Optimization Integrated Building Information Modeling for Building Design & Systems

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Process description

- **Create** an optimized model integrated with BIM
- Utilization of *combination tools* to obtain an optimized model integrated with BIM
- The assessment levels will be comprised of the following three stages:-
  - BIM model *(IFC/ ArchiCAD + integrated Eco designer +simple BIM)*
  - Energy model *(IDA-ICE)*
  - Optimization software *(Multi objective building optimization (MOBO))*

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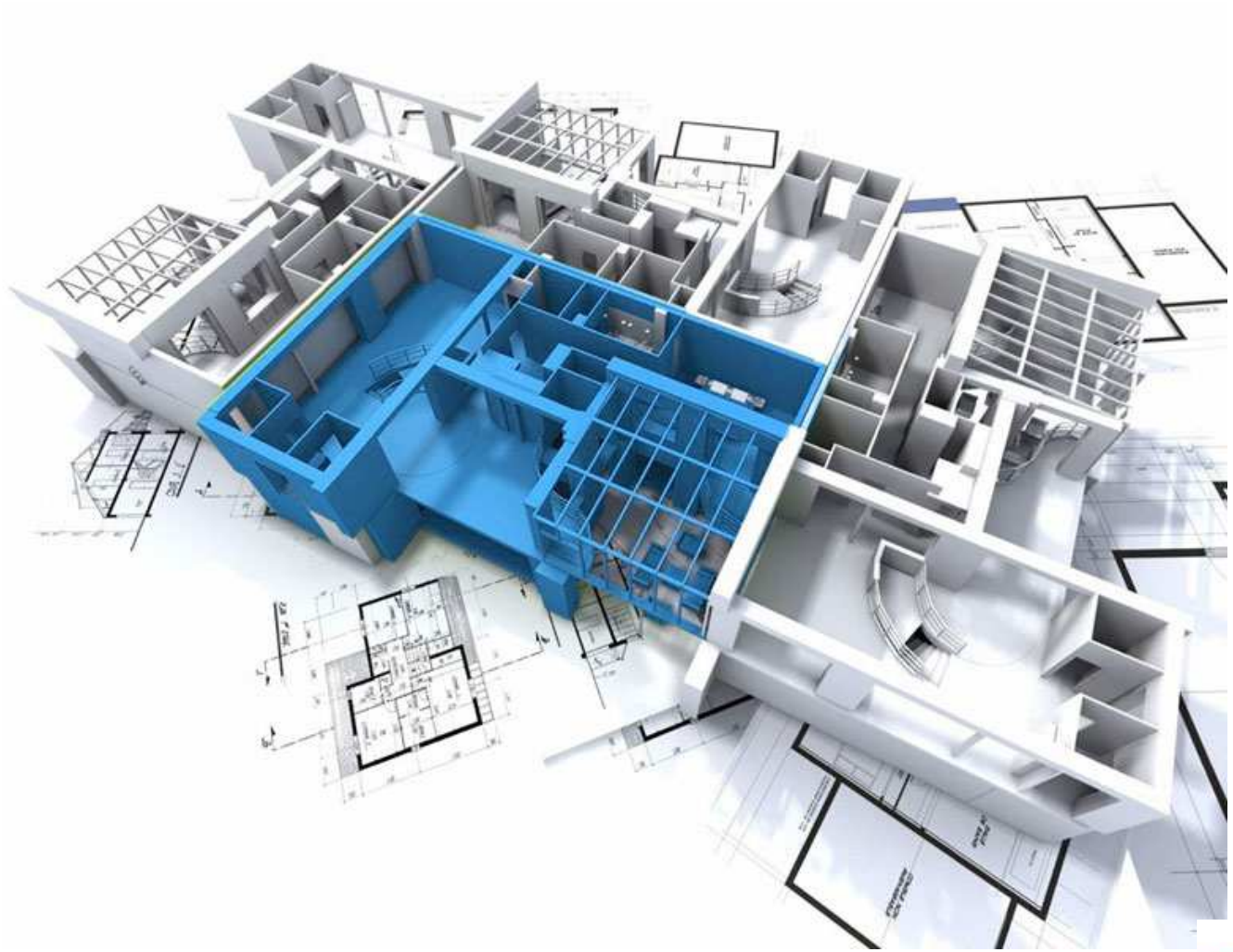
Building Information Modeling (BIM)



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Source: http://www.airport-int.com/article/

Industry Foundation Classes

- IFC provides an environment of interoperability among IFC-compliant software applications in the architecture, engineering, construction and facilities management (AEC/FM) industry (Bazjanac)

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how does.ifc file look like?

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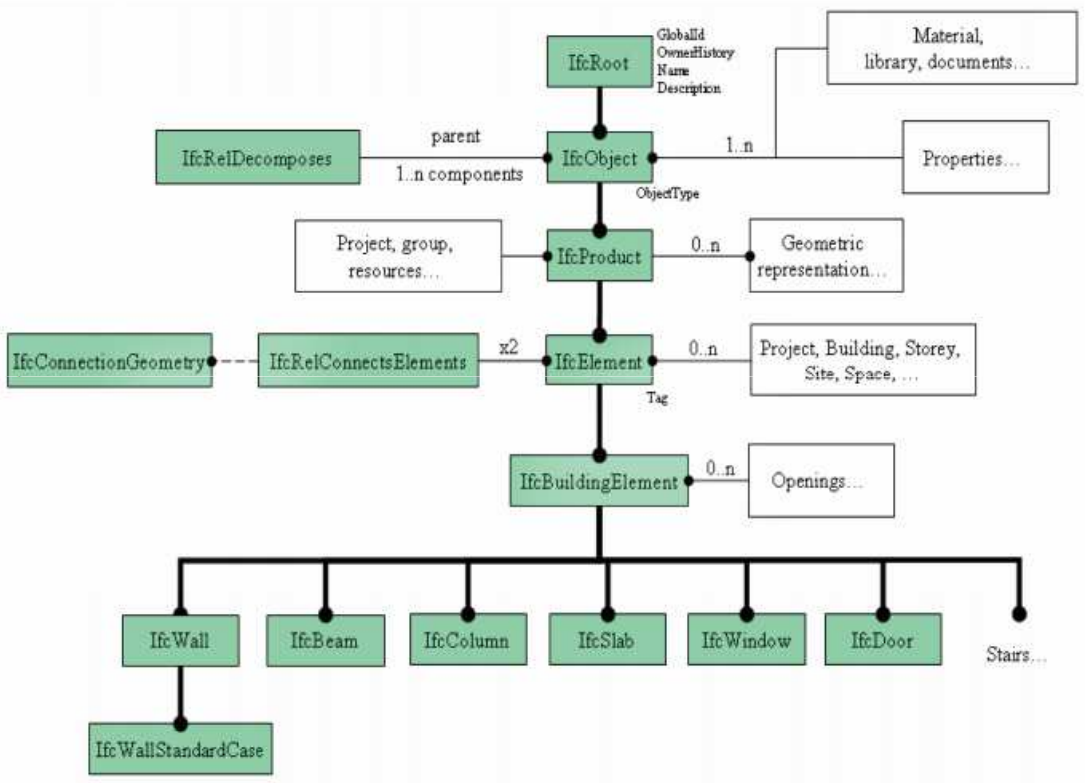

