

# OMOptim – Model-based optimization with OpenModelica

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## **OMOPTIM PRESENTATION**



## WHAT IS OMOPTIM ?

What OMOptim intends to be ?

Optimization **platform** designed to :

- Facilitate algorithms development
- Share optimization functions
- Apply optimization easily and efficiently

**End-user oriented**

## Two main users

### Academics

A platform to **develop and test optimization methods**

### Industrial

A user-friendly tool to **perform process optimizations**

## Applications

- Design optimization
  - Parameters optimization
  - Components selection (*beta*)
- Sensitivity analysis
- Optimal control
- Hybrid systems

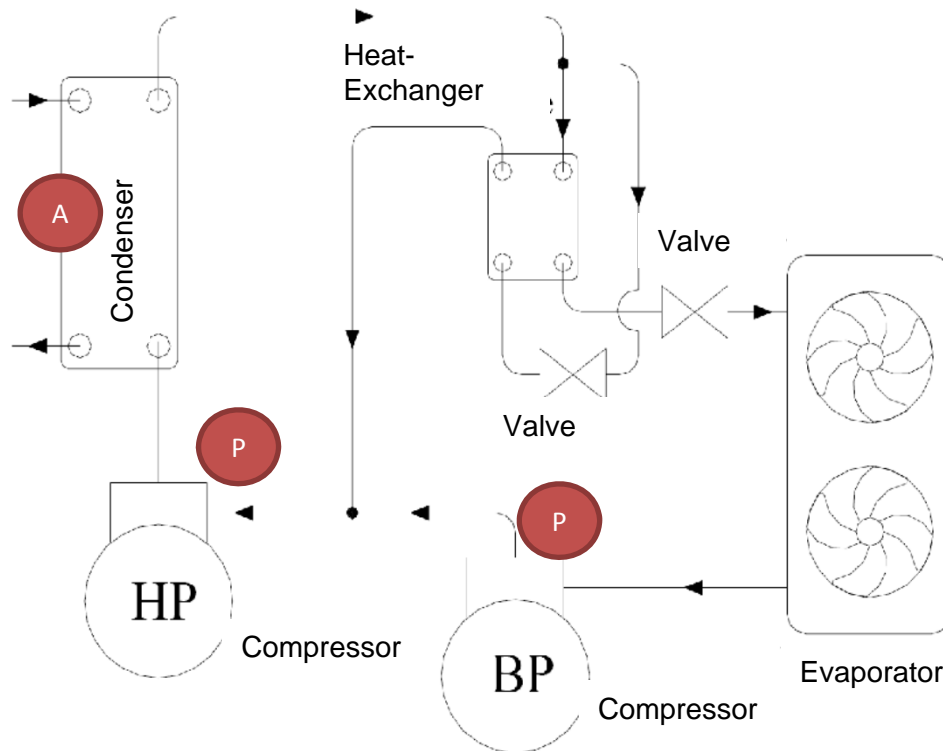
## Planned Optimization Methods

- Evolution strategies (e.g. genetic algorithms)
- Gradient based methods (e.g. SQP)
- Relaxation techniques
- Hybrid algorithms

What OMOptim can do ?

