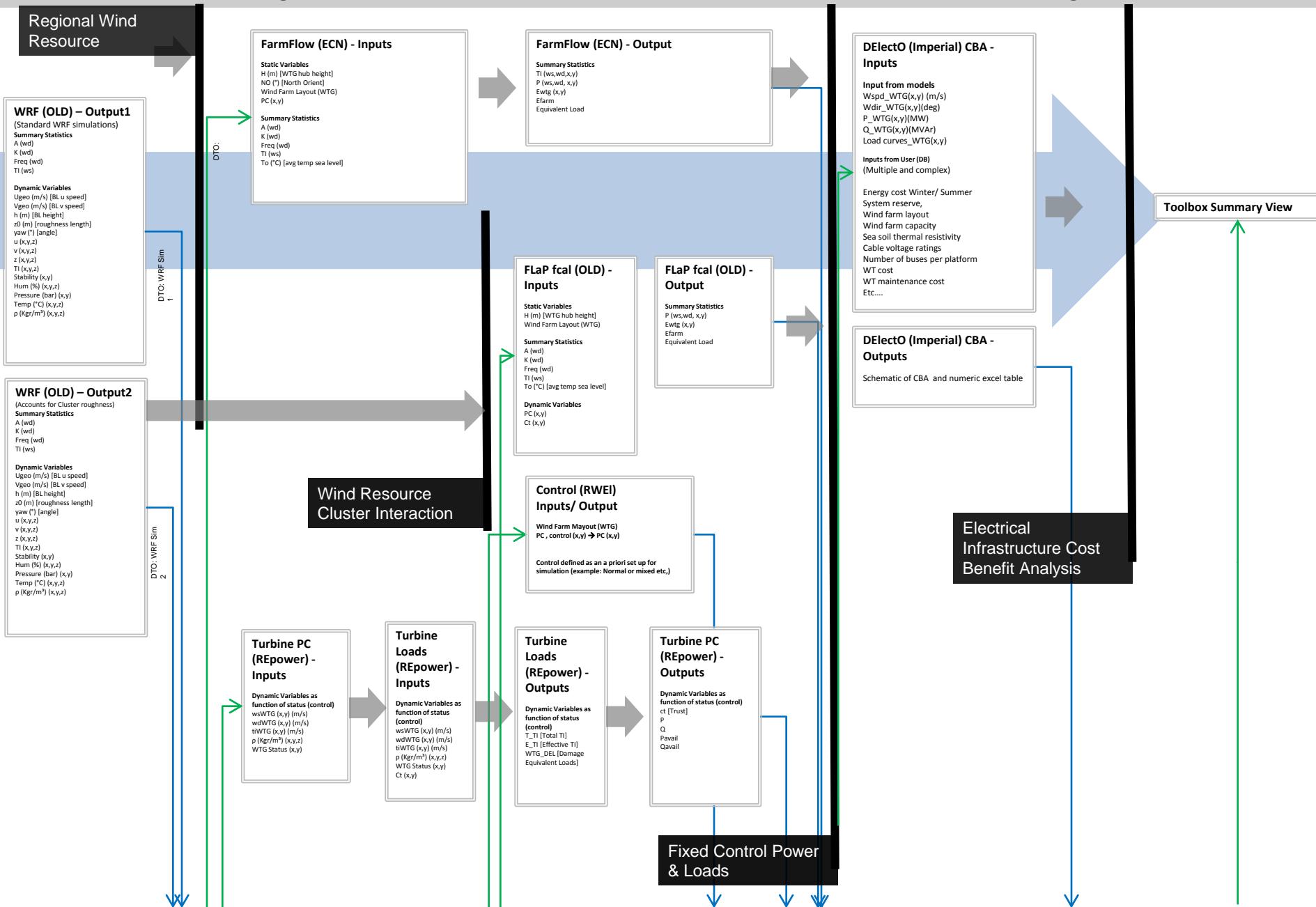
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Design Mode
Operations Mode

