GEEGLEE'S EXAMPLES BOOK V1.0

Geegle®

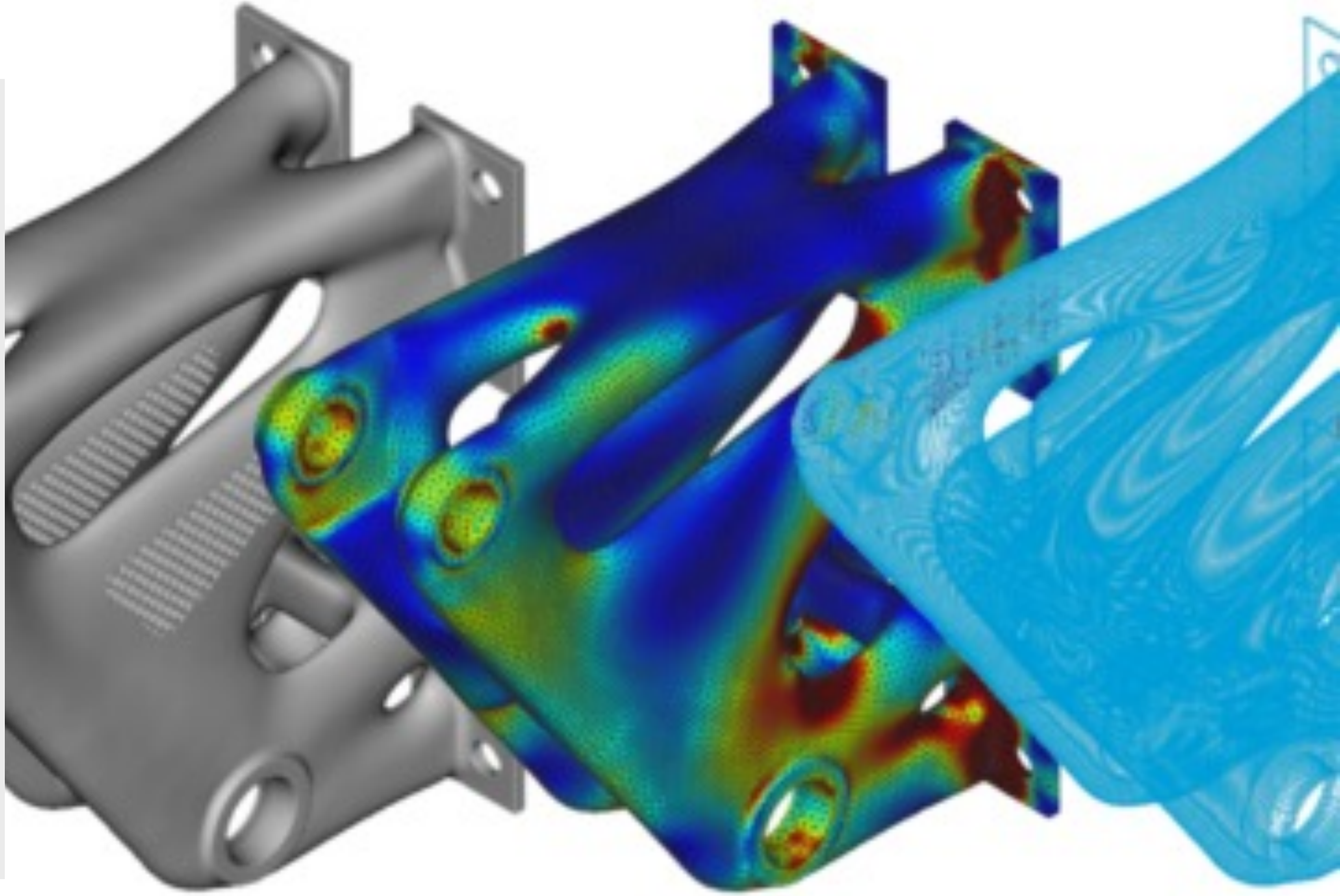
AUGMENTED HUMAN INTELLIGENCE

Know, Understand, Plan and Act

LA PLACE STRATÉGIQUE

17

Modeling examples using Geeglee



“

The theory is the practice!

An unknown, but clever, person

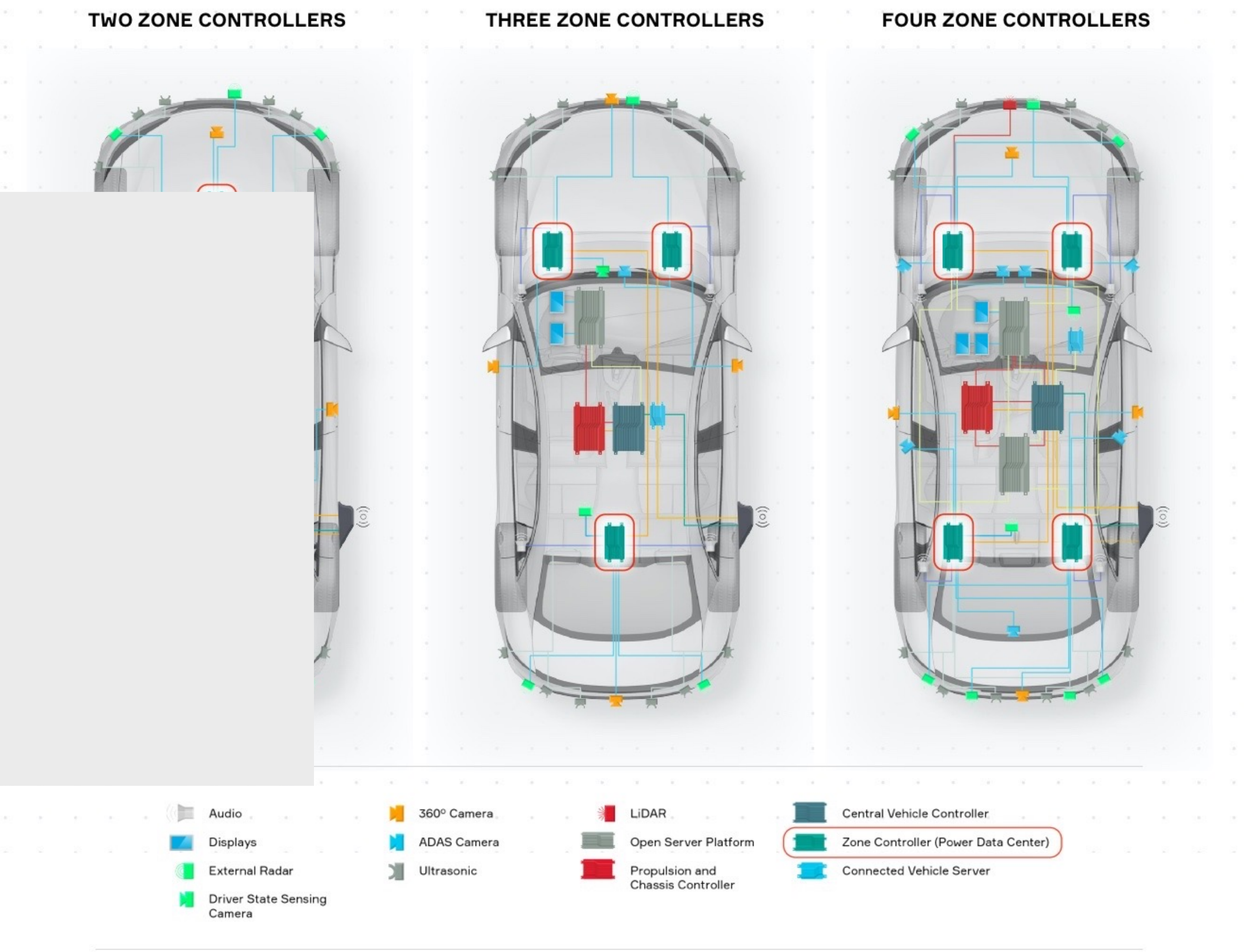
“

Modeling is not unique!

Thus, all the following demonstrations can achieved in another way

5th ex

Zone Controllers architecture

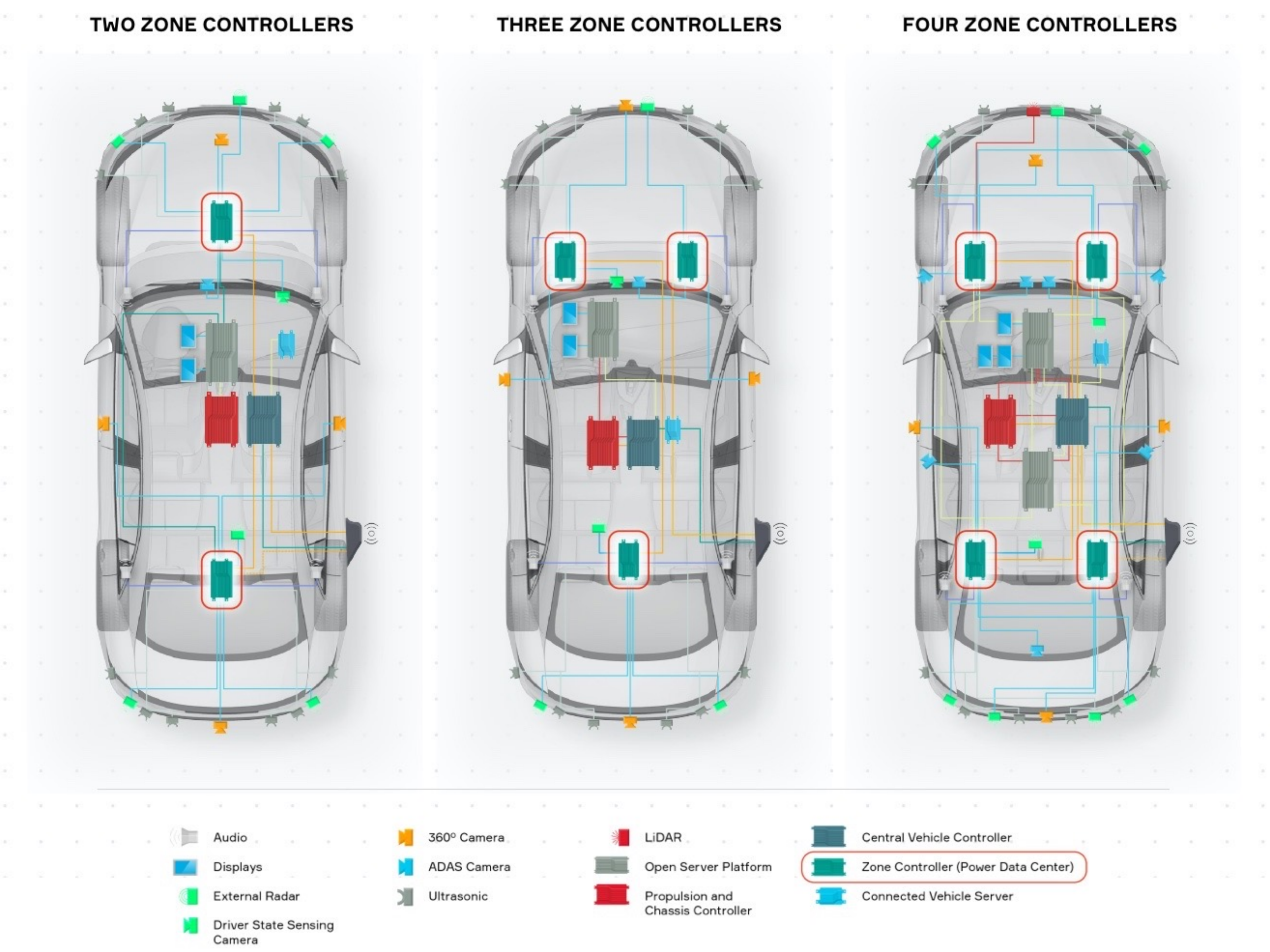


Problem Settings

INTRODUCTION

Modern car embedded more and more sensors/actuators (S&A) as well as intelligence to provide new function as ADAS, smart ambient light…

To provide function to driver, car's S&A must be connected together through Zone Controllers (ZC).



Example of Zone Controller architectures

Problem Settings

INTRODUCTION

Modern car embedded more and more sensors/actuators (S&A) as well as intelligence to provide new function as ADAS, smart ambient light…

To provide function to driver, car’s S&A must be connected together through Zone Controllers (ZC).

Engineers are looking to find the best architectures of ZC.