## **STATIC PARAMETERS OPTIMIZATION**

## e.g. Optimization of heat-pump parameters



Freedom

- pressure levels
- heat-exchanger area

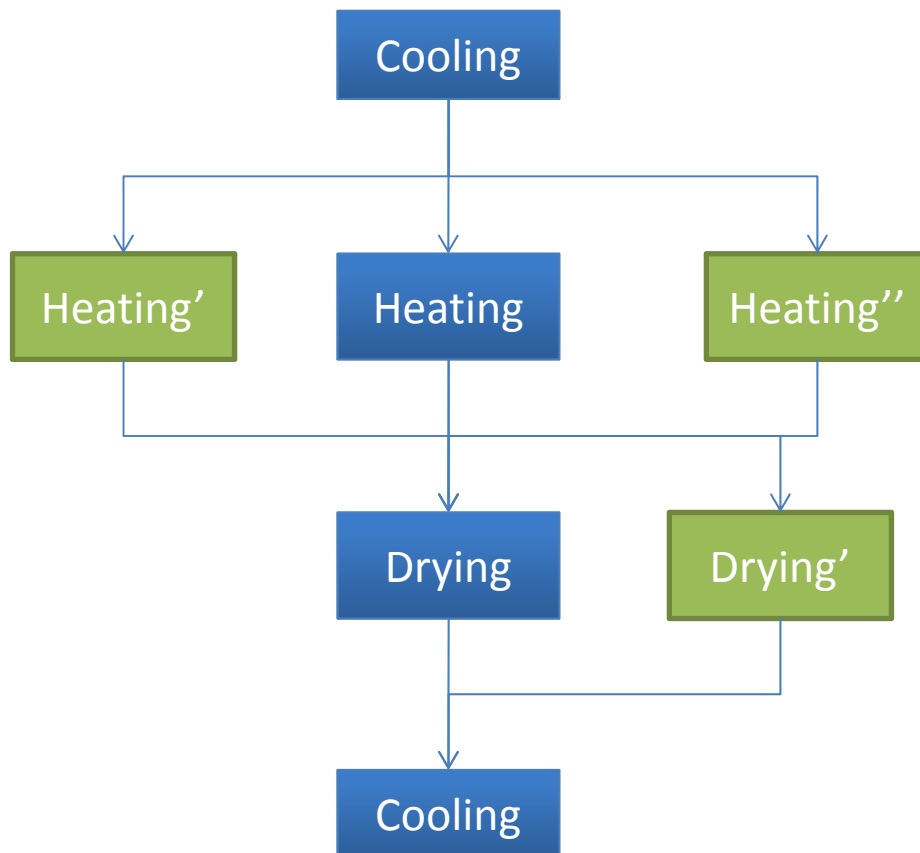
- Parameters are static : constant during one simulation
- Simulation can still be dynamic
- Objective functions can consider evolution

What OMOptim can do ?

## **STRUCTURE OPTIMIZATION**



## Structure optimization



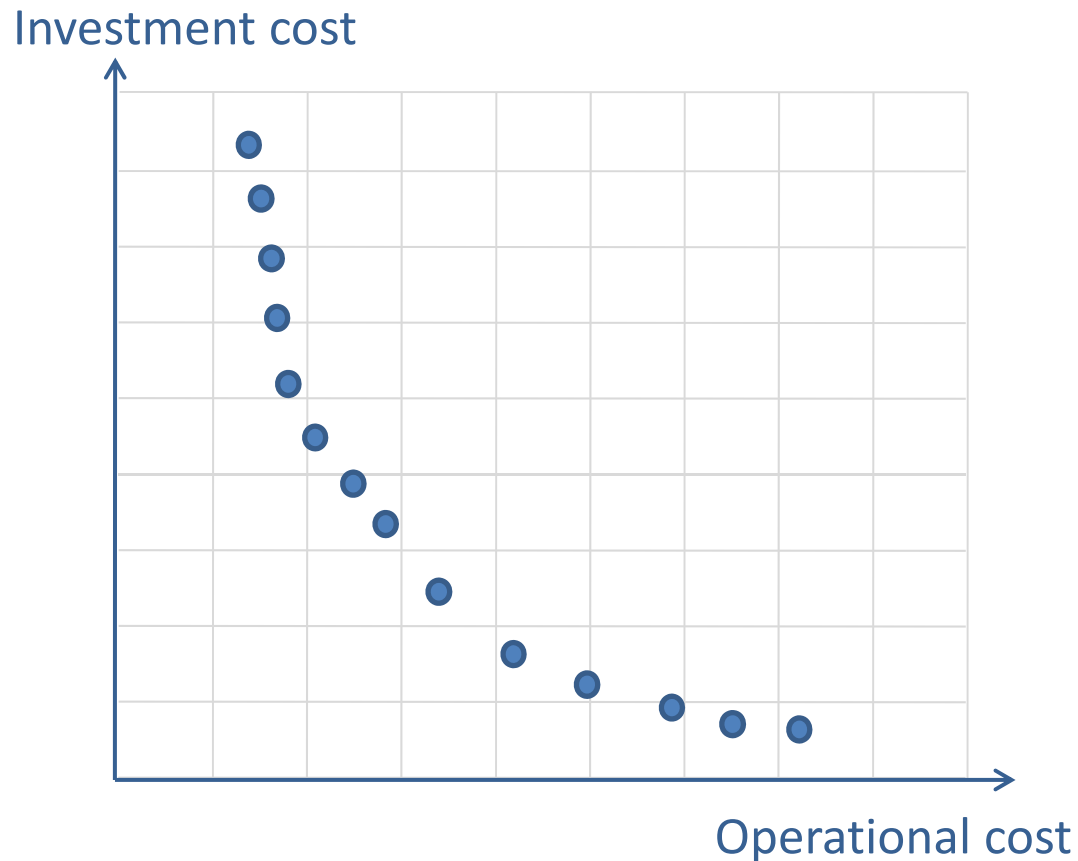
- Introduction of alternative options
- Optimal choice