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Cluster Design Toolbox – Variables and computational flow – Design mode A



Cluster Design Toolbox – Variables and computational flow – Design mode B

Regional Wind Resource

WRF (OLD) – Output1

(Standard WRF simulations)

Summary Statistics
A (wd)
K (wd)
Freq (wd)
Ti (ws)

Dynamic Variables
Ugeo (m/s) [Bl. u speed]
Vgeo (m/s) [Bl. v speed]
h (m) [Bl. height]
z0 (m) [roughness length]
yaw (*) [angle]
u (x,y,z)
v (x,y,z)
z (x,y,z)
Ti (x,y,z)
Stability (x,y)
Hum (%) (x,y,z)
Pressure (bar) (x,y)
Temp (°C) (x,y,z)
p (kg/m³) (x,y,z)

WRF (OLD) – Output2

(Accounts for Cluster roughness)

Summary Statistics
A (wd)
K (wd)
Freq (wd)
Ti (ws)

Dynamic Variables
Ugeo (m/s) [Bl. u speed]
Vgeo (m/s) [Bl. v speed]
h (m) [Bl. height]
z0 (m) [roughness length]
yaw (*) [angle]
u (x,y,z)
v (x,y,z)
z (x,y,z)
Ti (x,y,z)
Stability (x,y)
Hum (%) (x,y,z)
Pressure (bar) (x,y)
Temp (°C) (x,y,z)
p (kg/m³) (x,y,z)

Wind Resource Cluster Interaction

PALM (OLD) - Inputs

Static Variables
Wind Farm Layout (WTG)
H (m) [WTG hub height]
R (m) [Rotor diameter]
Ct [Trust curve]

Dynamic Variables
WTG (time/step)
WTG (rpm) [Rotational speed]
dt (time/date) [regional flow time]
ch (m) [chord length]
Lift (N) [lift coefficient]
Drag (N) [drag coefficient]
Pitch (deg) [pitch angle]
Additional
Multiple complex inputs

PALM (OLD) - Outputs

U (m/s)
V (m/s)
W (m/s)
T (ms)
H (m)
P(P)
T (°C)
Ad (kg/m³)
P (kW)
E (kWh)

DElectO (Imperial) CBA - Inputs

Input from models
Wspd_WTG(x,y) (m/s)
Wdir_WTG(x,y)(deg)
P_WTG(x,y)(MW)
Q_WTG(x,y)(MVAR)
Load curves_WTG(x,y)

Inputs from User (DB)
(Multiple and complex)

Energy cost Winter/ Summer
System reserve,
Wind farm layout
Wind farm capacity
Sea soil thermal resistivity
Cable voltage ratings
Number of buses per platform
WT cost
WT maintenance cost
Etc....

Toolbox Summary View

Fixed Control Power & Loads

Control (RWEl) Inputs/ Output

Wind Farm Layout (WTG)
PC_c, control (x,y) → PC_c (x,y)
Control defined as a priori set up for simulation (example: Normal or mixed etc.)

Electrical Infrastructure Cost Benefit Analysis

DElectO (Imperial) CBA - Outputs

Schematic of CBA and numeric excel table

Turbine PC (REpower) - Inputs

Dynamic Variables as function of status (control)
wsWTG (x,y) (m/s)
wtWTG (x,y) (m/s)
nwWTG (x,y) (m/s)
p (kg/m³) (x,y,z)
WTG Status (x,y)

Turbine Loads (REpower) - Inputs

Dynamic Variables as function of status (control)
wsWTG (x,y) (m/s)
wtWTG (x,y) (m/s)
nwWTG (x,y) (m/s)
p (kg/m³) (x,y,z)
WTG Status (x,y)

Turbine Loads (REpower) - Outputs

Dynamic Variables as function of status (control)
T_c [Total TI]
E_cTI [Effective TI]
WTG_DEL [Damage Equivalent Loads]