Example of Zone Controller architectures

Problem Settings

INTRODUCTION: FIRST STEP FOR LATER…

Sensors are characterized by:

- Their position in car (fixe one),
- Their type and number of I/O,
- The supply they need to work (supply is provided by ZC),
- The computation power to achieve the function (complexity of algorithm)

Each zone controller is defined by:

- Its PCB surface,
- Its volume,
- Its configuration,
- Its weight,
- Its cost

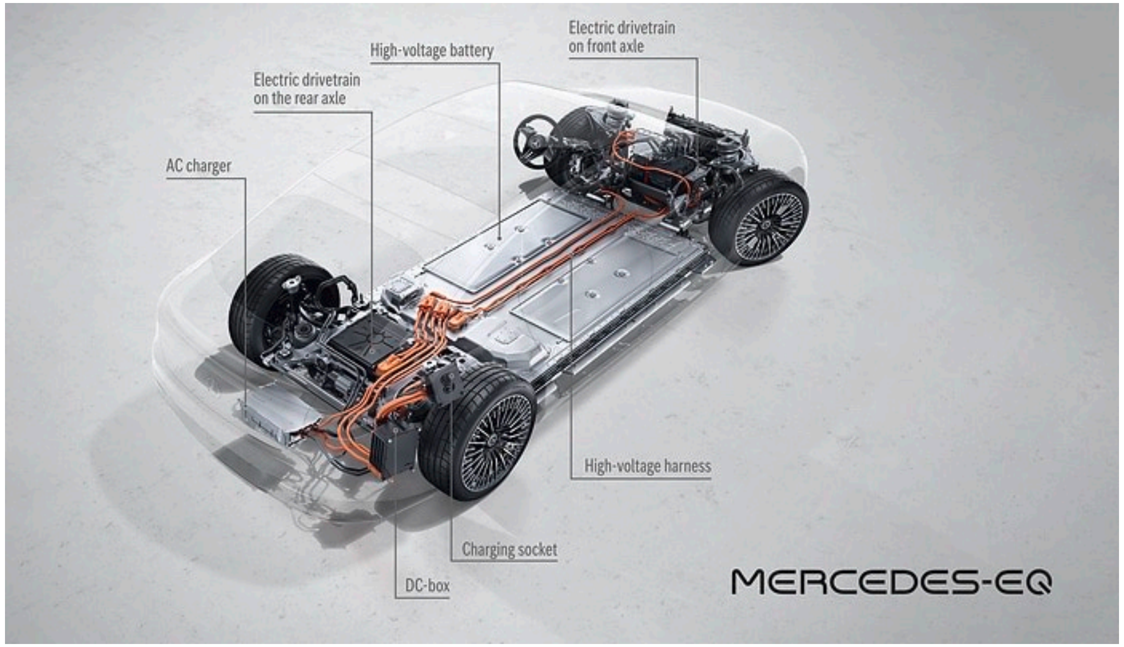
Problem Settings

INTRODUCTION

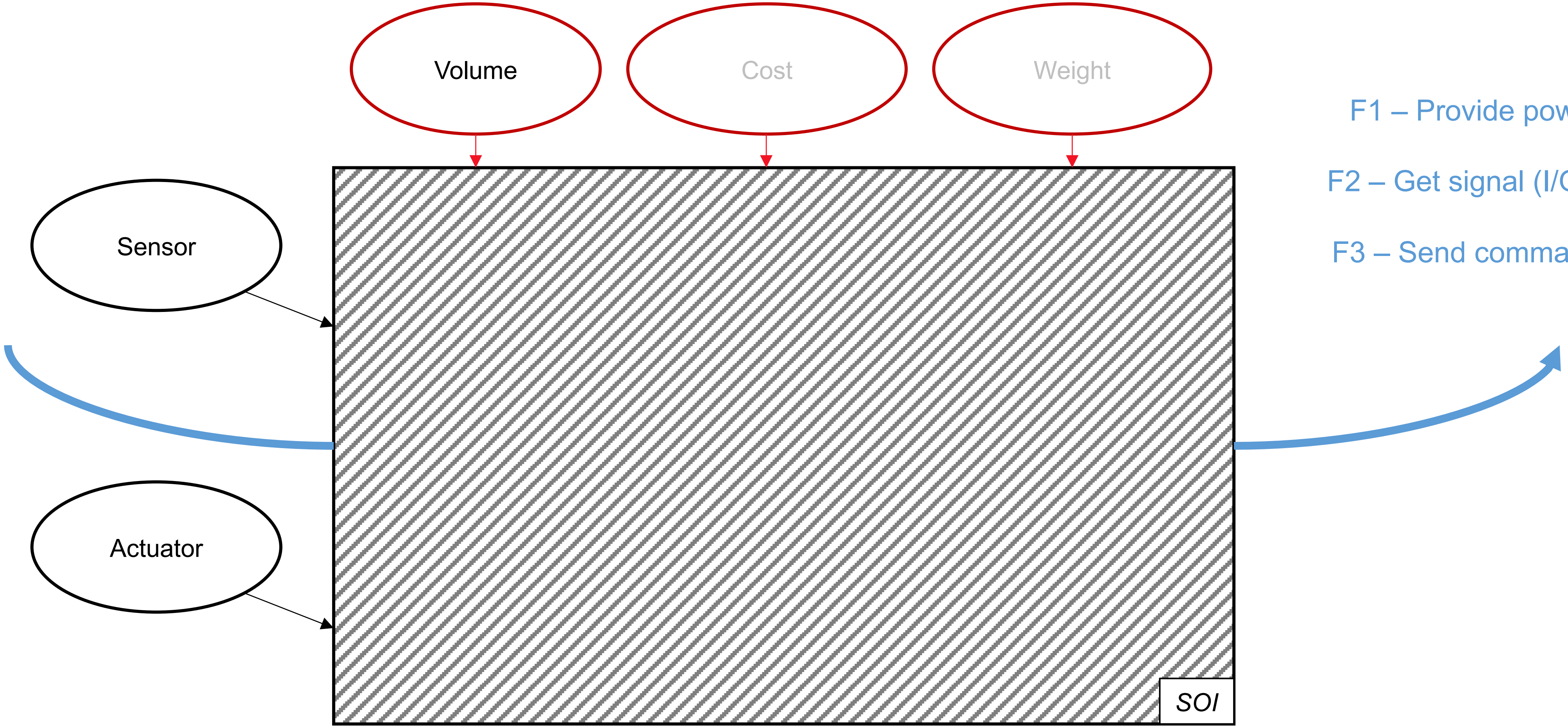
Each zone controller must be fit into one of the installation space constraints by the vehicle level.

One ZC per installation space.

It’s NOT mandatory to fill all installation space with ZC.



Problem Settings: The black box view



F1 – Provide power to sensor

F2 – Get signal (I/O) from sensor

F3 – Send command to actuator

Pattern it to Geeglee!

CREATE THE GEEGLEE PATTERN

Geeglee's model must cover the connexion of all S&A to a ZC allocated into installation space (and insure it must fit in).

More over, due to car's configuration, some sensors might not needed. Project management is looking to a robust architecture.

Cluster definition

FIRST APPROACH

The problem can solved by a clustering approach.

Each S&A will be allocated to a cluster and then Geeglee will be used to find the best allocation of cluster to zone controller.

The advantage of this approach is to avoid a large combination to test that can be irrelevant (as, for instance, to set two sensors, physically close, to a front and a rear ZC – so far away ZCs).

In this objective, Geeglee model owner must set the smallest size he want to analyse. In this example, we propose four (left representation beside) but it should be much more to refine quality of exploration (including asymmetrical ones).

Example of clusters definition

Cluster definition

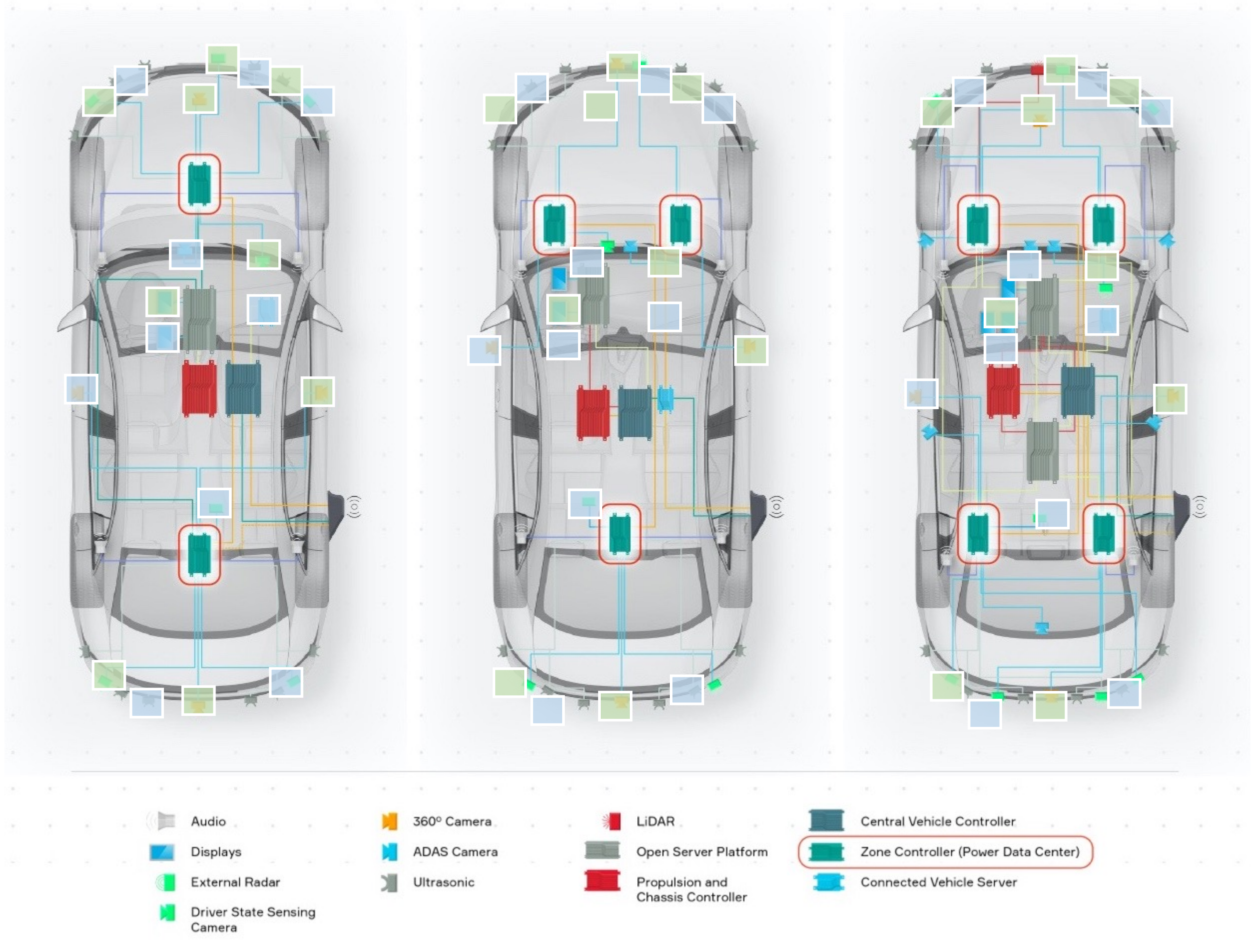
SECOND APPROACH

The problem can solved by testing all allocation of S&A to any potential ZC.

It's the same principle of allocating cluster to ZC but using directly S&A to ZC.

The disadvantage of this approach is to test a very large combination some that could be for sure, irrelevant. But for sure, sometimes counter-intuitive solutions can be a breakthrough!

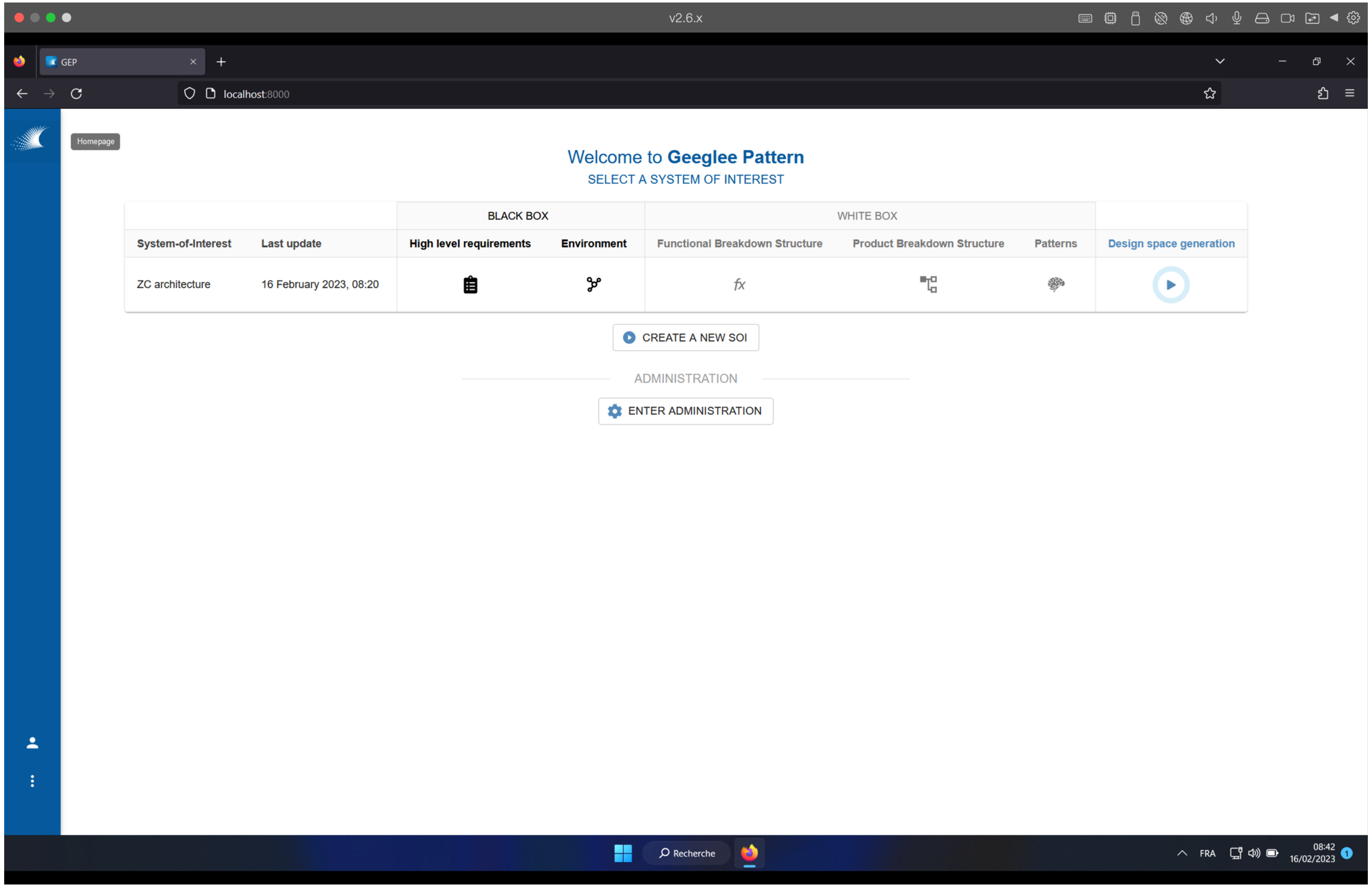
For the rest of this exercise, the first approach, using clusters, have been selected