What OMOptim can do ?

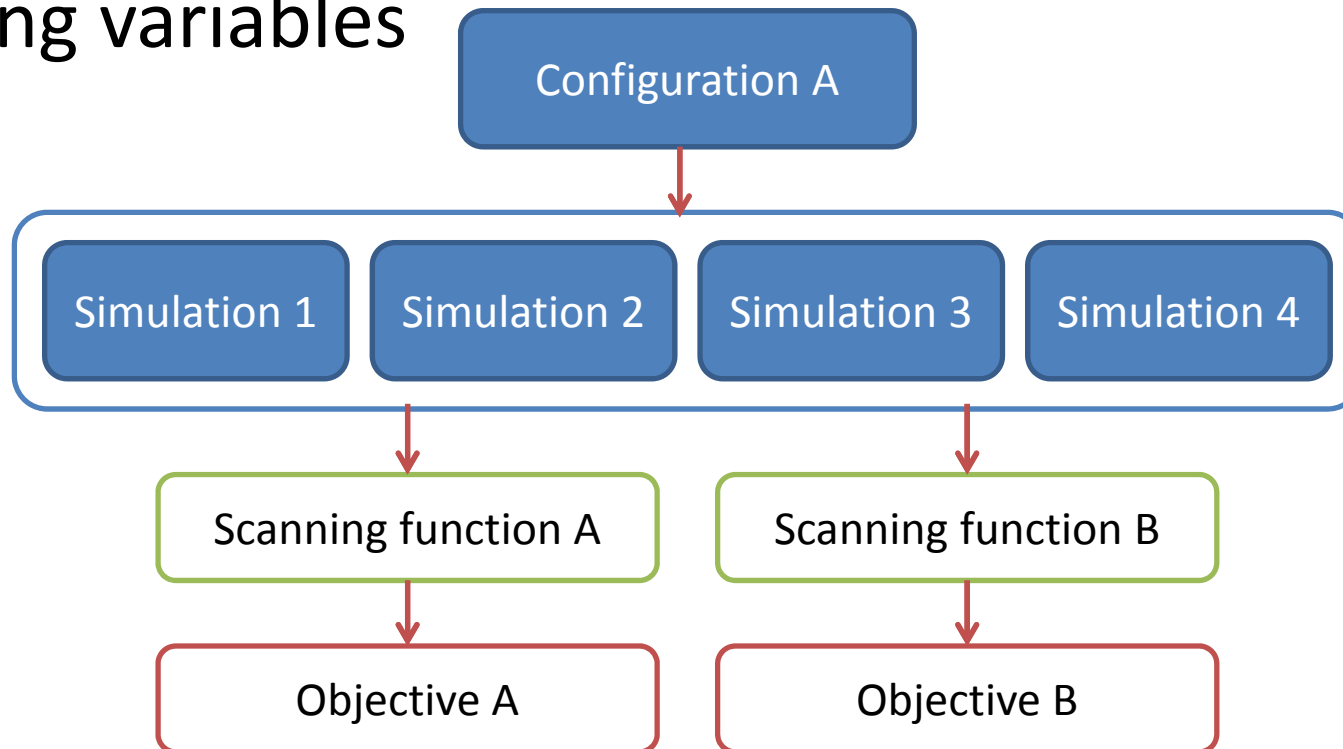
## WHICH OBJECTIVES ?