FIGURE 5 BACKBONE OF THE IFC DATA MODEL (EXPRESS-G DIAGRAM)

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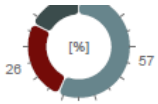
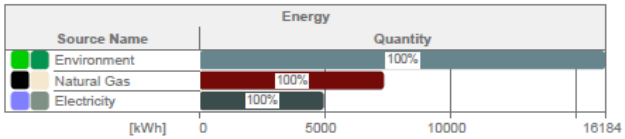
Eco designer output

(integrated with ArchiCAD)

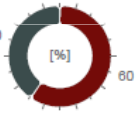
Target Name	Energy Quantity kWh/a	Cost GBP/a	Primary kWh/a	CO_2 Emission kg/a
Heating	0	0	0	0
Cooling	16184	0	0	0
Hot Water Generation	7384	0	8122	1595
Ventilation Fans	0	0	0	0
Lighting & Appliances	4995	0	14985	1078
Total:	28563	NA	23108	2673



Energy Costs



CO_2 Emission



Energy Performance Evaluation

[Project Number] [Project Name]

Key Values

General Project Data
Location:
Primary Operation Profile: Personal office (100%)
Evaluation Date: 15.5.2013 11:45

Building Geometry Data

Gross Floor Area:	207,14	m²
Building Shell Area:	155,24	m²
Ventilated Volume:	537,94	m³
Glazing Ratio:	4	%

Building Shell Performance Data

Air Leakage:	1.16	ACH
Outer Heat Capacity:	43.81	J/m²K

Heat Transfer Coefficients U value [W/m²K]

Building Shell Average:	1.66
Floors:	-
External:	1.57 - 1.57
Underground:	-
Openings:	2.99 - 3.19

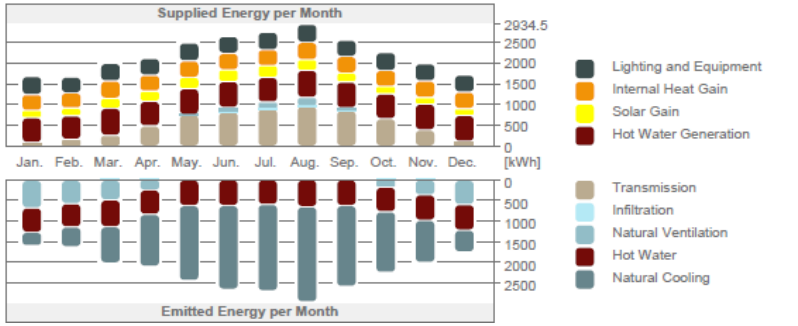
Specific Annual Demands

Net Heating Energy:	0.00	kWh/m²a
Net Cooling Energy:	84.24	kWh/m²a
Total Net Energy:	84.24	kWh/m²a
Energy Consumption:	148.67	kWh/m²a
Fuel Consumption:	64.44	kWh/m²a
Primary Energy:	120.28	kWh/m²a
Operation Cost:	--	GBP/m²a
CO_2 Emission:	13.92	kg/m²a

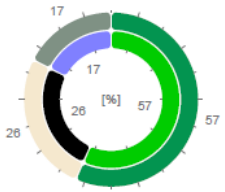
Energy Consumption by Sources

Source Type	Source Name	Energy Quantity kWh/a	Cost GBP/a	CO_2 Emission kg/a
Renewable	Environment	16184	NA	0
Fossil	Natural Gas	7384	--	1595
Secondary	Electricity	4995	--	1078
Total:		28563	Not Applicable	2673*

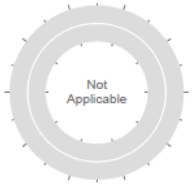
Monthly Energy Balance



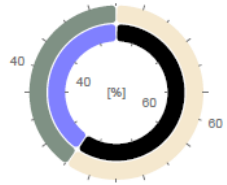
Energy Quantities



Energy Costs



CO_2 Emission



* This amount of CO_2 is absorbed in one year by 0.0 hectares (roughly equivalent to 0.5 tennis-courts) of tropical forest.