Example of clusters definition

Step 0: Set your project & SOI

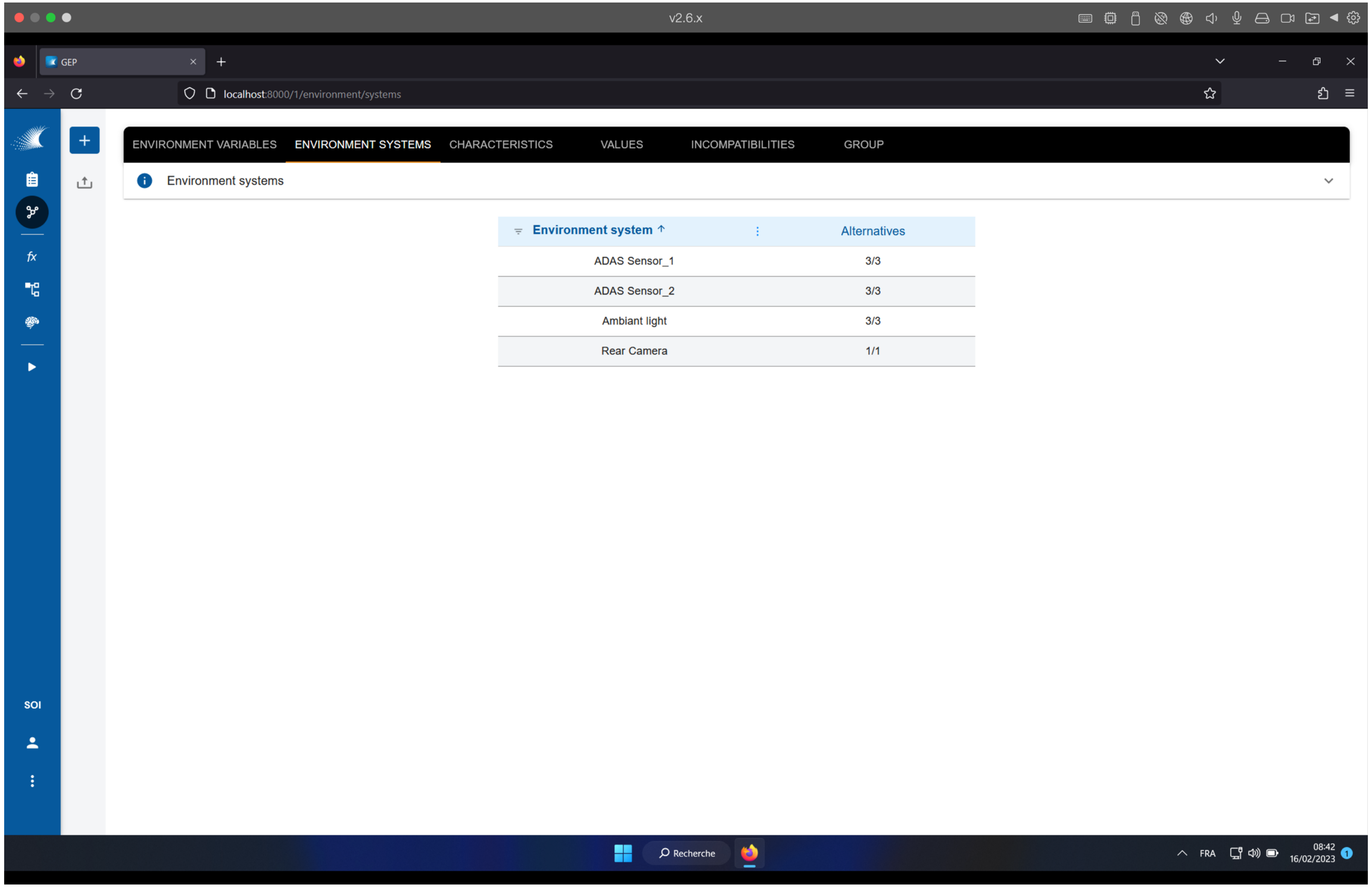
- ✓ Nothing special here, create:
  - ✓ A SOI: « ZC architecture » for instance (but it work also if you choose another name),
  - ✓ An architecture: « ref. » for instance,
  - ✓ A first module: « M1 » for now,
  - ✓ A first alternative: « A1 » for « M1 »



Step 1: Set sensors list to Environment systems

BLACK BOX

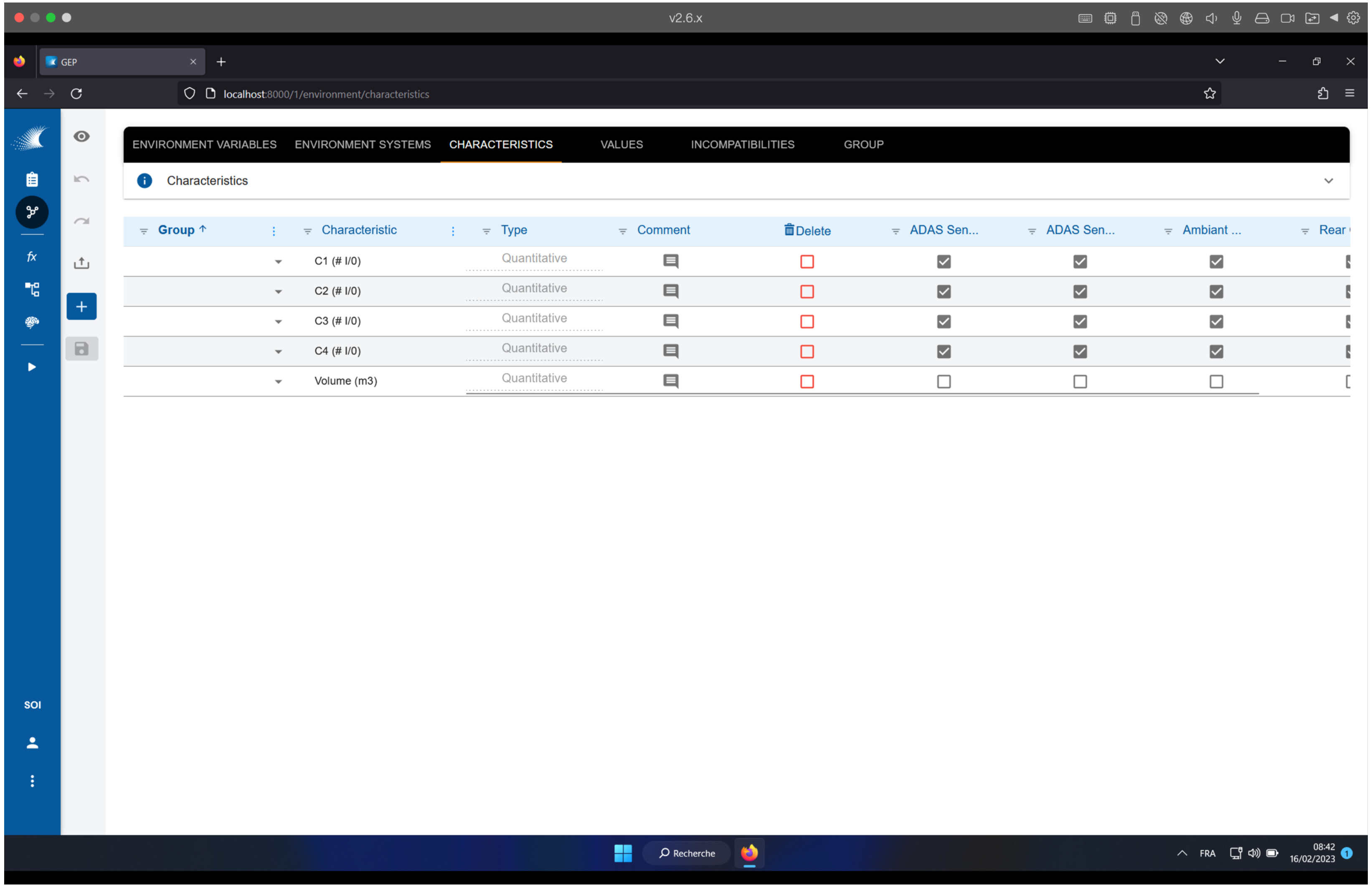
- ✓ As you are not the person in charge of the selection of sensors & actuators embedded into the car, it’s, for you, an environment systems
  - ✓ For our example, four has been listed here but you must list (or import) all the potential car S&A!



Step 2: Set characteristics to describe sensors

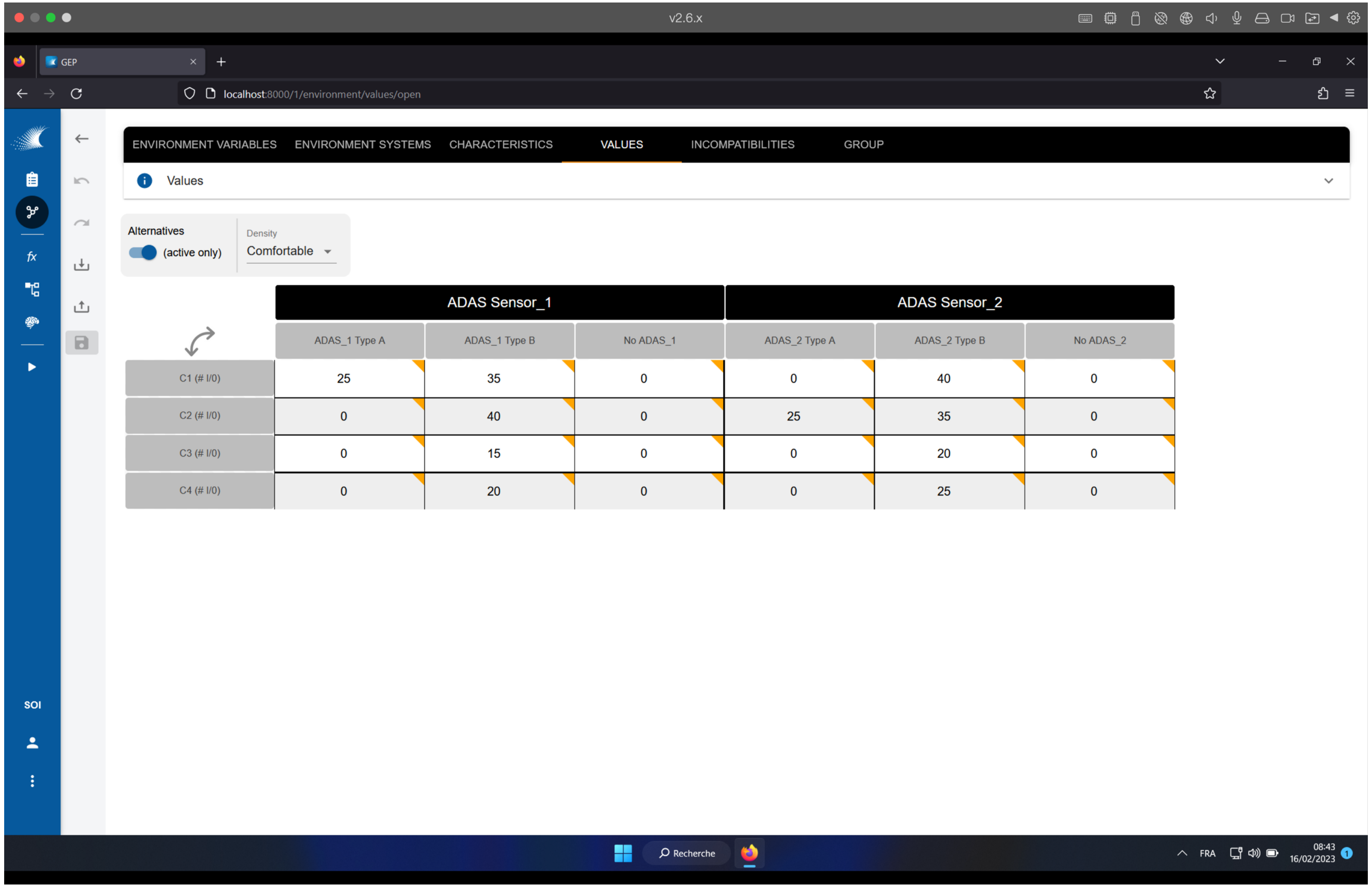
- ✓ Sensors can be characterized by their number of I/O per cluster (thus their location are implicite to the cluster). To explain that to the software, characteristics « Cx (# I/O) » has been created.
  - ✓ X =[1..n], n the number of cluster

- ✓ *A perspective should be to set all type of I/O per cluster*



Step 3: Set values for environment alternatives (1/2)

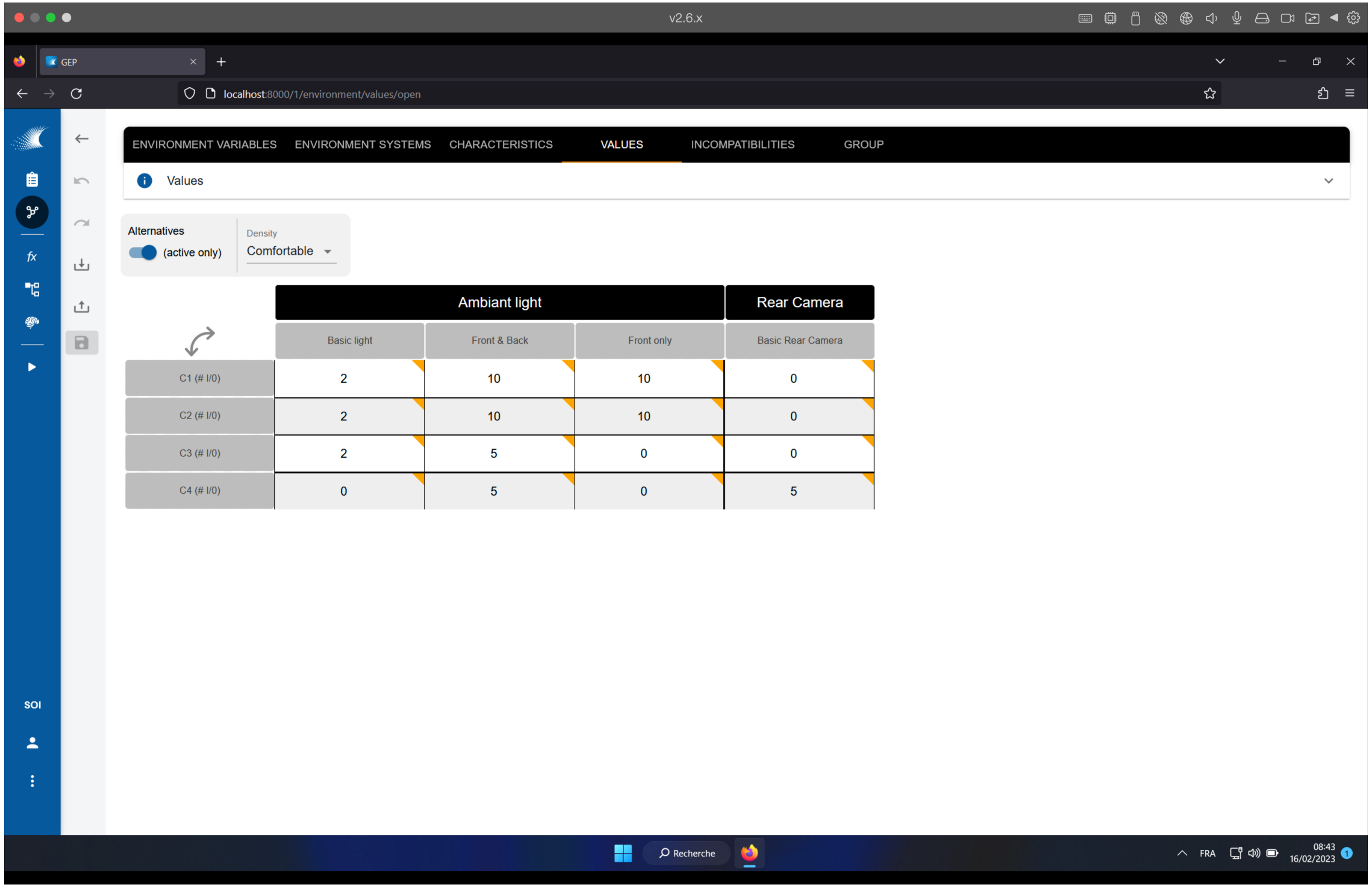
- Define the number of I/O for each sensor/actuator.
- *Remark that:*
  - *a sensor can be shared between clusters,*
  - *ADAS is composed, in this case, of two sensors,*
  - *An alternative « No ADAS_X » has been created to set the case of no ADAS is installed in the car. These alternatives has been set with « 0 » values for each cluster.*