## Multi-objectives

Pareto criteria allows several objectives simultaneously



## Scanning variables



e.g.

- minimize total energy consumption over the four seasons
- minimize standard deviation of temperature related to mass flow

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## PROJECTS



## Two energy related projects

### EDOP

- Integration of modelization and optimization
- Dynamic optimal control of startup and load cycles

### CERES

- Identify best energy paths within industrial processes
- Design optimization

## OPTIMIZATION ALGORITHMS

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Meta-heuristics

- Many simulations required
- Model as a *Black-box*

Gradient based

- Require jacobians

Relaxation techniques

- cf. EDOP project

...



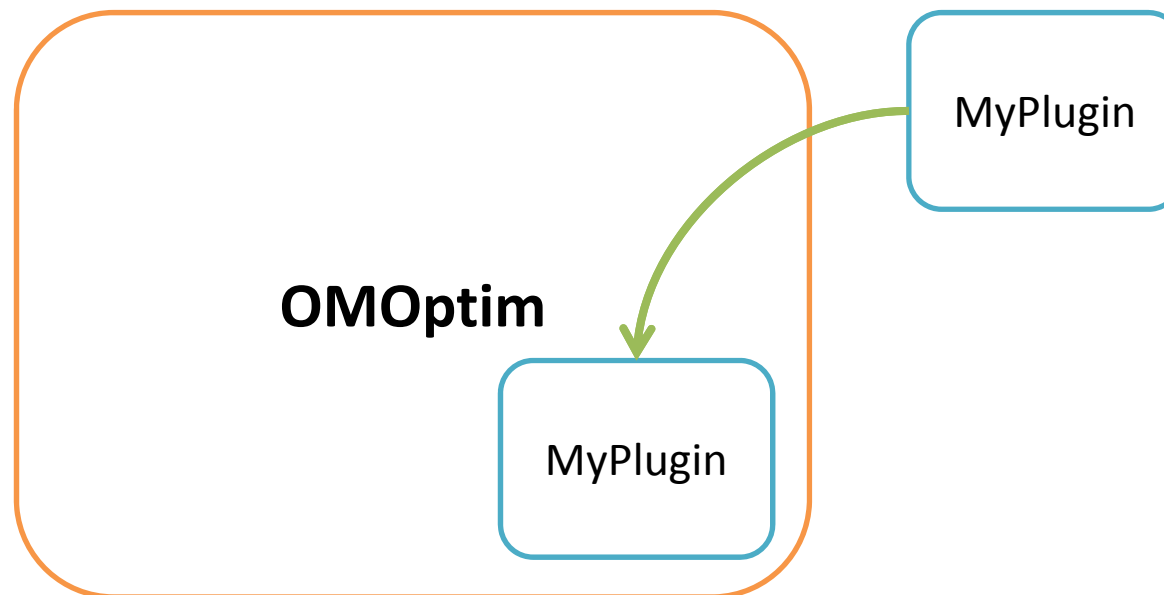
## Meta-heuristic algorithms implemented

- Evolutionary strategies (SPEA2, NSGA2)
- Particle Swarm Optimization
- Simulated Annealing