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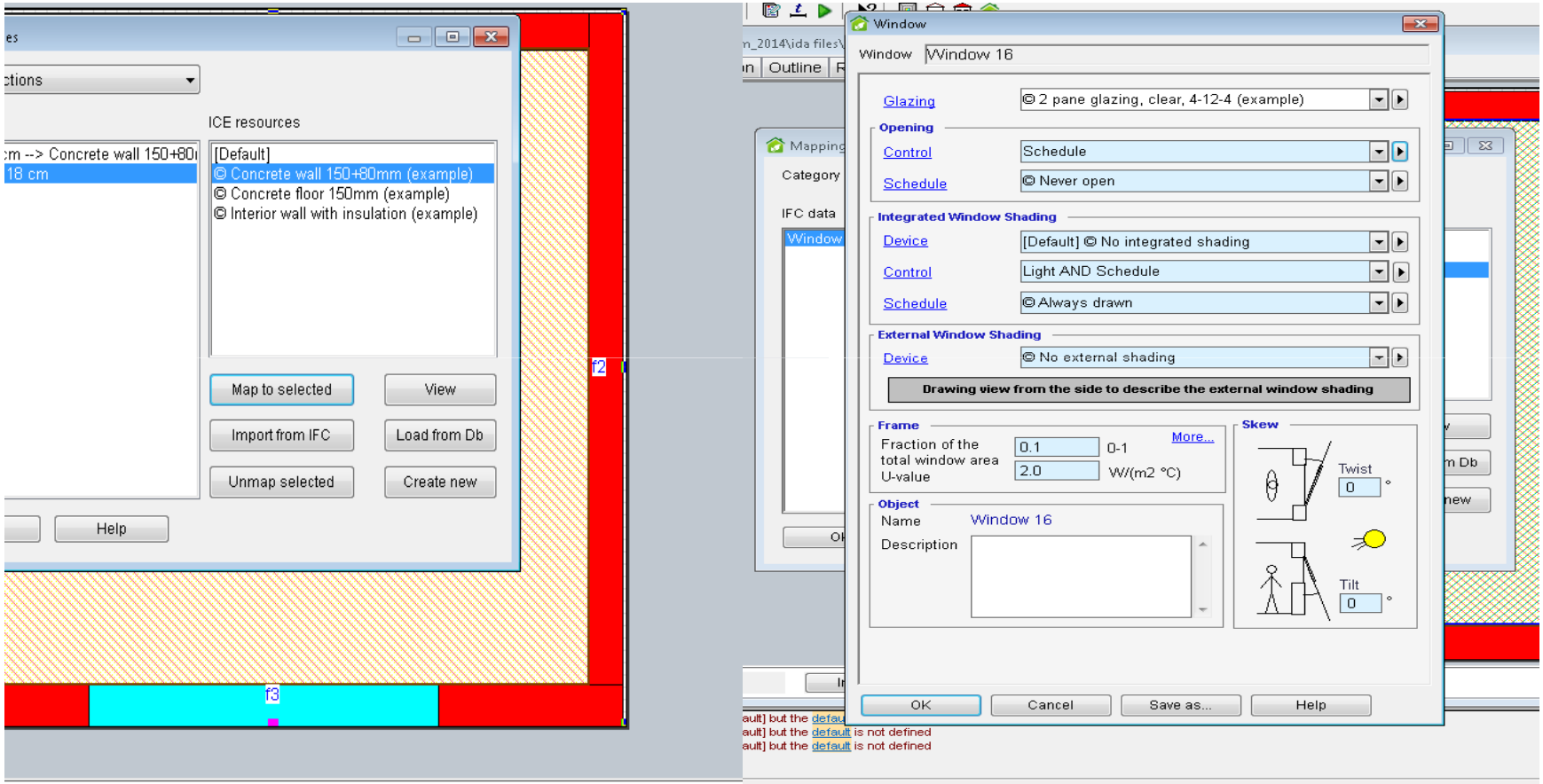
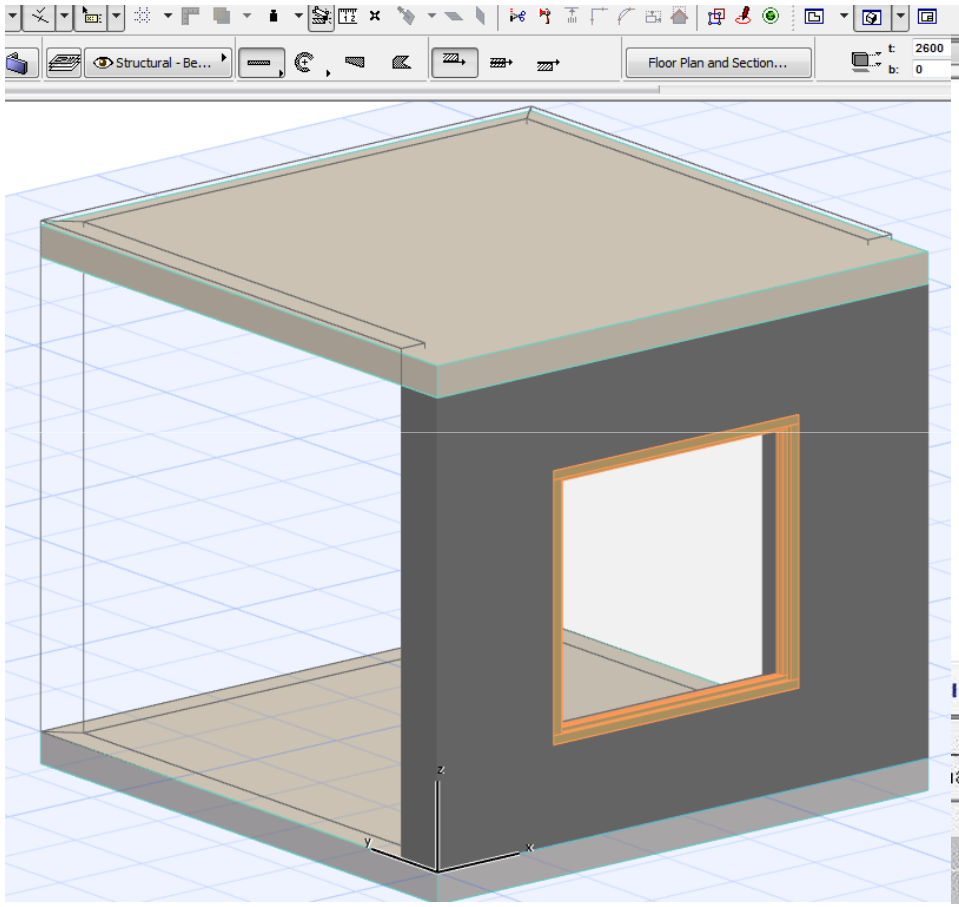
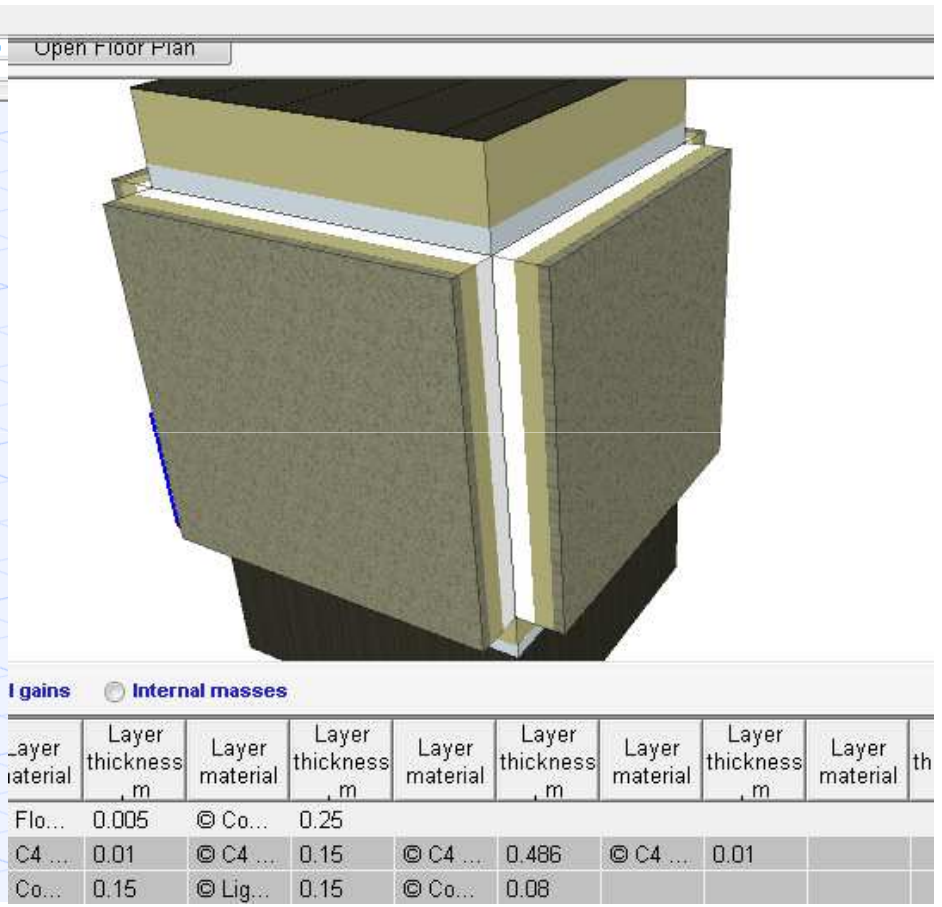
Mapping .ifc to IDA