System Value

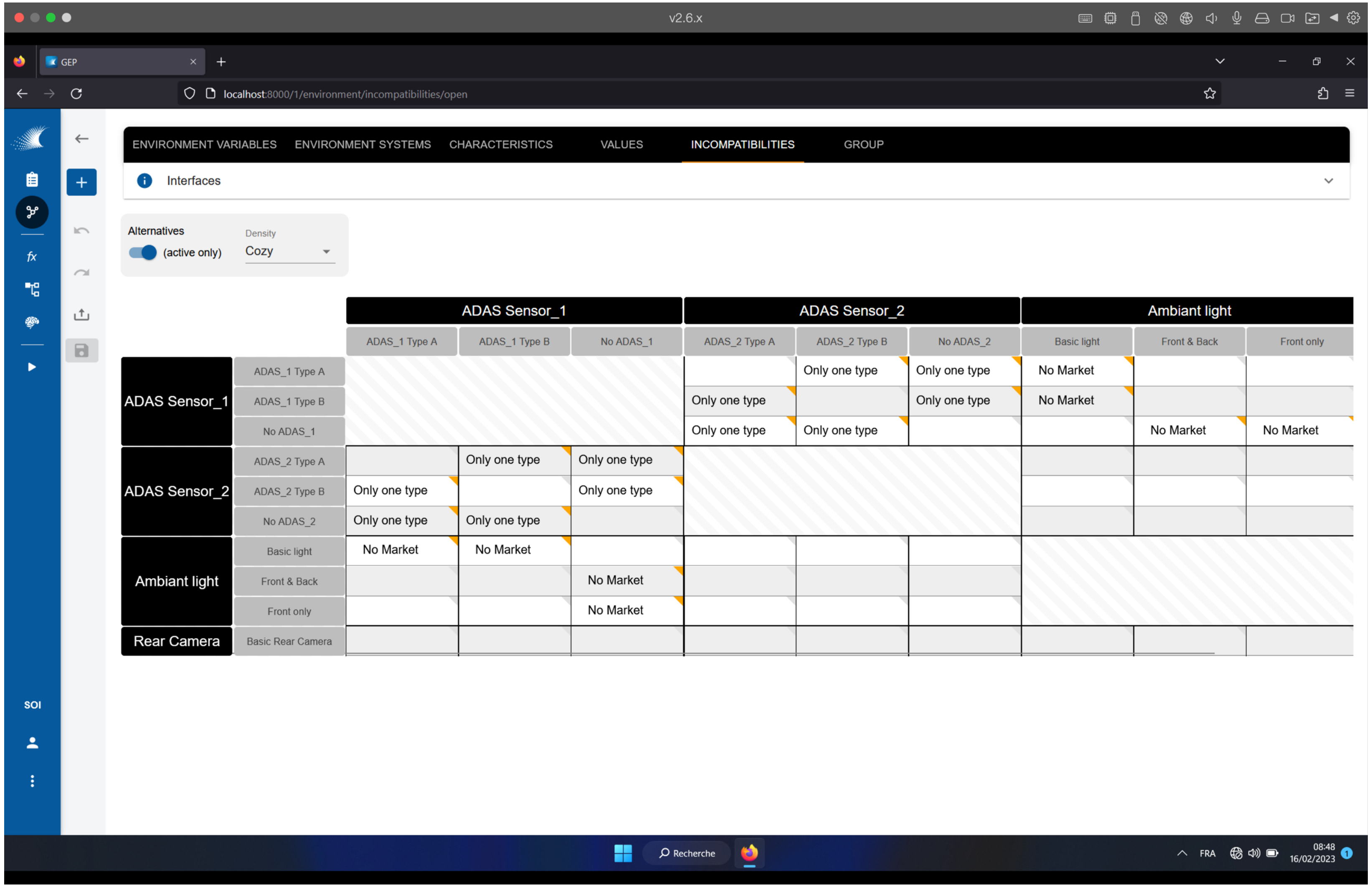
Step 4: Set values for environment alternatives (2/2)

- Define the number of I/O for each sensor.
- *Remark that:*
  - *a sensor can be shared between cluster,*
  - *« Ambiant light », as well as, « Rear Camera » is still embedded into the car but with various alternatives, for « ambiant light ».*



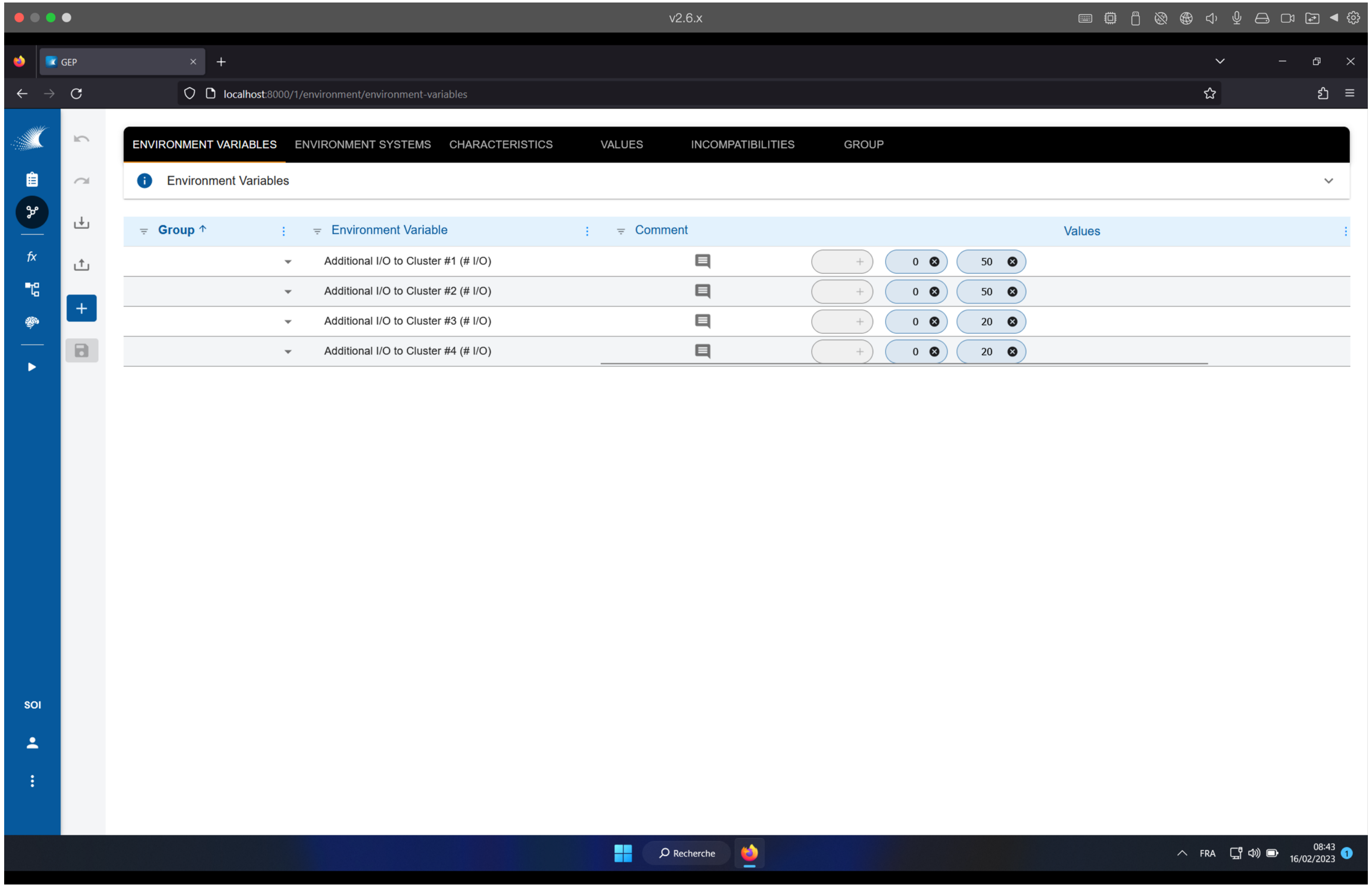
Step 5: Set incompatibilities

- ✓ Due to market expectations some sensors must not be installed in a car together.
  - ✓ In our case, « Not market » means that nomarket exist for instance for a car using « Front & Back ambiant light » and « No ADAS_1 »
- ✓ Another constraint is due to the need to used only compatible type of ADAS: « Only one type »



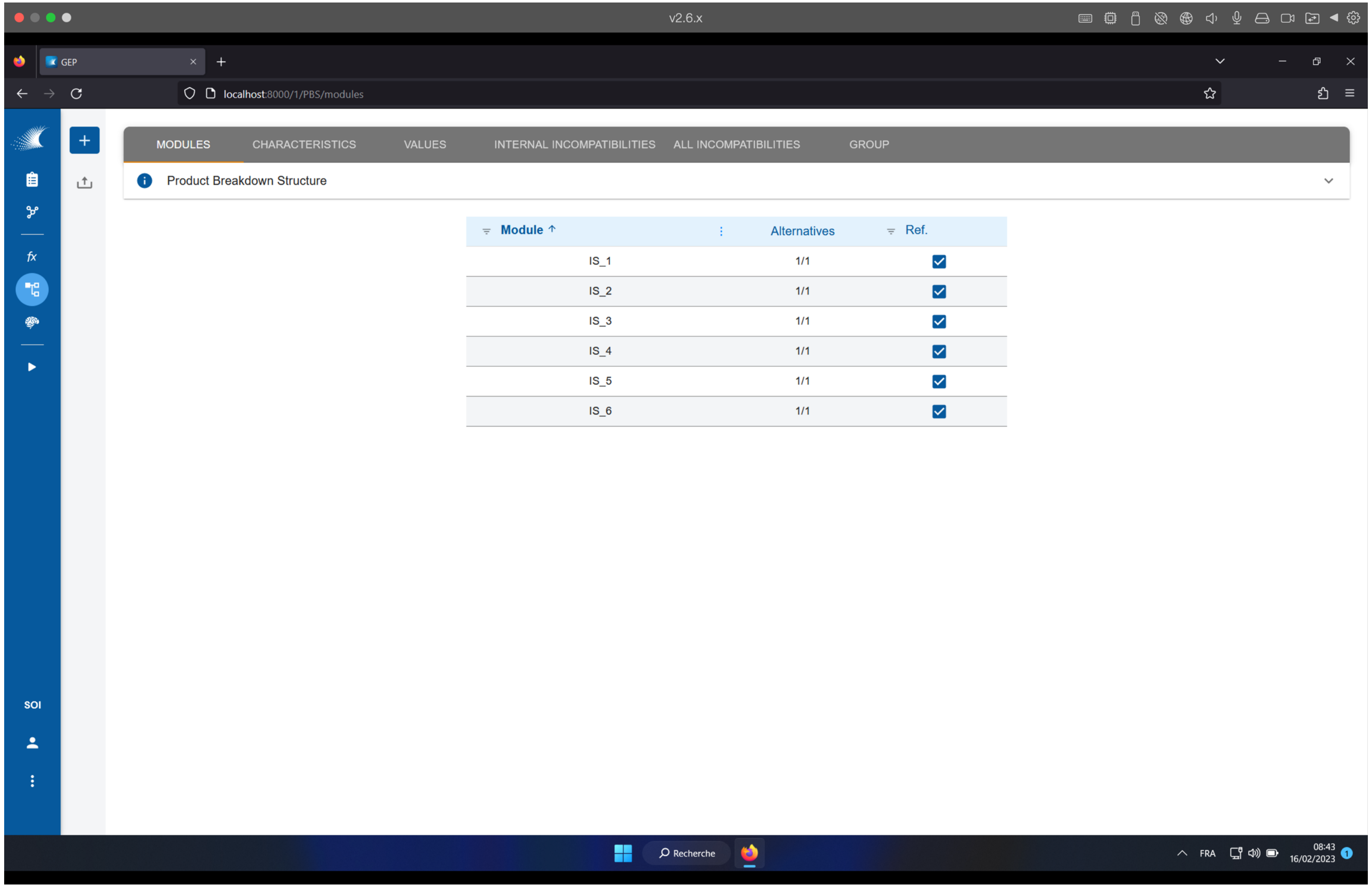
Step 6: Optional – add additional I/O for each cluster