## PLUGIN FUNCTIONALITY

## Plugin

- Allows to implement specific functionalities
- Dynamically/Statically linked



## Energy integration plugin

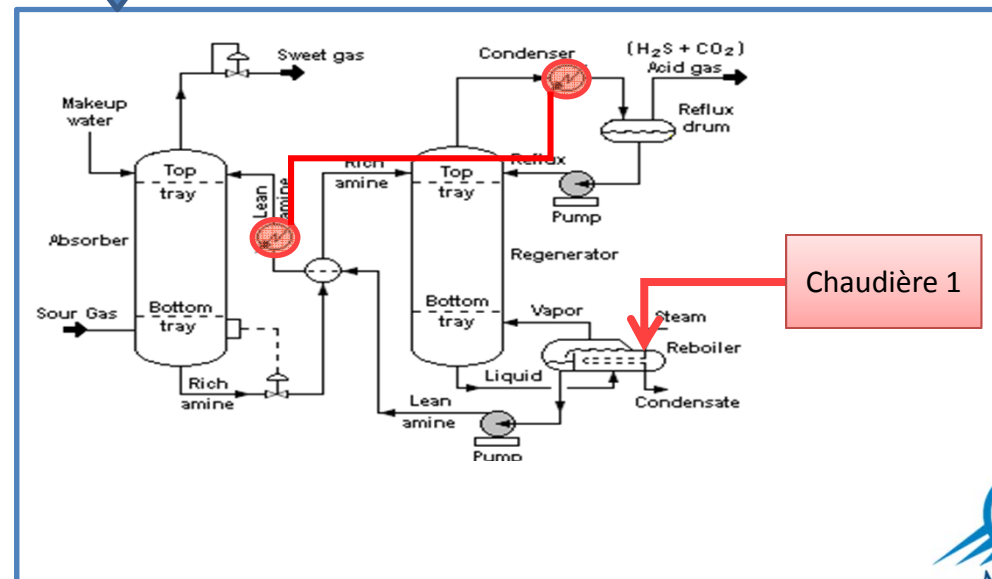
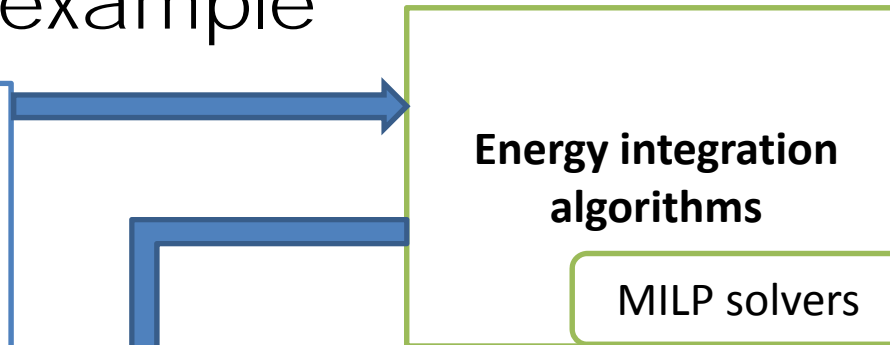
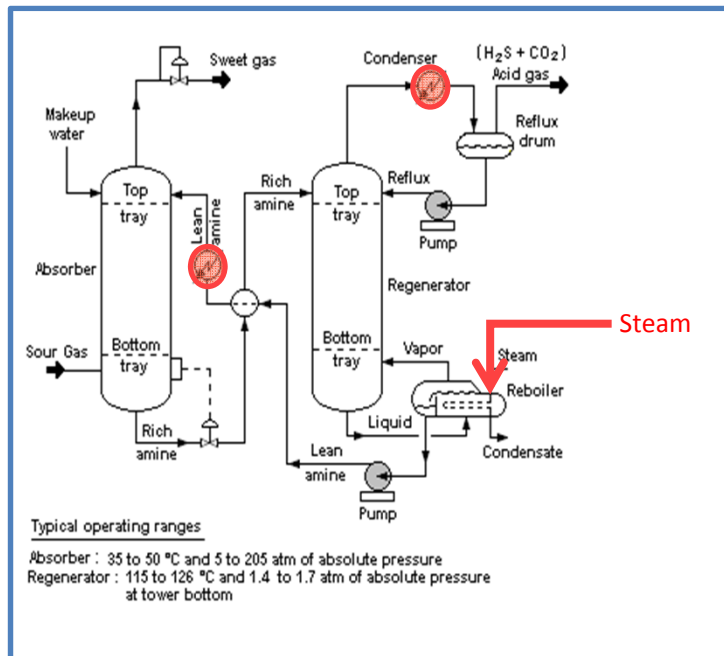
### CERES project