- Errors!





ArchiCAD Model

IDA Model

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Connection between IDA ICE and MOBO

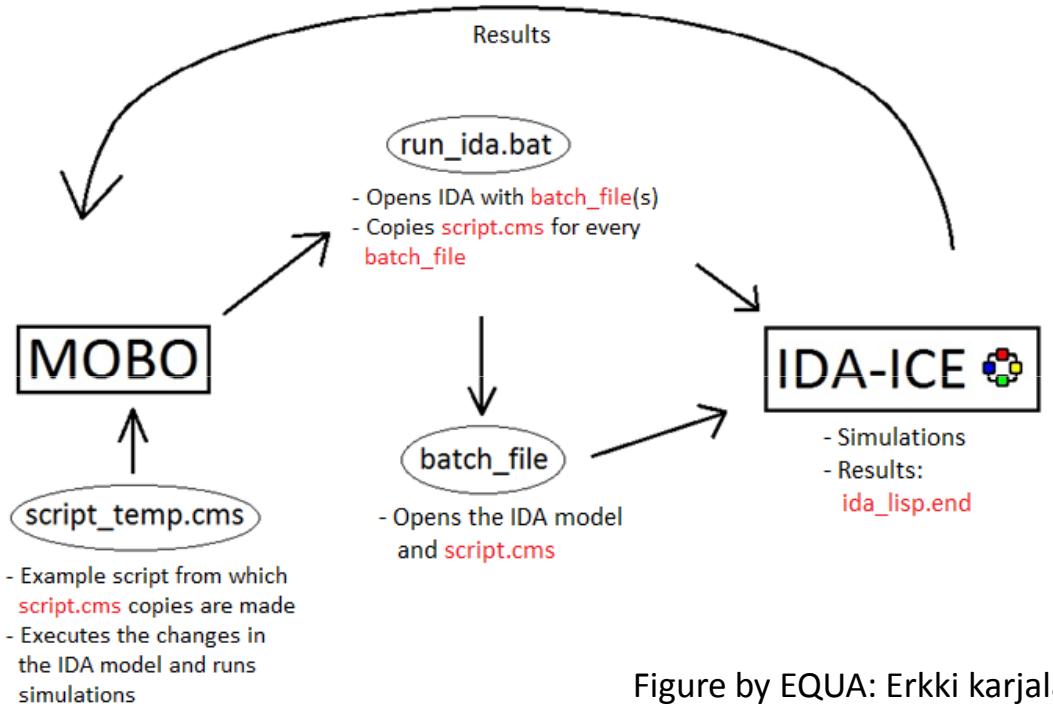
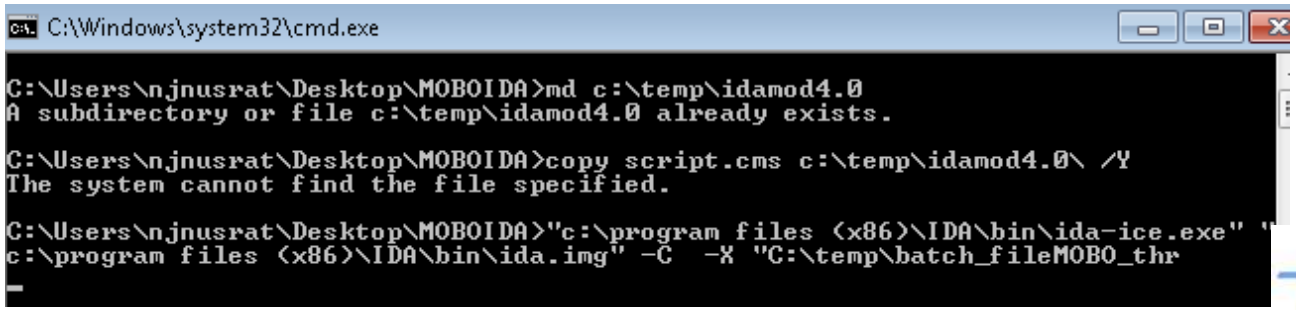