- *To manage design engineering risk…*
  - *« 0 » will be the nominal case,*
  - *« 50 » / « 20 » will be the worst test case (from engineer's REX, risk is higher in clusters #1 and #2)*



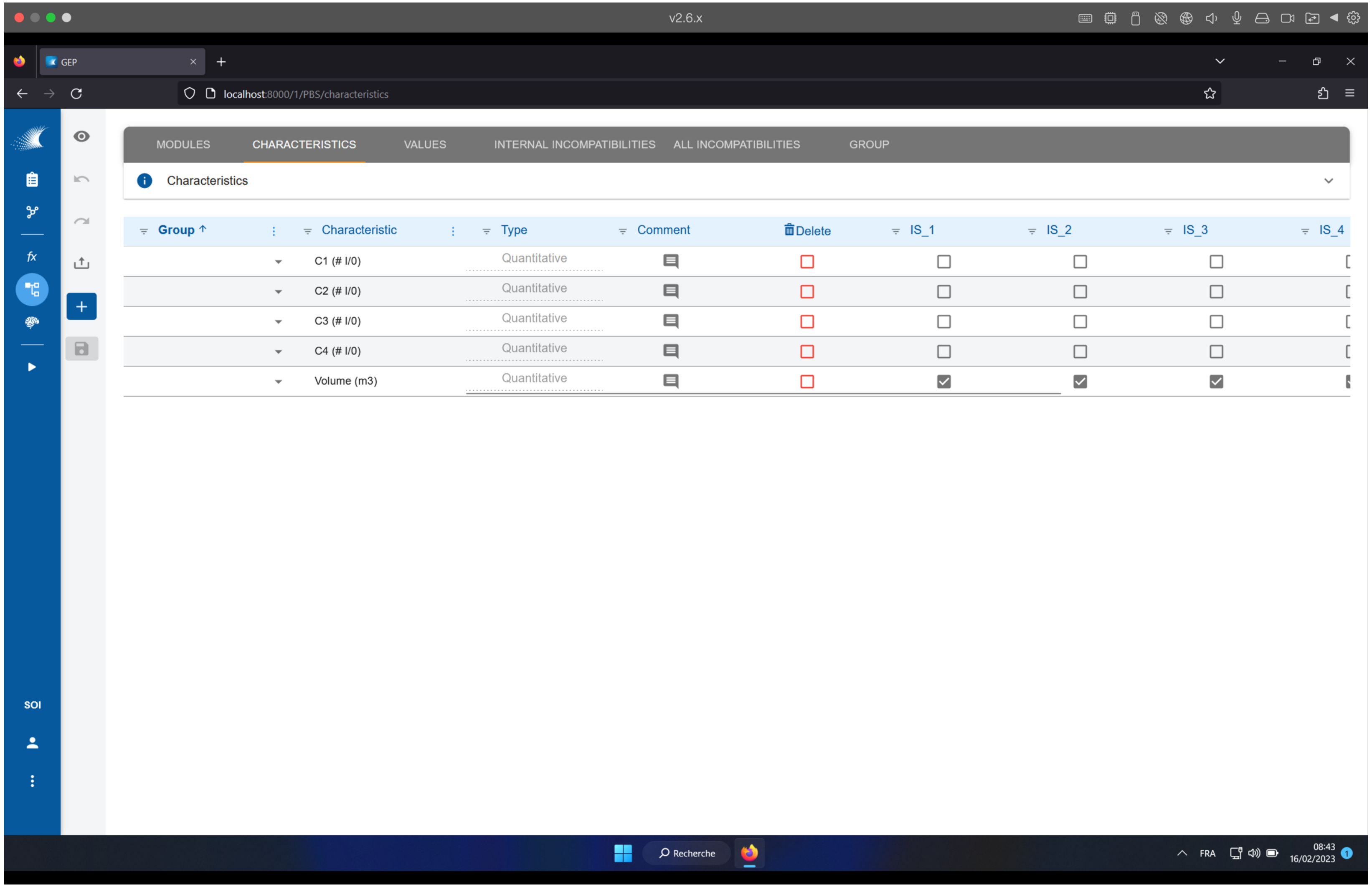
Step 7: Set installation space as module

- ✓ Car’s architect is proposing several spaces to install ZC. As you are the person in charge of the decision to locate ZC in intallations spaces, it’s modules for you.
- ✓ In our project, six intallations spaces are proposed.



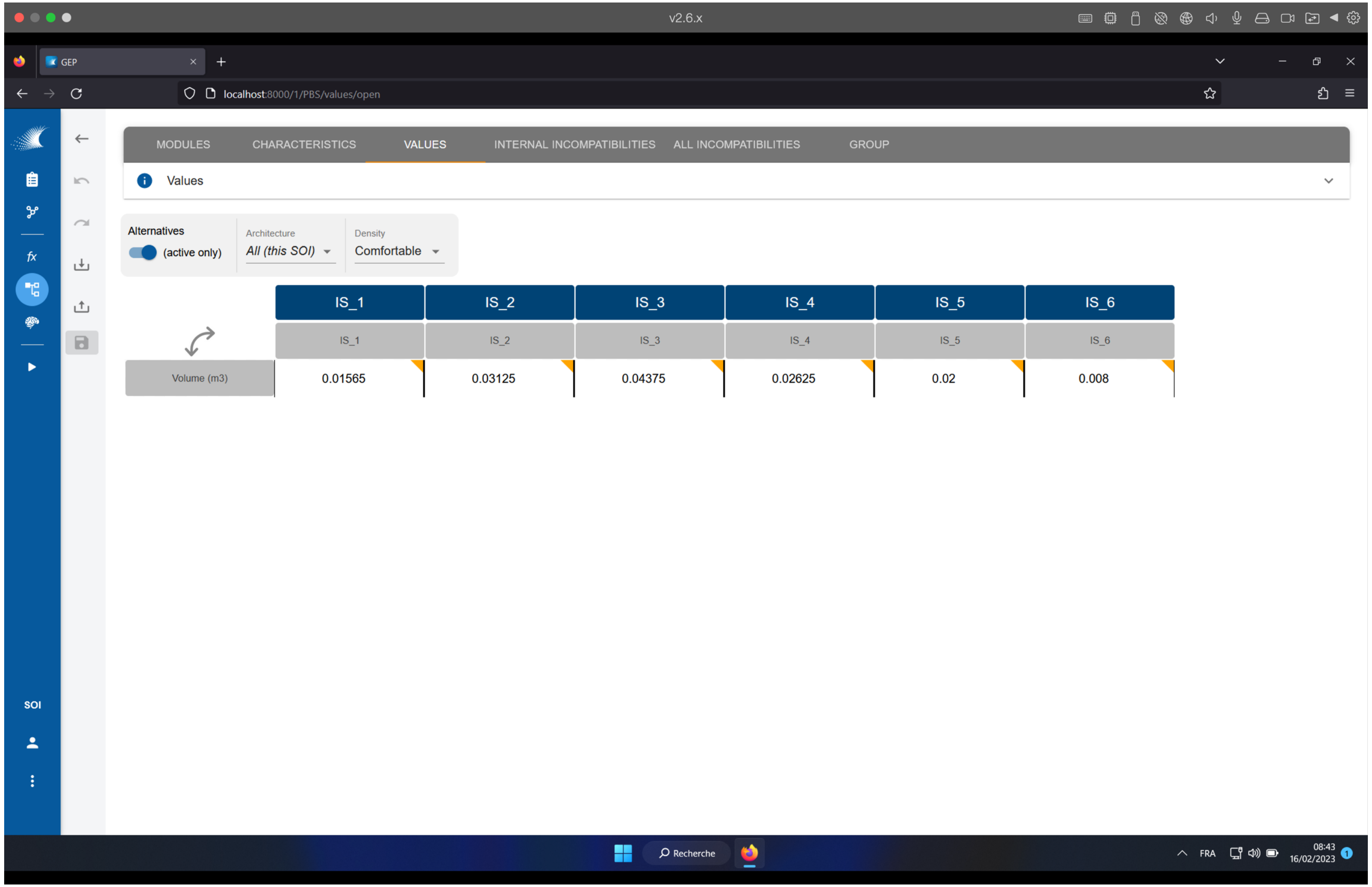
Step 8: Set characteristics for modules

- ✓ Instalation spaces (IS) are characterized by their volum (m³)



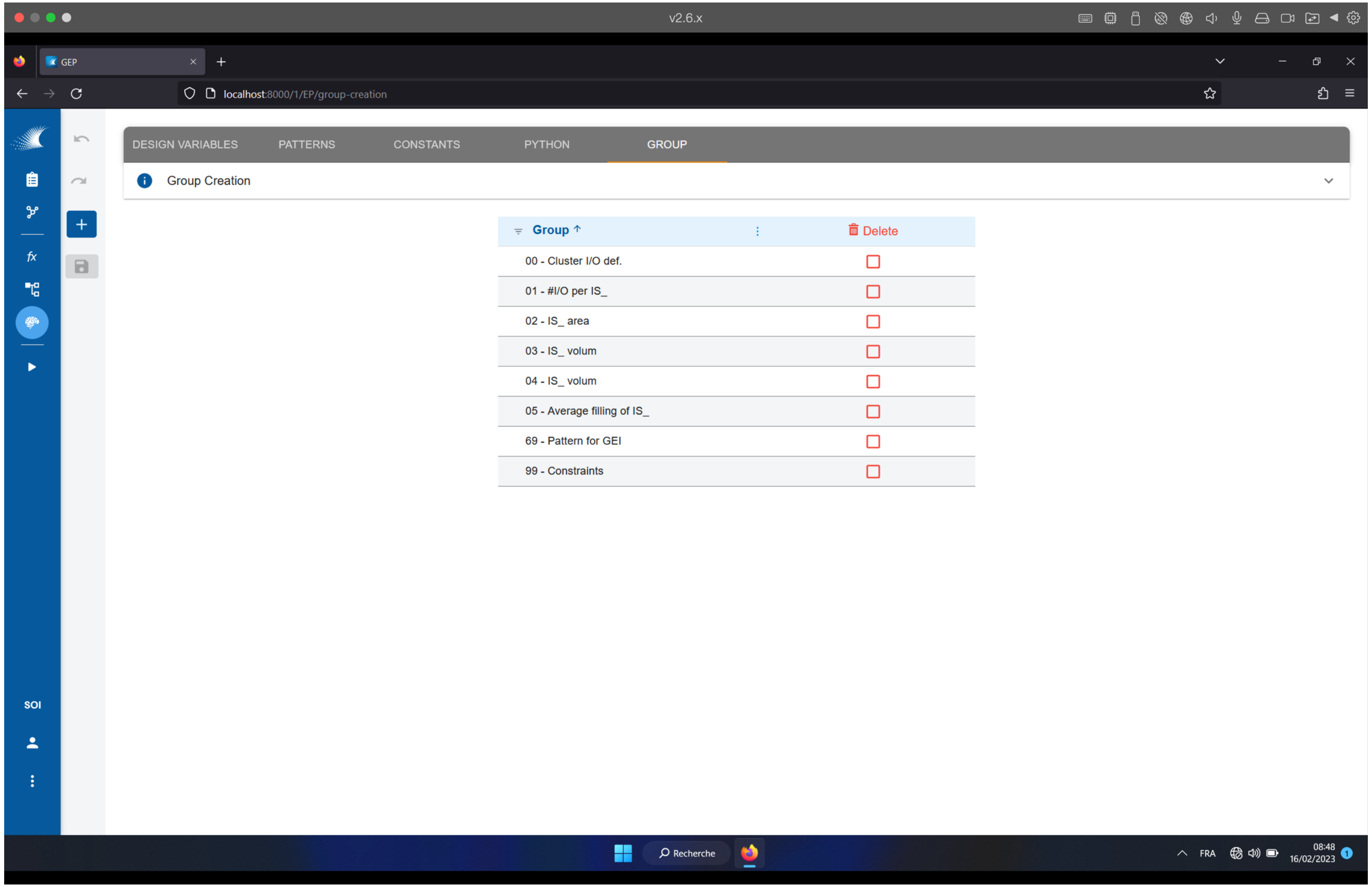
Step 9: Set value for each installation spaces

✓ Set the volum (m³) of each IS



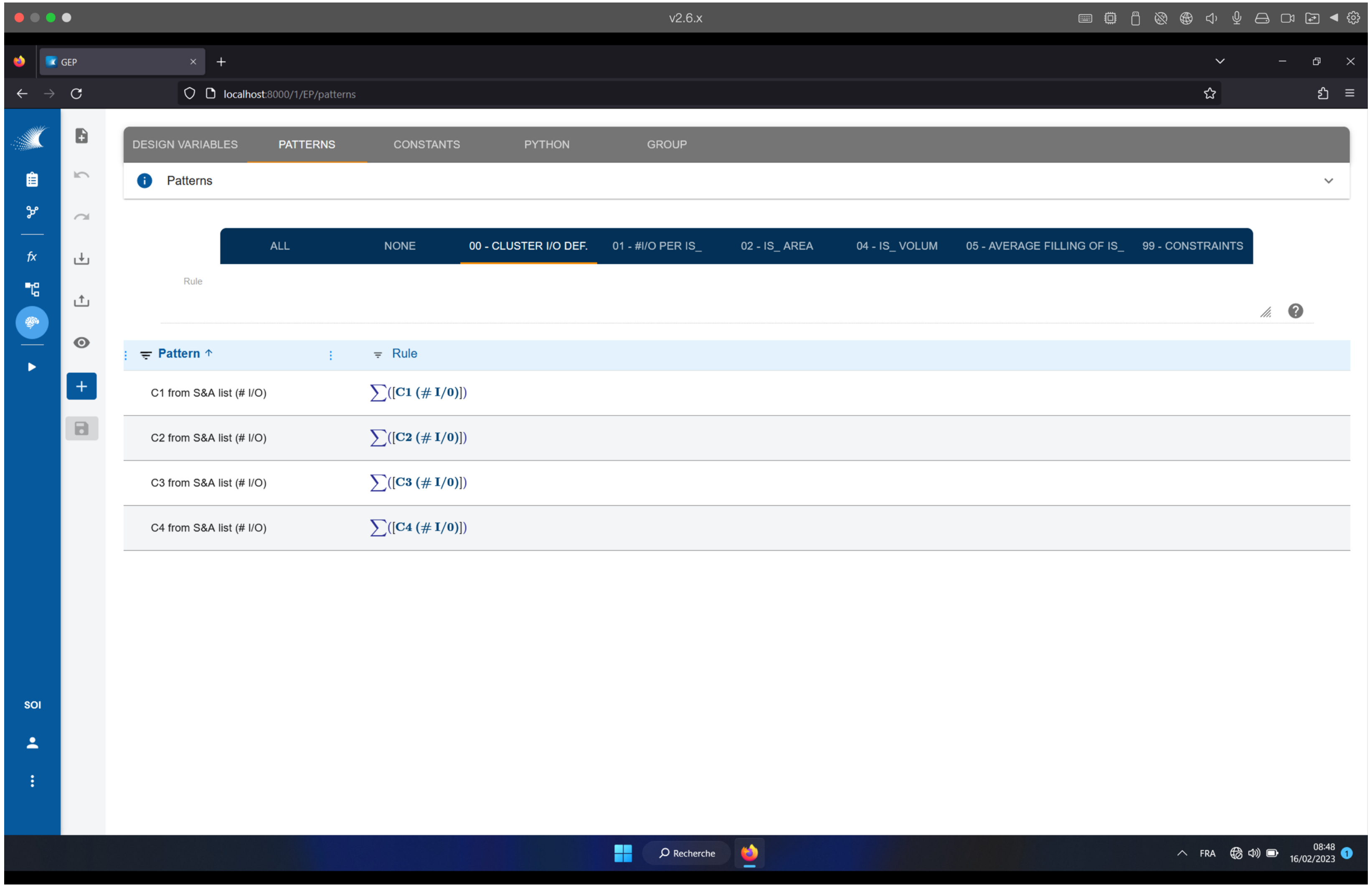
Step 10: Set group to describe your logic

- A good practice while using groups is to set your logic of thinking:
  - What is the first step of analysis, the second…
- In our project:
  - « 00 – Cluster I/O def. »
  - « 01 - #I/O per IS_ »
  - « 02- IS_area »
  - …
  - The logic of each group is explain on the following slides.