- Increase heat recovery within processes
- Select best fitted utilities
- Build heat exchangers network

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## Energy integration - example



## Plugin

- Why not a NMPC plugin ?
- Parameter identification

## FUTURE DEVELOPMENTS

## First developments

- FMI compliance
- Parallelization
- Gradient based methods



## Applications

- Design optimization
  - Continuous parameters
  - Components selection (*beta*)
- Sensitivity analysis
- Optimal control
- Hybrid systems

## Planned Optimization Methods

- Evolution strategies (e.g. genetic algorithms)
- Gradient based methods (e.g. SQP)
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## DEMONSTRATION

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**INTERESTED IN ?**



# OMOptim – Model-based optimization with OpenModelica

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- Website
  - [www.openmodelica.org](http://www.openmodelica.org)



- Source code

<https://openmodelica.org/svn/OpenModelica/trunk/OMOptim/>

- Mail

[hubert.thieriot@mines-paristech.fr](mailto:hubert.thieriot@mines-paristech.fr)

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**THANKS FOR YOUR ATTENTION**



Model structure

Model Variables

Optimized parameters

Optimized Objectives

The screenshot displays the MinEIT software interface with the following components:

- Model structure (left panel, red border):** A list of model components including Pc, Va, Vb, Ia, Ib, Ic, Ea, Eb, Ec, coutinvestissement, gaincouteoperationnel, EmCO2PAC1, Ca, Cb, Cc, Puissae, Puissbe, Puissce, n, na, nb, nc, Ocb, OChp, coutdefonctavecPAC, TOSygmaA, TOSygmaB, TOSygmaECS, COPECSsystem, PElecCSMax, EchIAOutCold, Sortieeffluents, echA, Sourcemod, scenarioEchA, scenarioPACA, and echB.
- Variables (center panel, green border):** A table listing model variables with their values and descriptions. The table is filtered and contains the following data:

Name	Value	Description
global.sourceeadeville.h	1,18294e+06	[J/kg]
global.sourceeadeville.flowPort.p	100000	
global.sourceInEchColdB.h	1,41347e+06	[J/kg]
global.sourceInEchColdB.flowPort.p	100000	
global.sourceInEchColdB.debit	12,78	[kg/s]
global.sourceEffluentsECS.h	1,35495e+06	[J/kg]
global.sourceEffluentsECS.flowPort.p	100000	
global.sourceEffluentsECS.etat	1	
global.sourceEffluentsECS.debit1	0	
global.sourceEffluentsECS.debit	1	[kg/s]
global.sourceEffluentsB.h	1,35495e+06	[J/kg]
global.sourceEffluentsB.flowPort.p	100000	
global.sourceEffluentsB.etat	1	
global.sourceEffluentsB.debit	1,22612	[kg/s]
global.sourceEffluentsA.h	1,35495e+06	[J/kg]
global.sourceEffluentsA.flowPort.p	100000	
global.sourceEffluentsA.etat	1	
global.sourceEffluentsA.debit	0,601234	[kg/s]
global.scenariosourceEaudeville.debit	0,940001	[kg/s]
global.scenariodepartB.z	0	
- Optimized variables (right panel, blue border):** A table showing optimized parameters with their descriptions and optimal minimum values.

Name	Description	Opt Minimum
global.sourceEffluentsB.debit	[kg/s]	0
global.sourceEffluentsA.debit	[kg/s]	0
global.scenarioPACB.MySpecPcomp		0
global.scenarioPACA.MvSpecPromo		0
- Scanned variables (right panel, white border):** A table for scanned variables with columns for Name, Description, Scan Minimum, and Scan Maximum.
- Optimization objectives (right panel, orange border):** A table showing optimization objectives with their descriptions, directions, and values.