Figure by EQUA: Erkki karjalainen



Run_ida.bat and Batch_file

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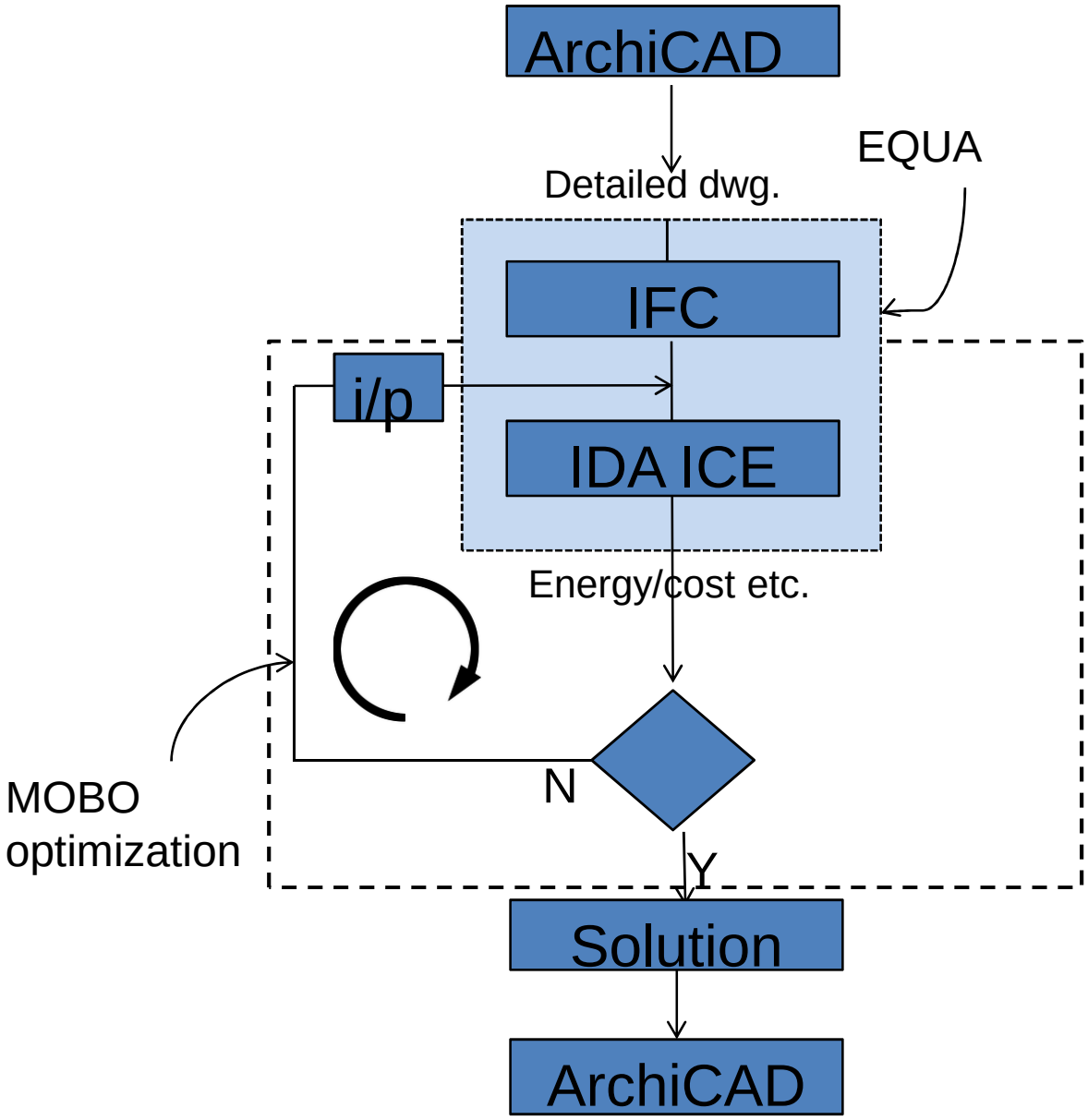

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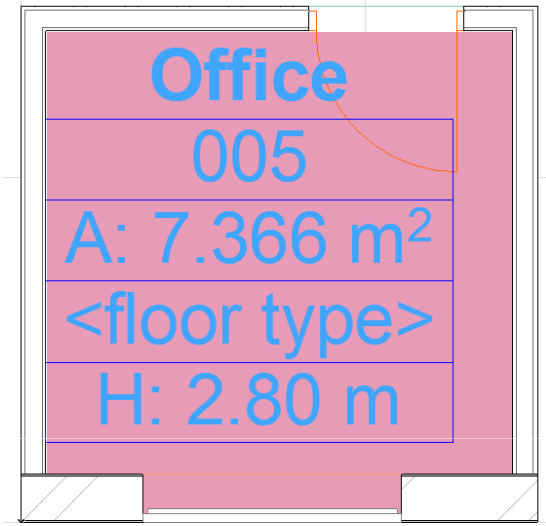
Case description

- Office room 3x3 (part of an office building)
- Window
- Door
- Intermediate slab as floor and ceiling
- Climate IDA: Kalmar, sweden
- MOBO: Minimize energy: a bi-objective problem (f1-cooling energy, f2-heating energy)
- optimization problem to find the optimum dimensions of the window (dx, dy)