Step 11: Set pattern to calculate the number of I/O per cluster

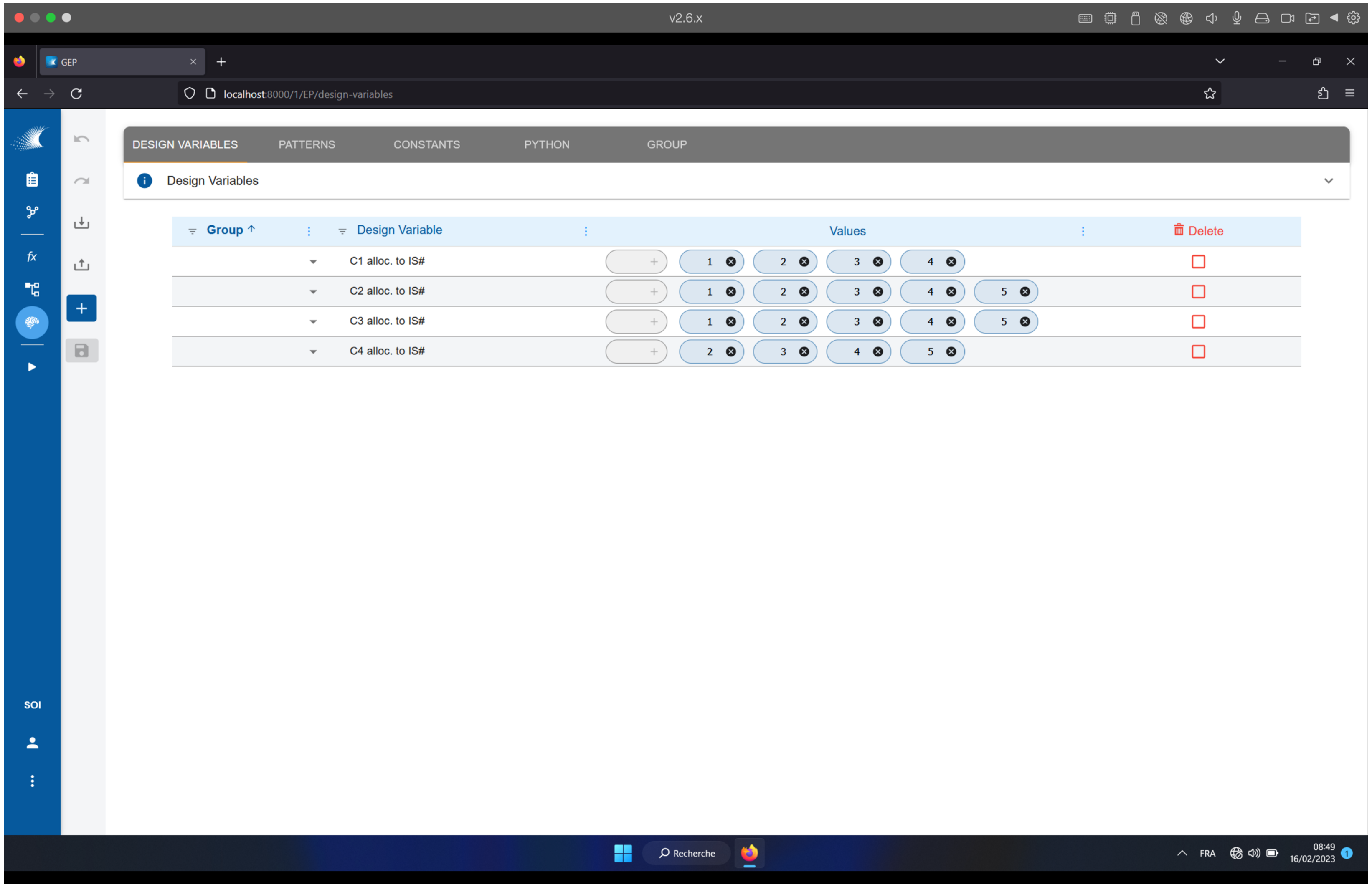
- ✓ In this case, the architect use a vector function of Geeglee to summarize the number of I/O per cluster:
  - ✓ Sum(.« Cx (#I/O))



Step 12: Set Design Variable to test the allocation of cluster to installation space

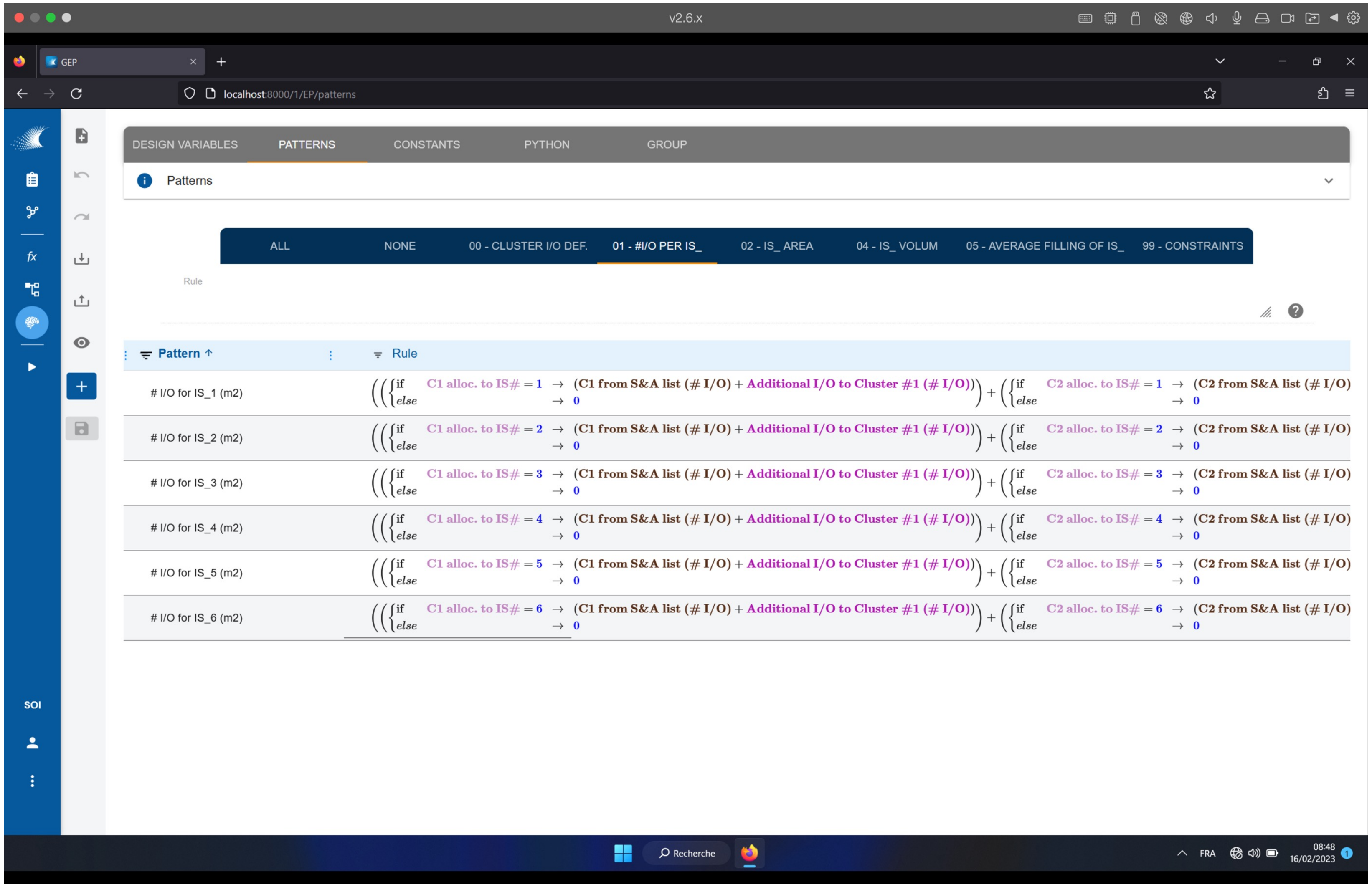
- ✓ Design Variable, part of your white box (because you will decide where to allocate clusters), is used to set the allocation of clusters to Intallation Space #X

- ✓ *In this example, the testing is made to show how, the architect, can pre-specify the allocation to test:*
  - ✓ *C1 in IS 1 to 4*
  - ✓ *C2 in IS 1 to 5*
  - ✓ *C3 in IS 1 to 5*
  - ✓ *C4 in IS 2 to 5*
  - ✓ *So no Cx into IS6 to test!*



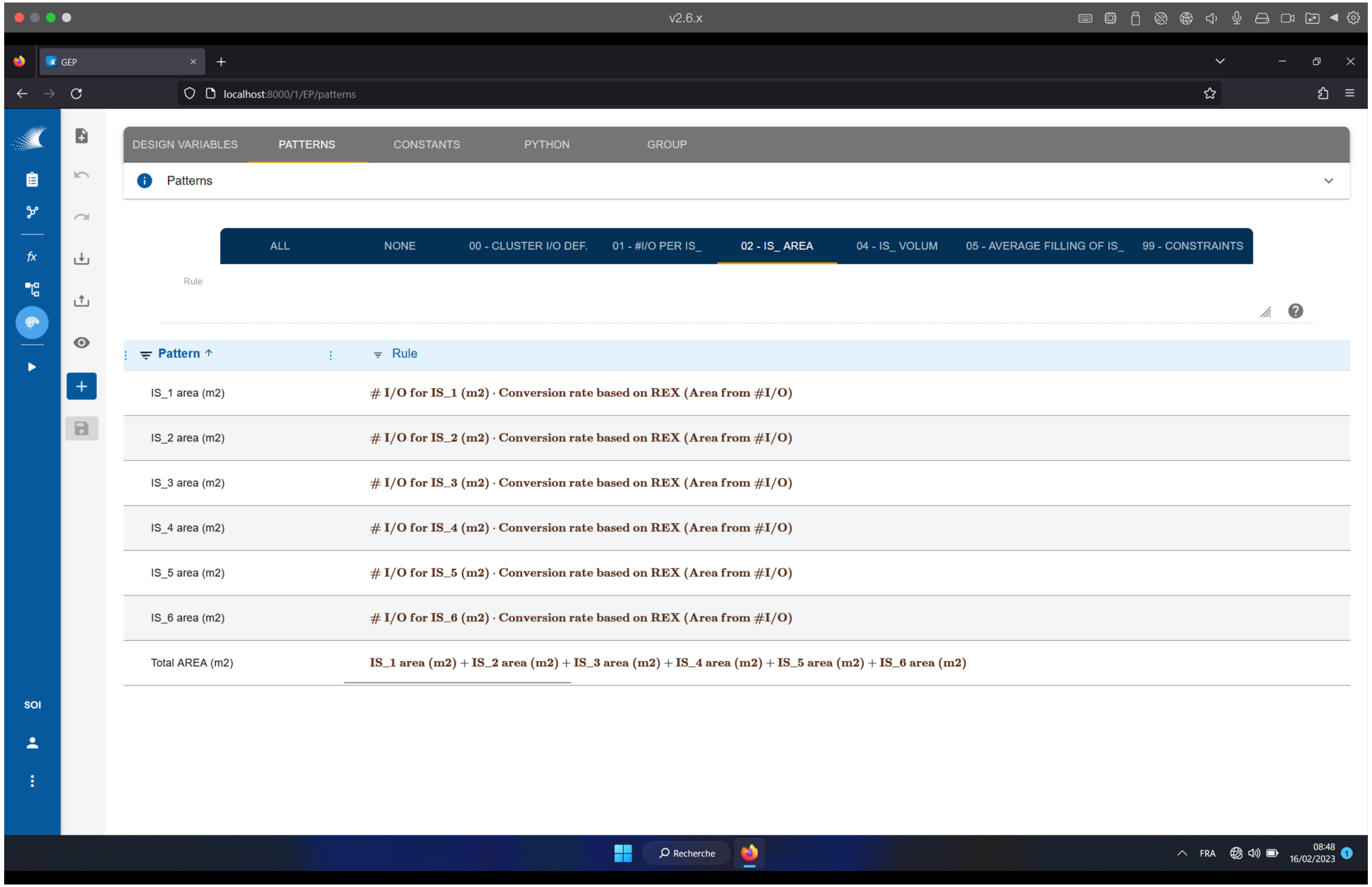
Step 13: Set pattern to calculate the number of I/O per installation space