Turbine PC (REpower) - Outputs

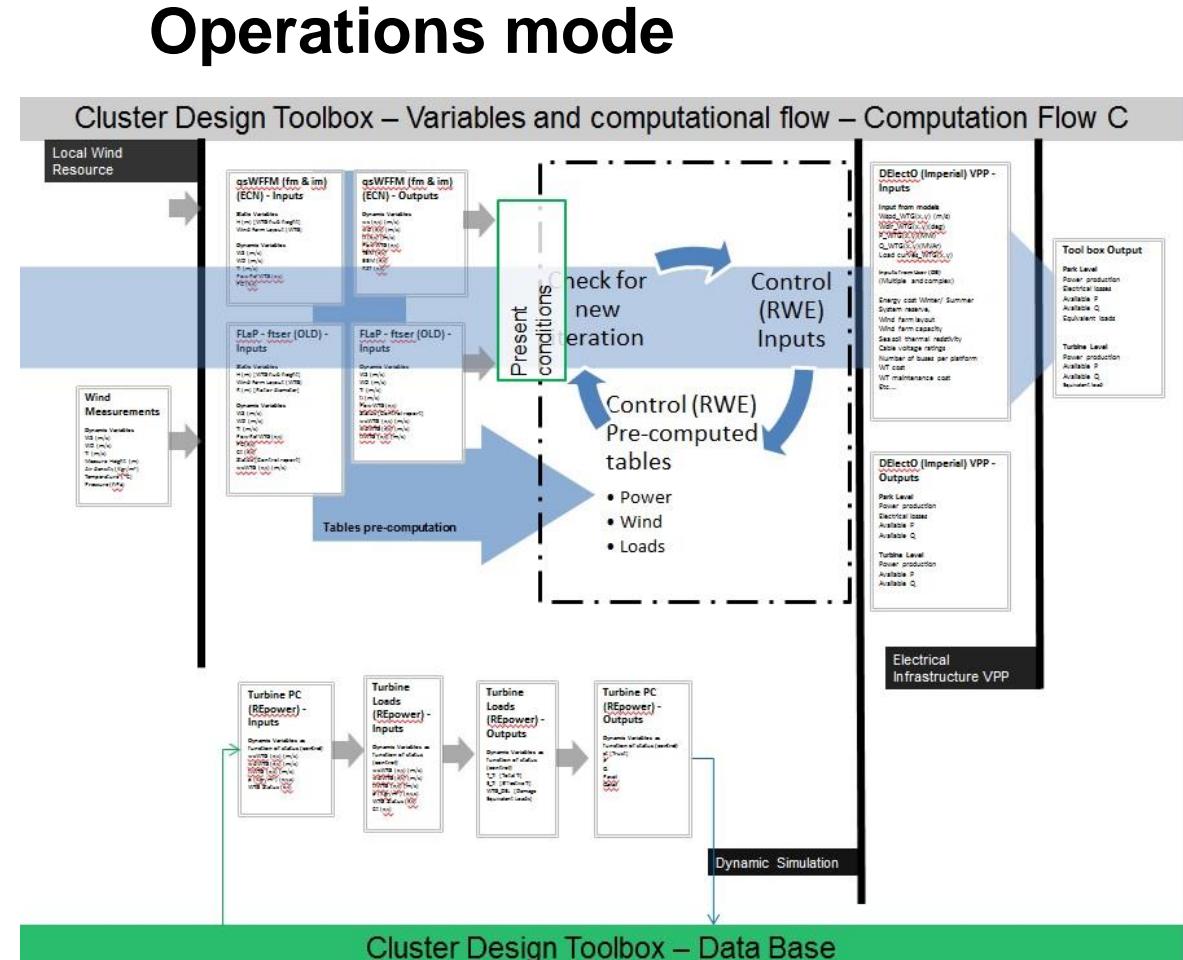
Dynamic Variables as function of status (control)
ct [Trust]
P
Q
Pavail
Qavail