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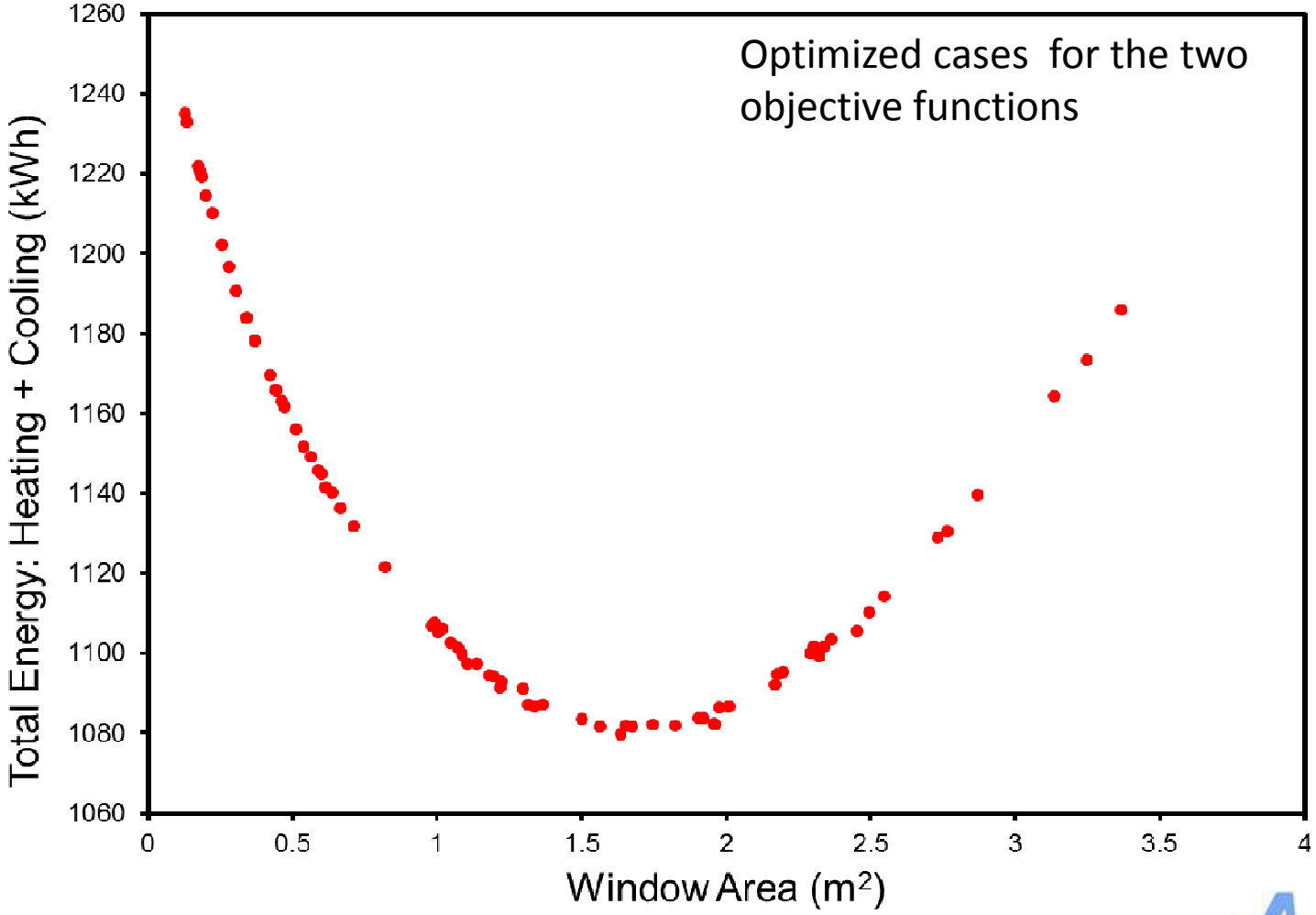
Effect of the window area on the total energy = heating + cooling



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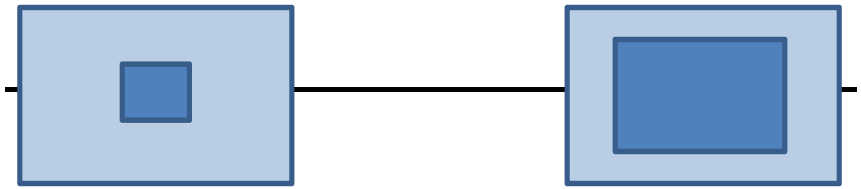
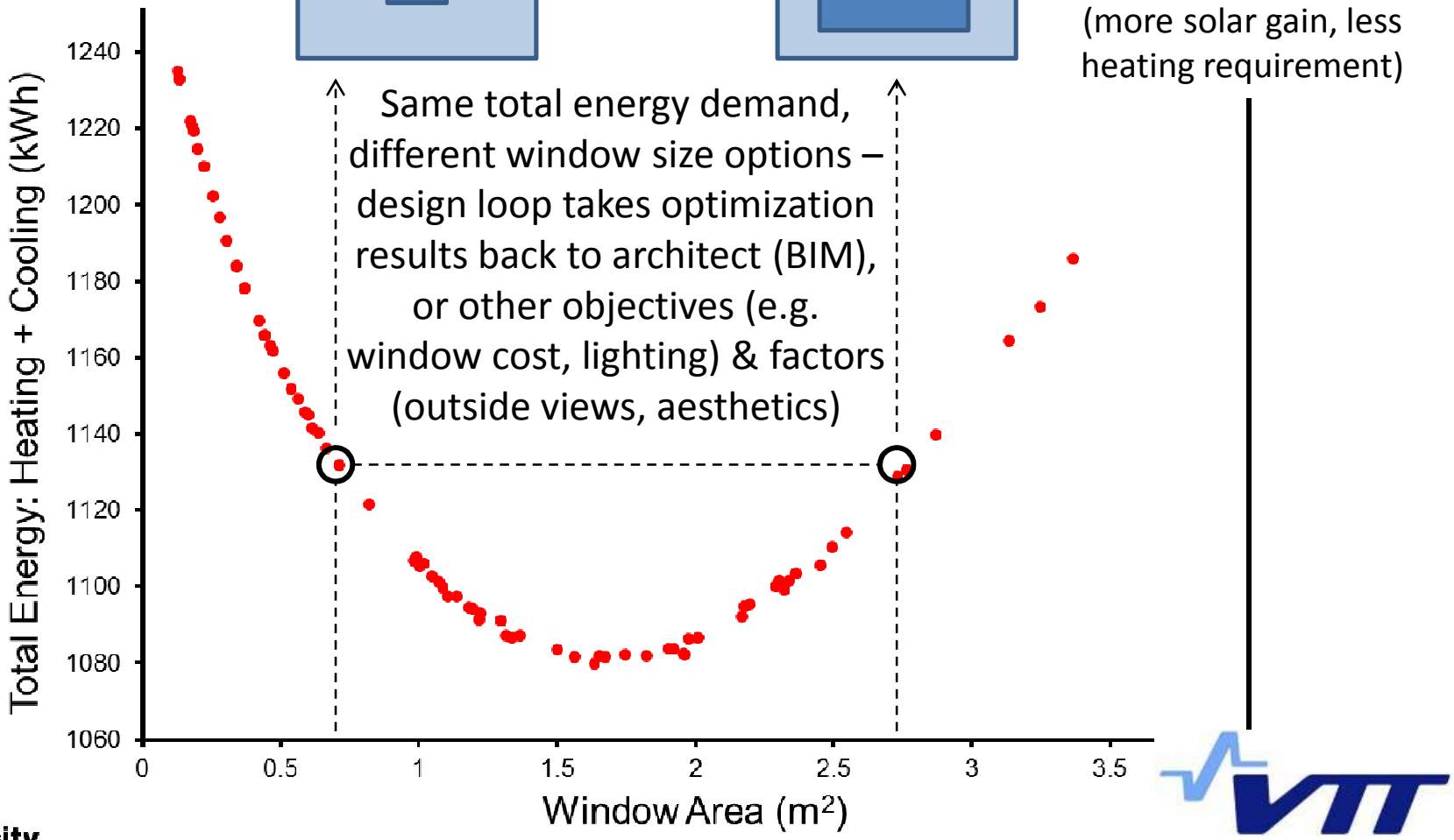
Effect of the window area on the total energy = heating + cooling