- ✓ Calculate the number of I/O allocated to IS_#



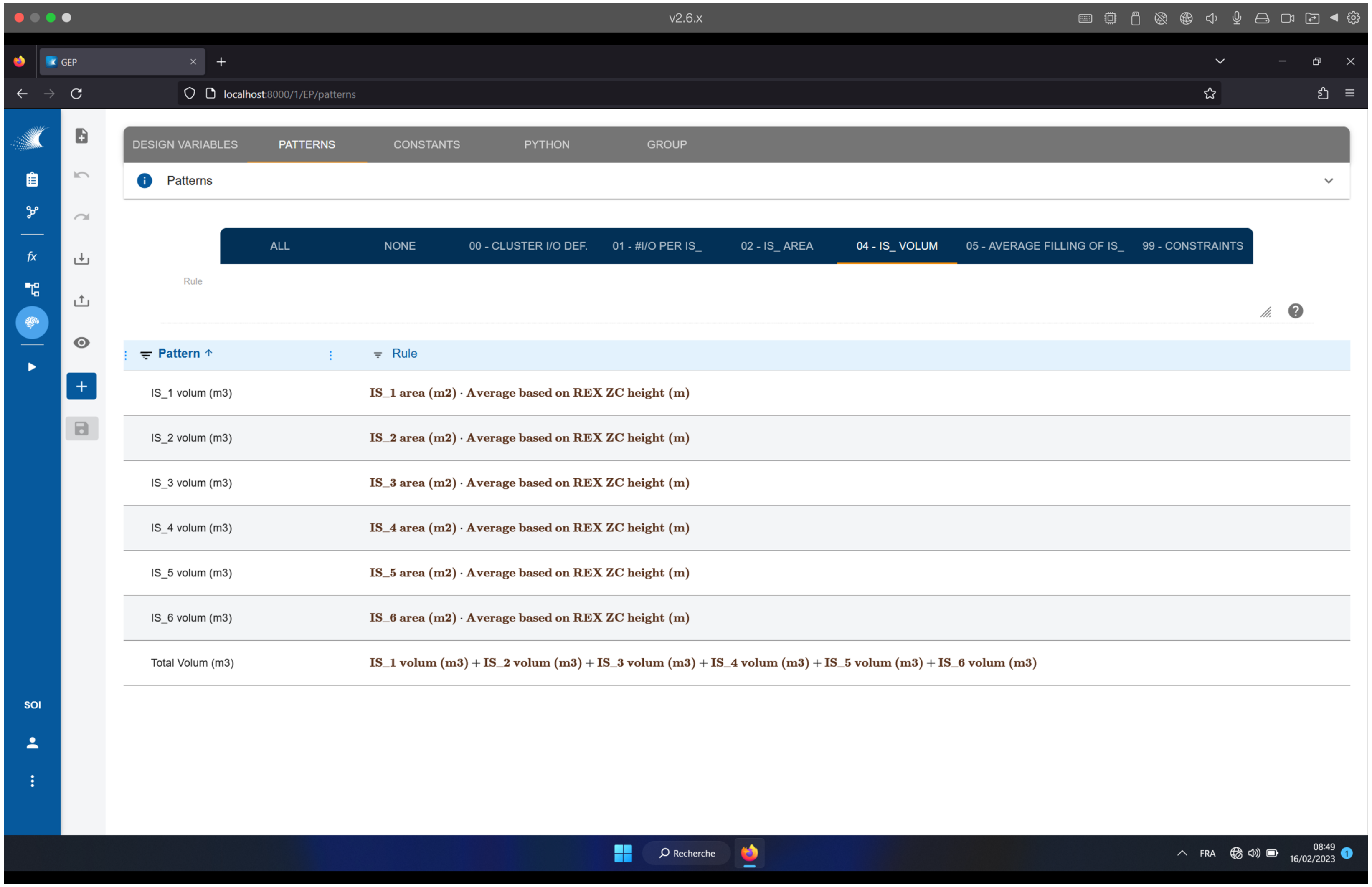
Step 14: Set pattern to calculate zone controler area per installation space

- ✓ In this case, engineers are using a « Conversion rate based on REX » to calculate the surface of ZC based on the number of I/O per IS_
  - ✓ The « Conversion rate based on REX » is set in « Constants » of Geeglee but it could be a complex function too!



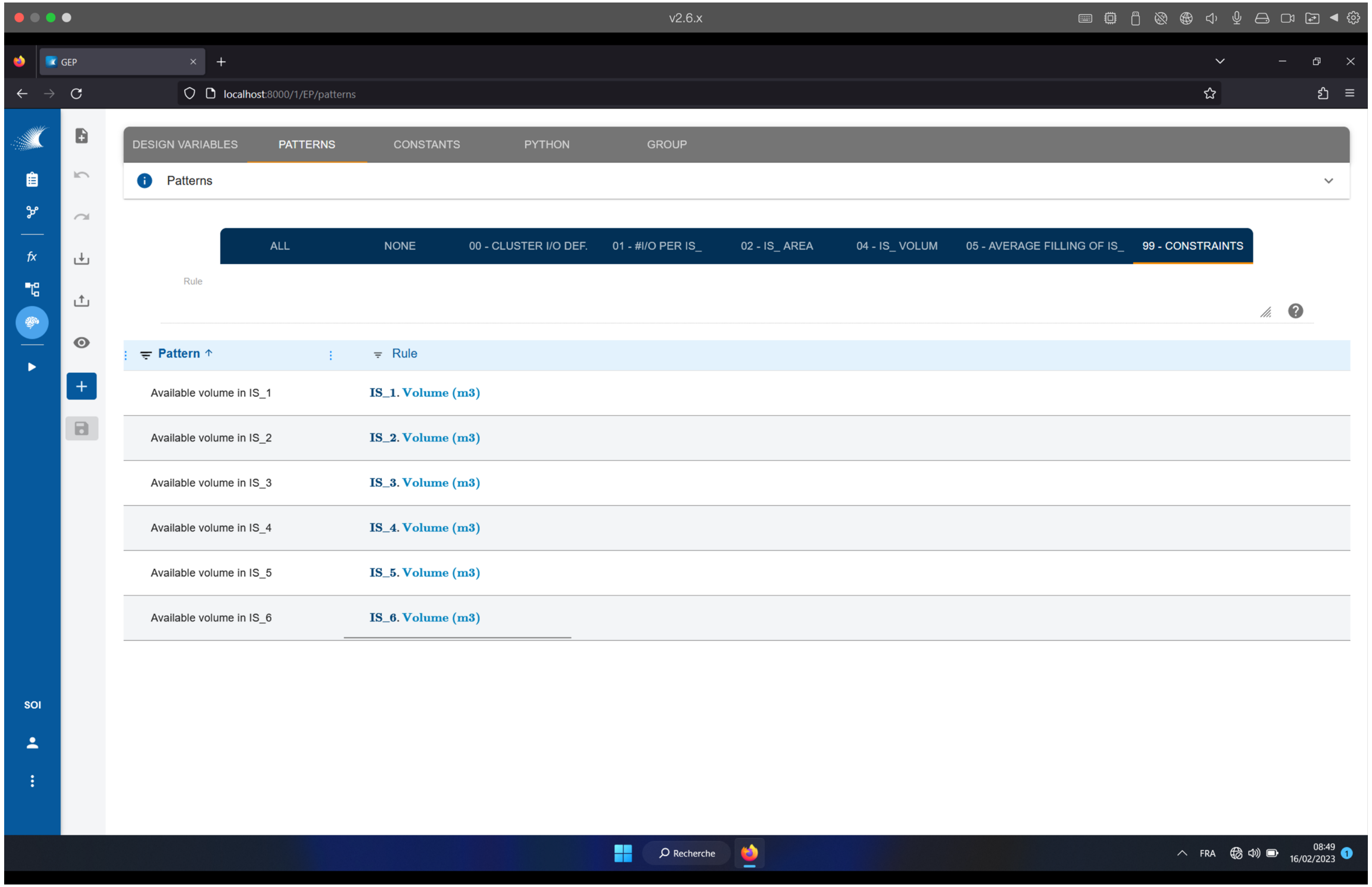
Step 15: Set pattern to calculate the volume of each zone controler per installation space

- In this case, engineers are using an « Average based on REX » to calculate the volum of ZC based on the surface of ZC (called IS_ here)
  - The « Average based on REX » is set in « Constants » of Geeglee but it could be a complex function too!



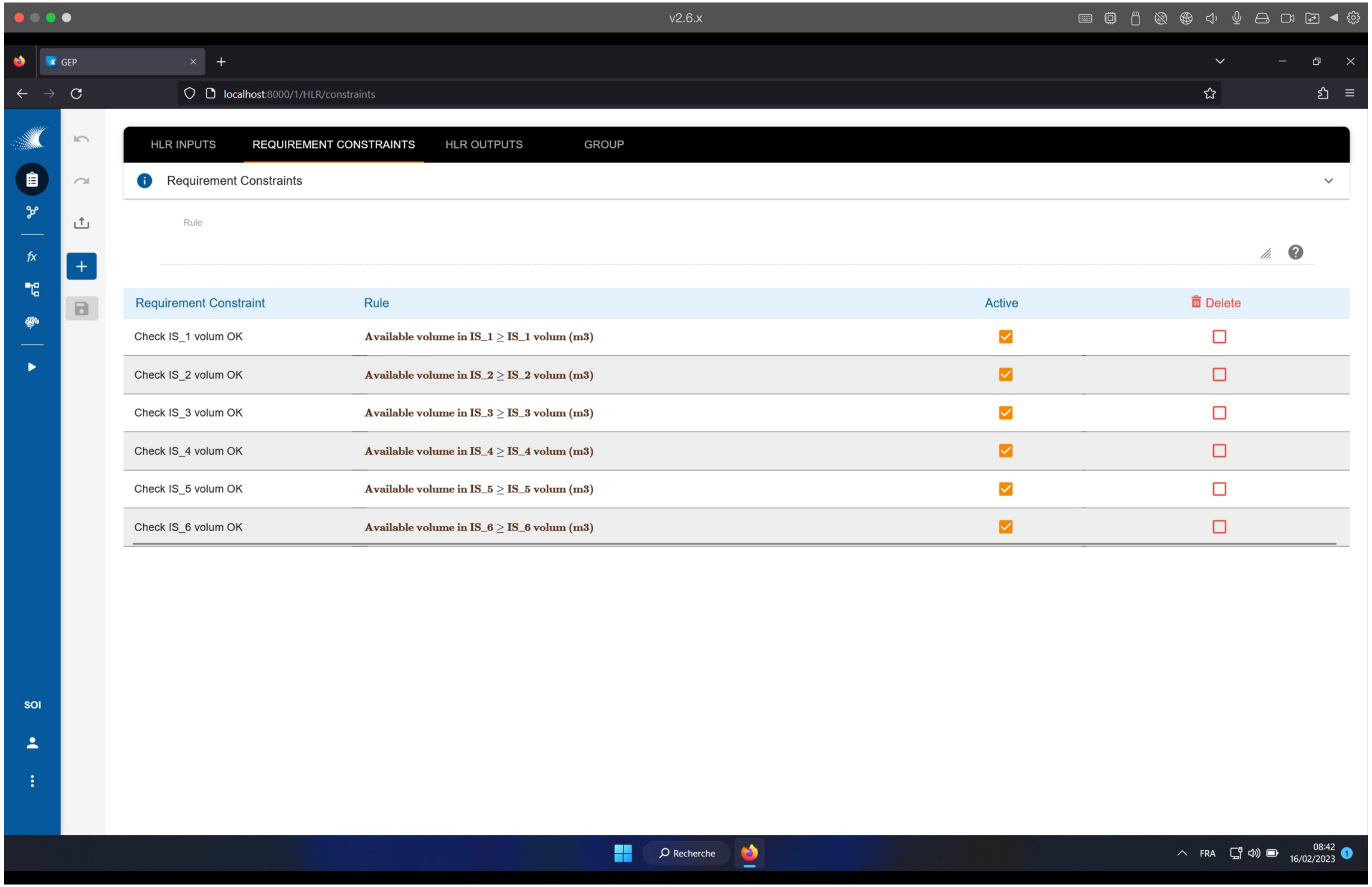
Step 16: Set pattern to validate that zone controler volum is not over installation space volum

- ✓ « Constraints », in Geeglee, cannot be set using the following form: « module ».« characteristics » so to use it, it’s needed to set pattern first. It’s the goal of this group