Cluster Design Toolbox – Data Base



Presentation Outline

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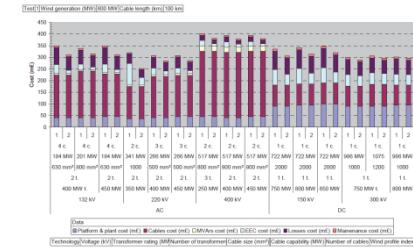
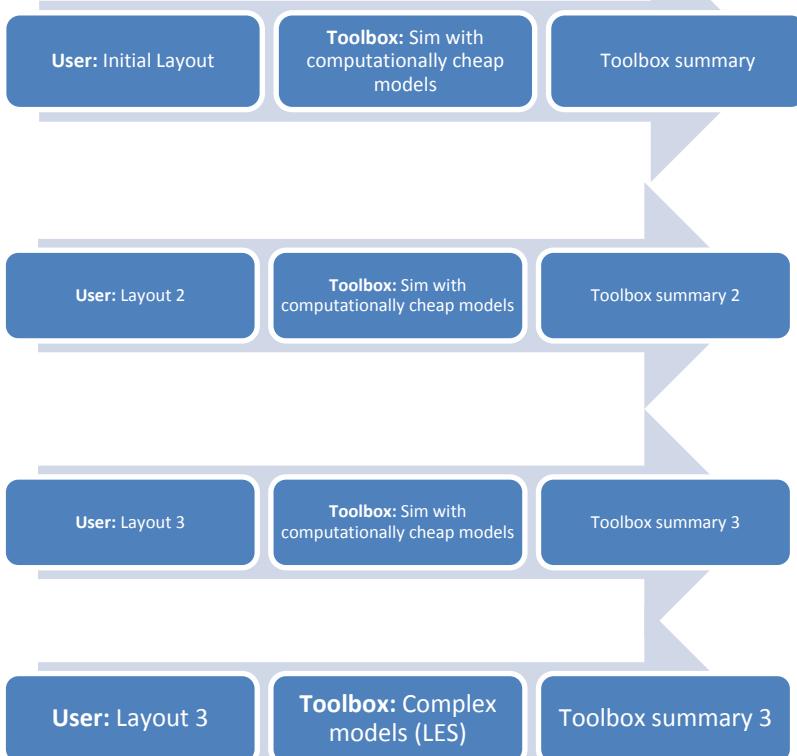




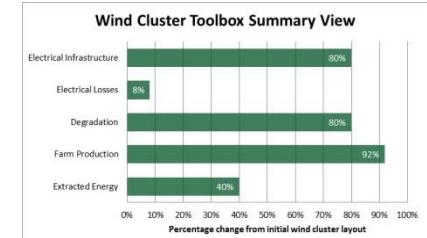
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Use of Design



User: decision on optimal solution based on summary reports





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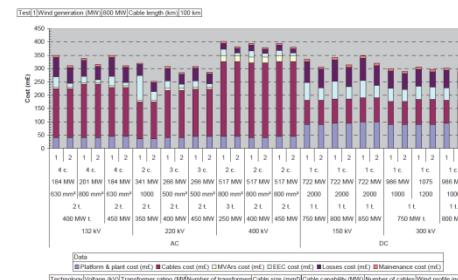
Use of Operations