Small window 0.62 m²:
Cooling: 50 kWh (less cooling)
Heating: 1091 kWh



Large window 2.87 m²:
Cooling: 127.4 kWh
Heating: 1012 kWh
(more solar gain, less heating requirement)



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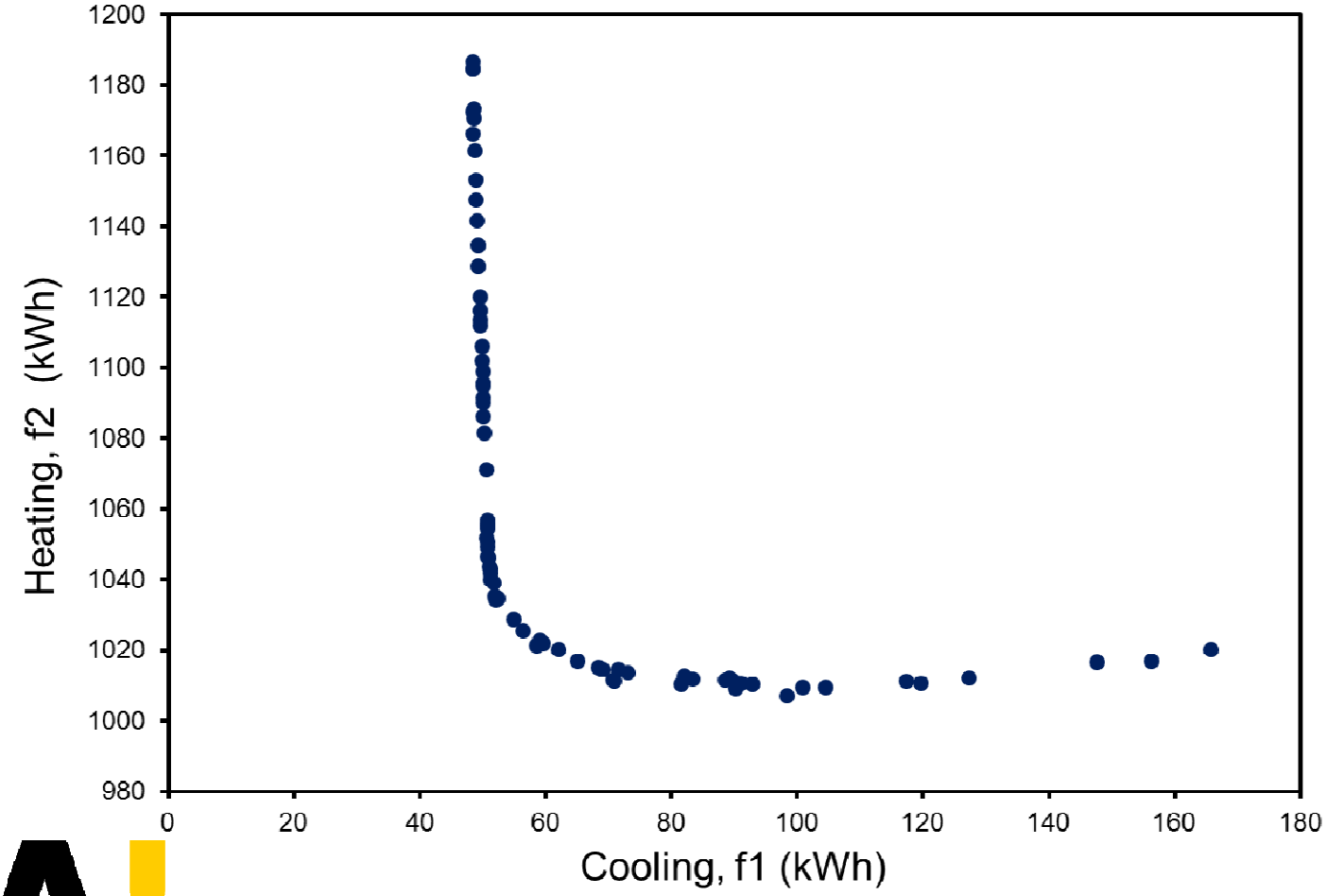
Results from MOBO
Cooling energy vrs Heating energy