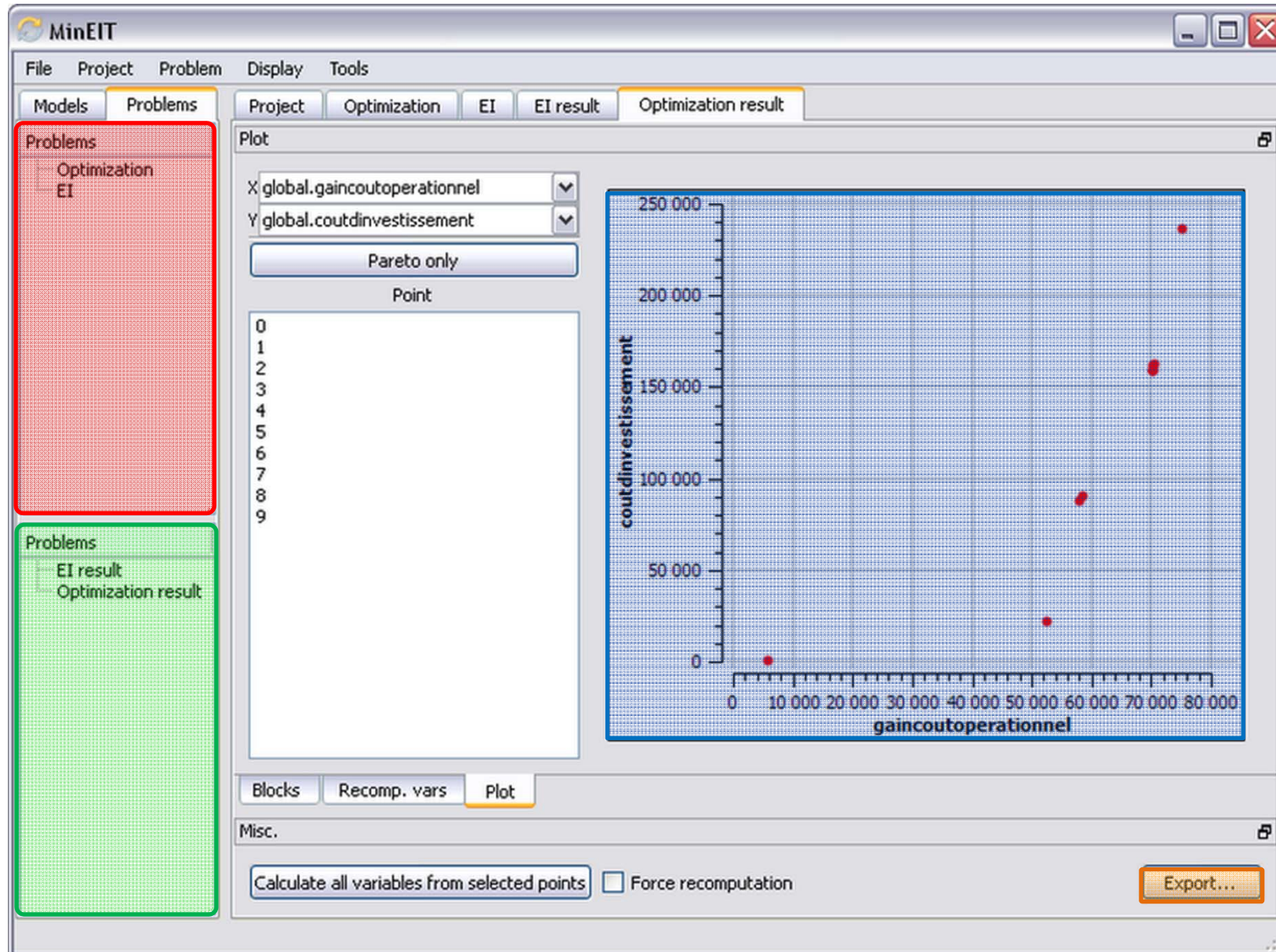
Name	Description	Direction	M
global.gaincouteoperationnel		Maximize	0
global.coutinvestissement		Minimize	0