User: Site Conditions

Toolbox: Wind farm
pre-computed matrixes

Output
→ Energy
→ Losses
→ Loads

Optimize selection of WTG operation modes



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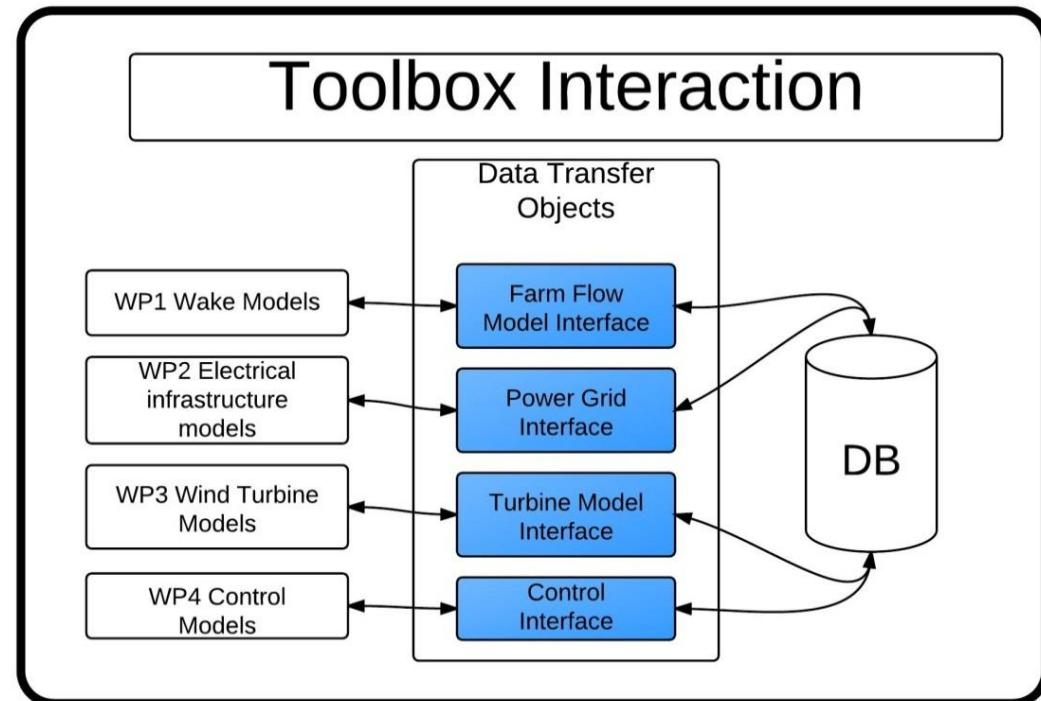




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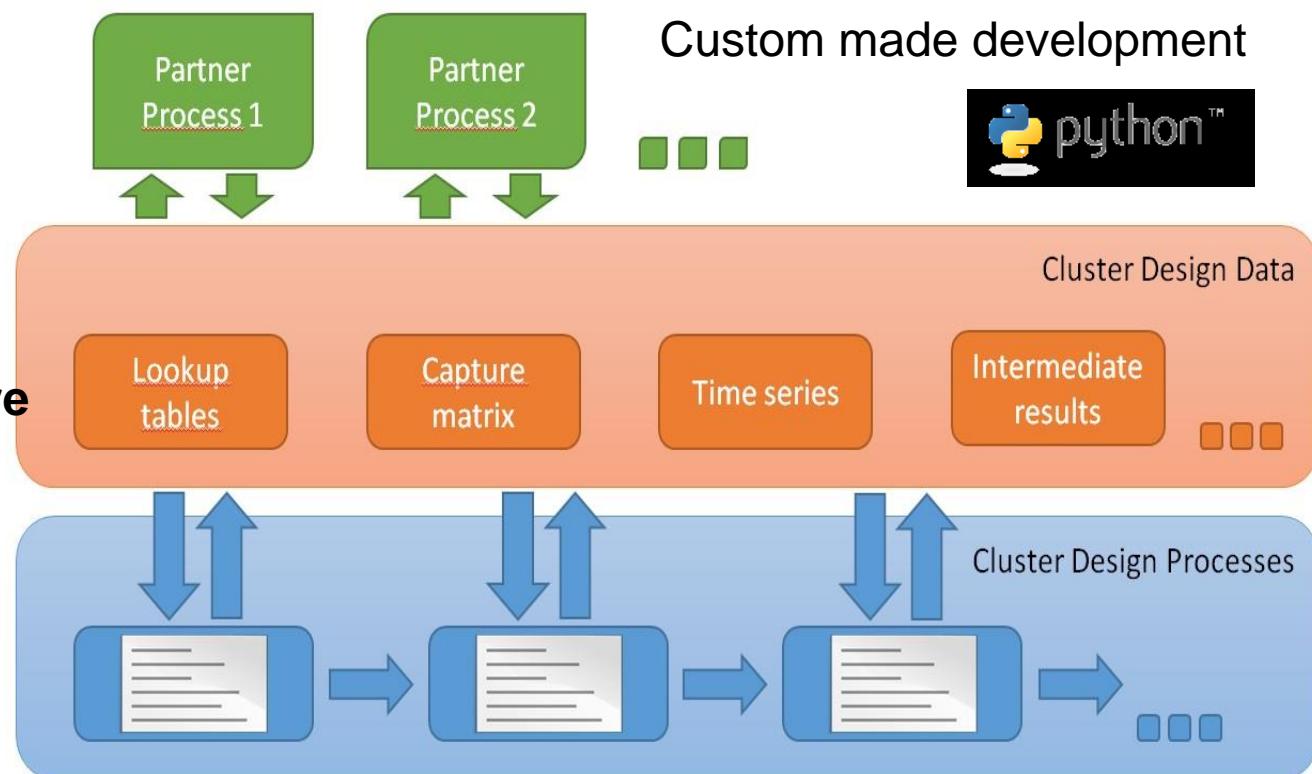
Models are host in dispersed locations (partners)