Optimization problem: Find optimum dx &dy

Objective function:
F1- >Cooling
F2-> heating
(annual demand)

Algorithm: NSGA II

Population Size: 10

Mutation: 0.2

Crossover: 0.85

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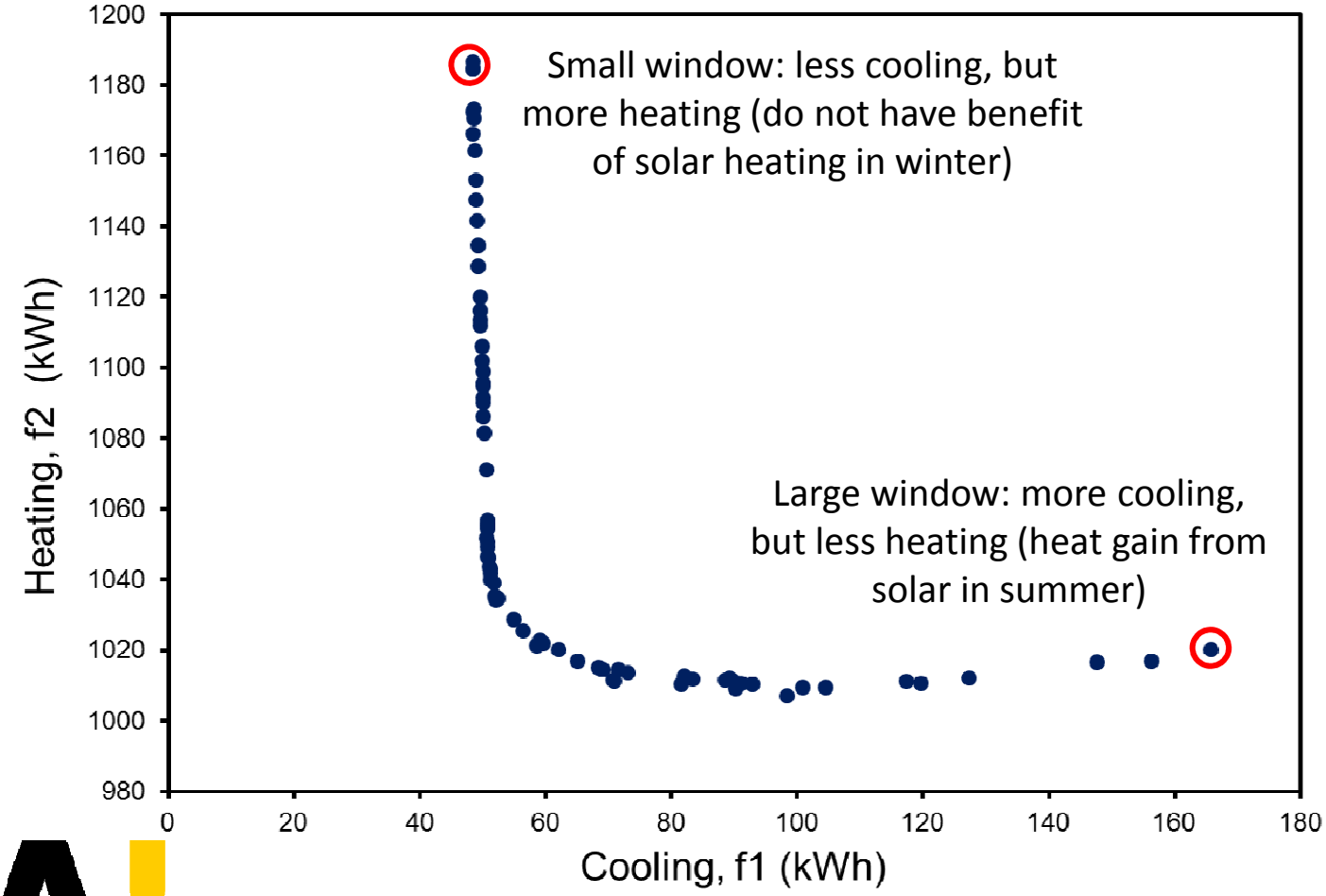
Results from MOBO
Cooling energy vrs Heating energy



Optimization problem: Find optimum dx &dy

Objective function:
F1- >Cooling
F2-> heating

Algorithm: NSGA II
Population Size: 10
Generation: 8
Mutation: 0.2
Crossover: 0.85

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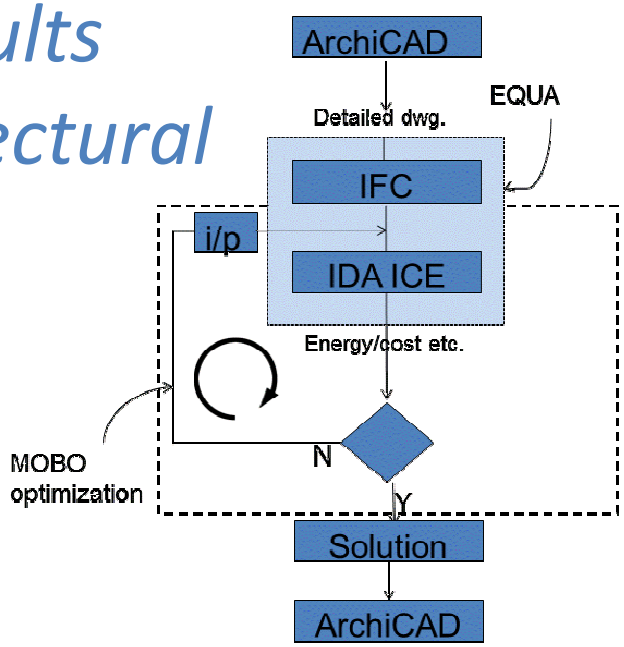
MOBO → Design

- Simple case – but it allows us to see the potential of *optimization results* (IDA + MOBO) *influencing architectural design* (BIM –ArchiCAD)
- Case can be further enhanced by introducing multi-objective optimization (e.g. cost, natural ventilation)



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Many thanks to

- Mika Vuolle (EQUA)
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