Problems

Solved problems

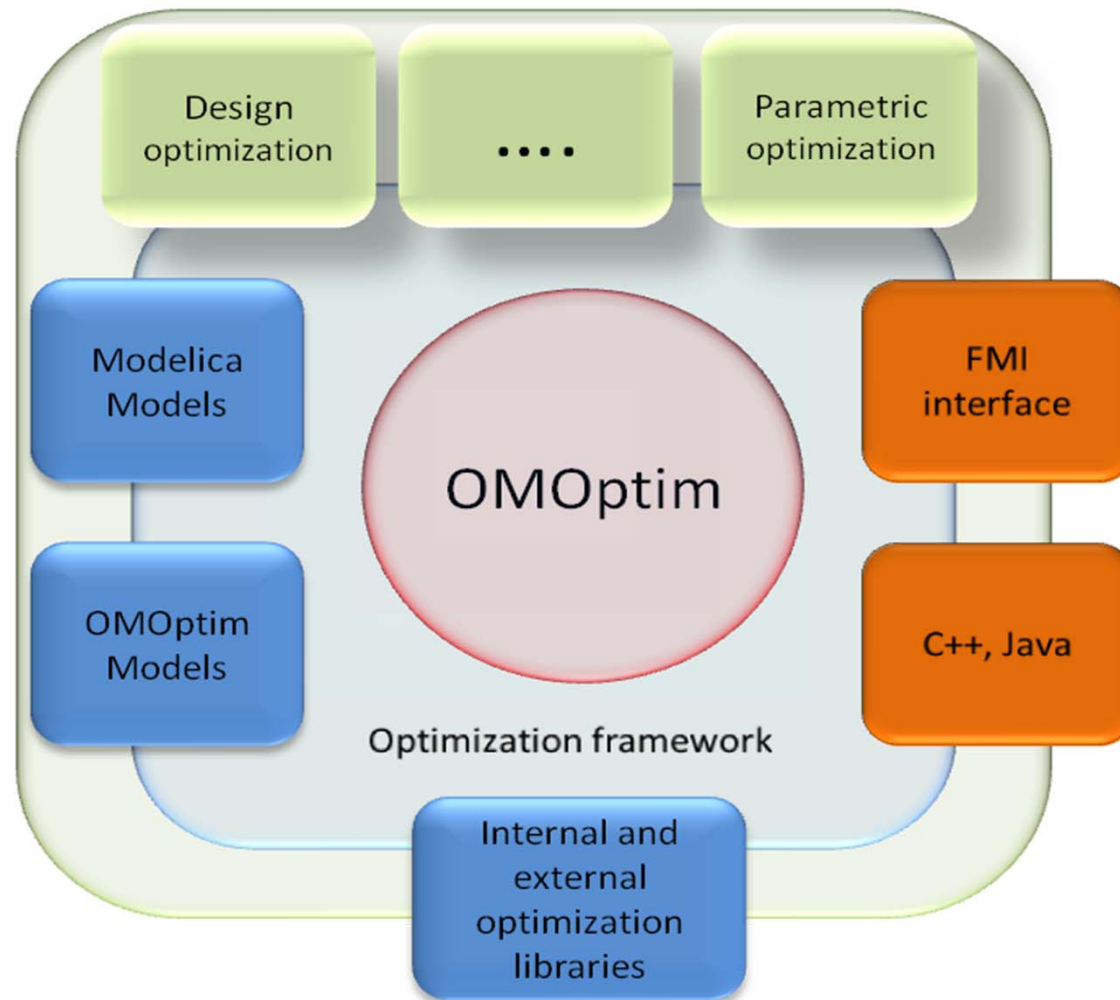
Result plot

Export result data .csv



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Top-level conceptual view of OMOptim and its interfaces



To be done ...

- Finalize OMOptim **structure**
- Strengthen **link** Simulation – Optimization
  - Derivative information
  - Structural change
  - Parallelization
- Organize **sharability** of optimization functions

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