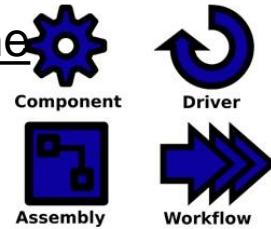
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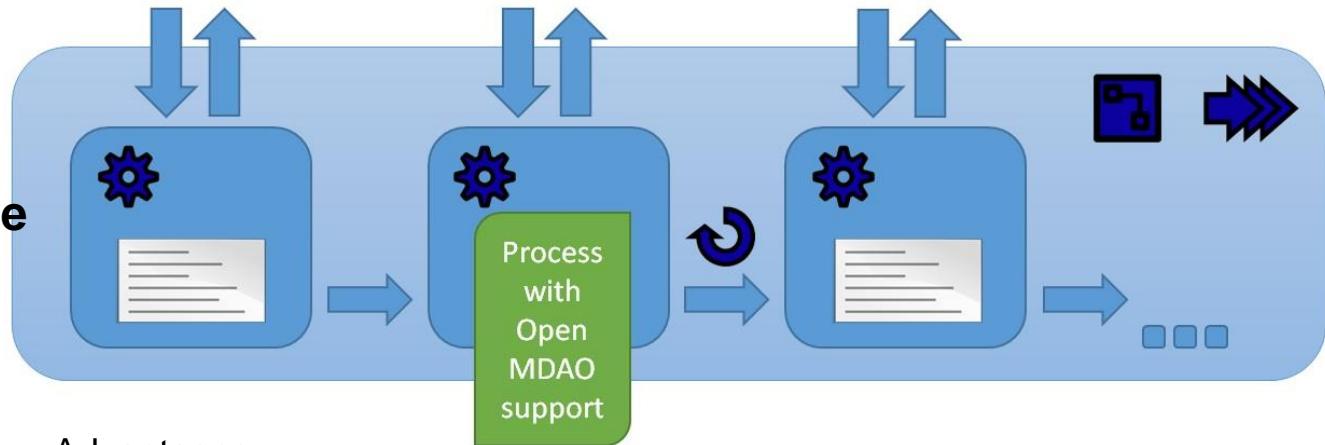
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openMDAO

OpenMDAO components instead of custom code modules

OpenMDAO Assembly / Workflow instead of custom made processes



Advantages:

- Standardization / documentation
 - GUI Workflow editing
 - Inter-changeability of components
 - Solver/ optimization
 - Open source



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Cluster Design Toolbox for
integrated Cluster design

Pilot release – June 2014

Thank you for your attention

Q&As / discussion

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