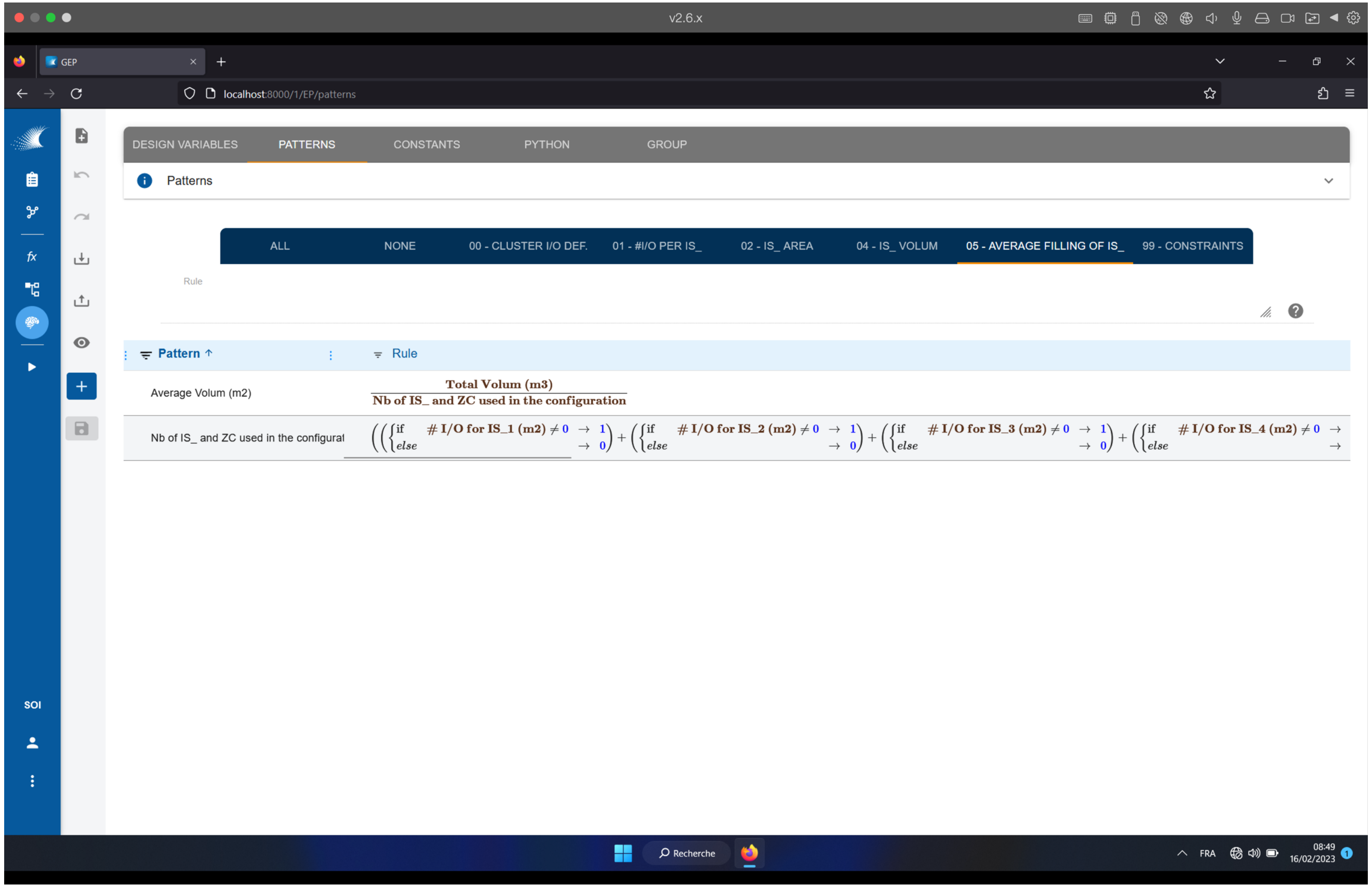


Step 17: Set constraints to validate that zone controler volum is not over installation space volum

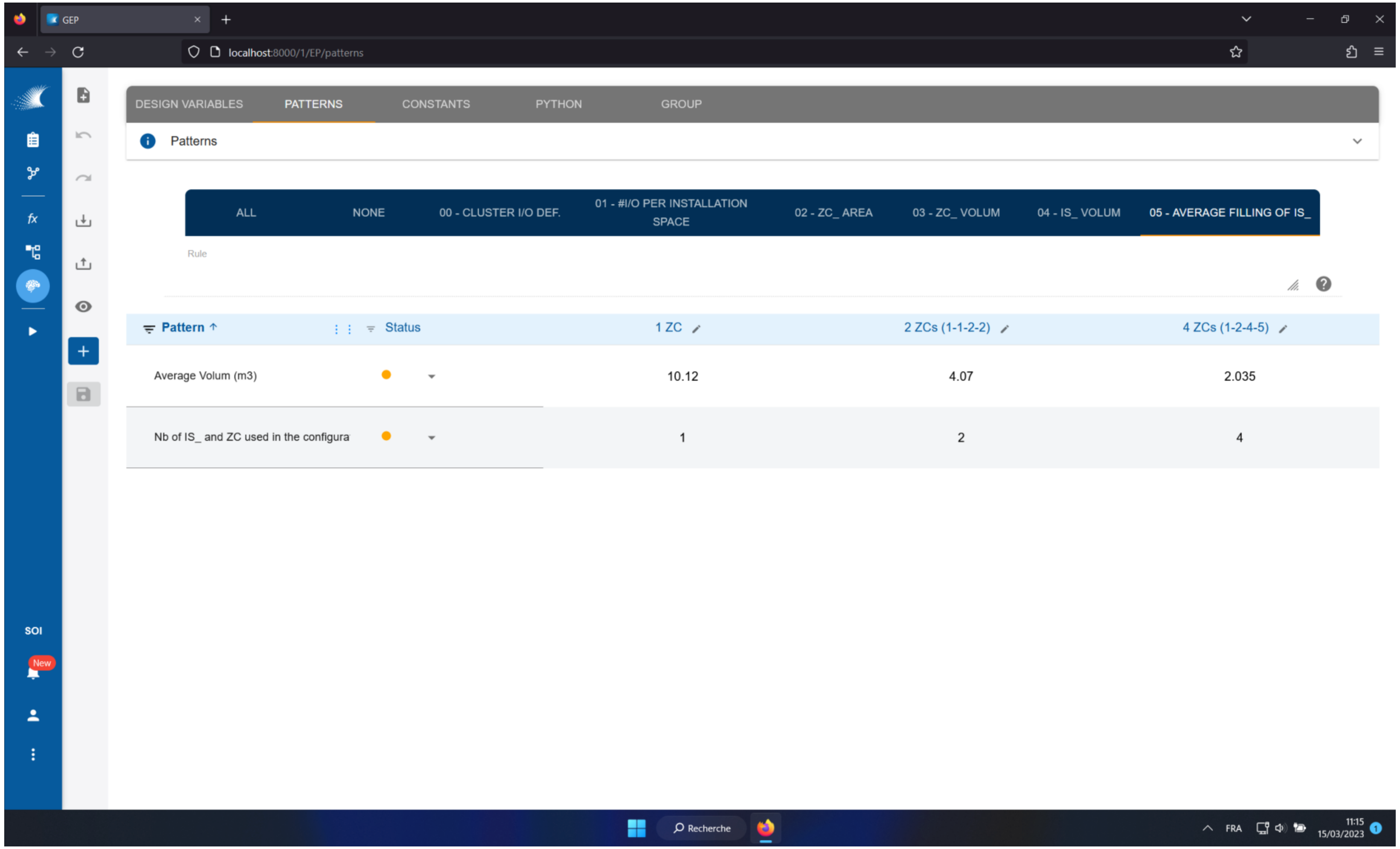
- ✓ « Requirement constraints » can be then set for each Installation Space.
- ✓ *As Geeglee explore the full design space (all the possible allocation of I/O (thus ZC) into IS_) if, it's not fitting, it can be delete (unfaisible solution)*



Step 18: Set pattern to calculate the average volum for each used installation zone

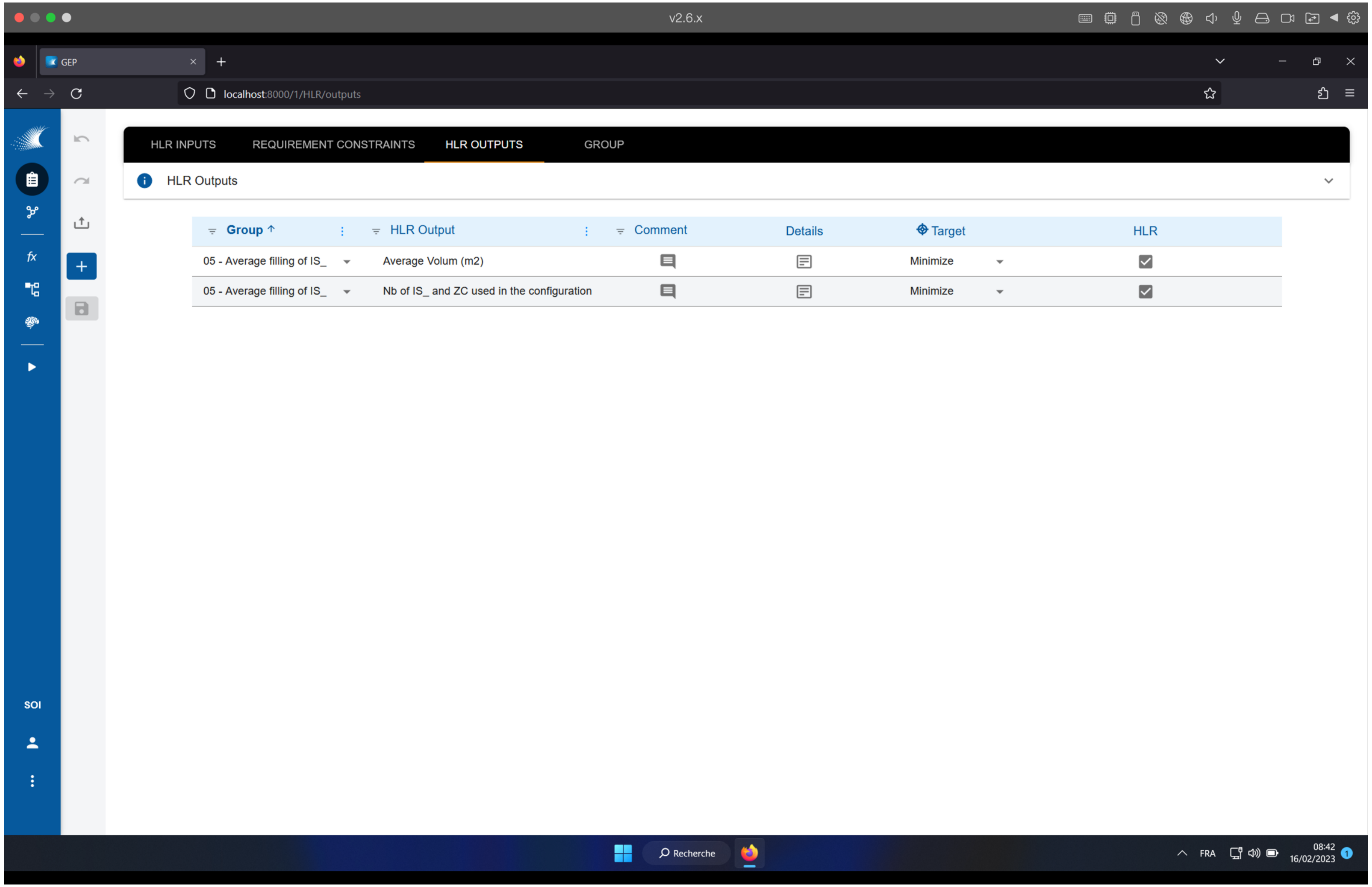


Step 19: Set reference configuration to validate your patterns



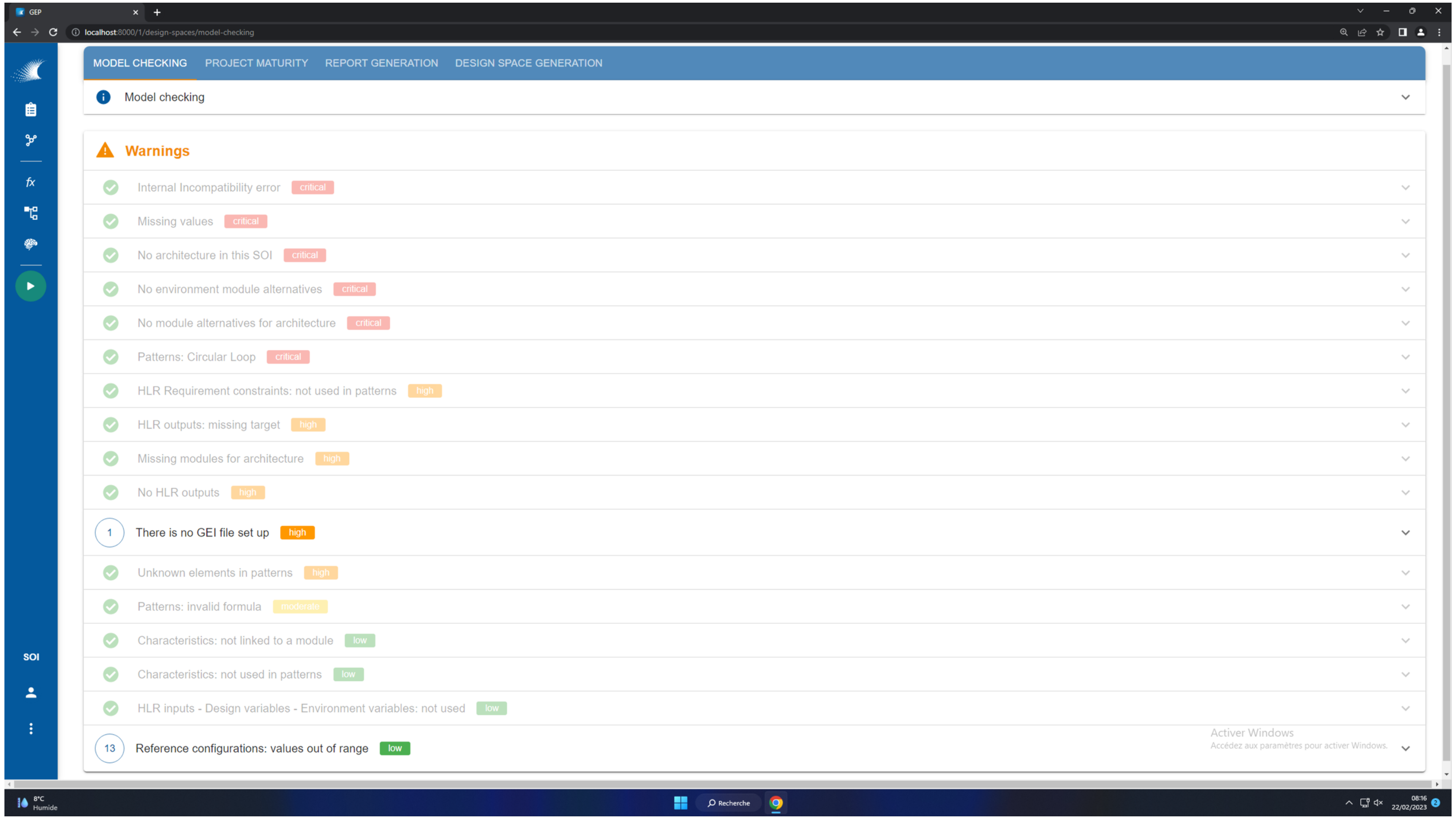
Step 20: Set HLR output as decision KPIs

- ✓ Set main KPIs to let Geeglee find the pareto front



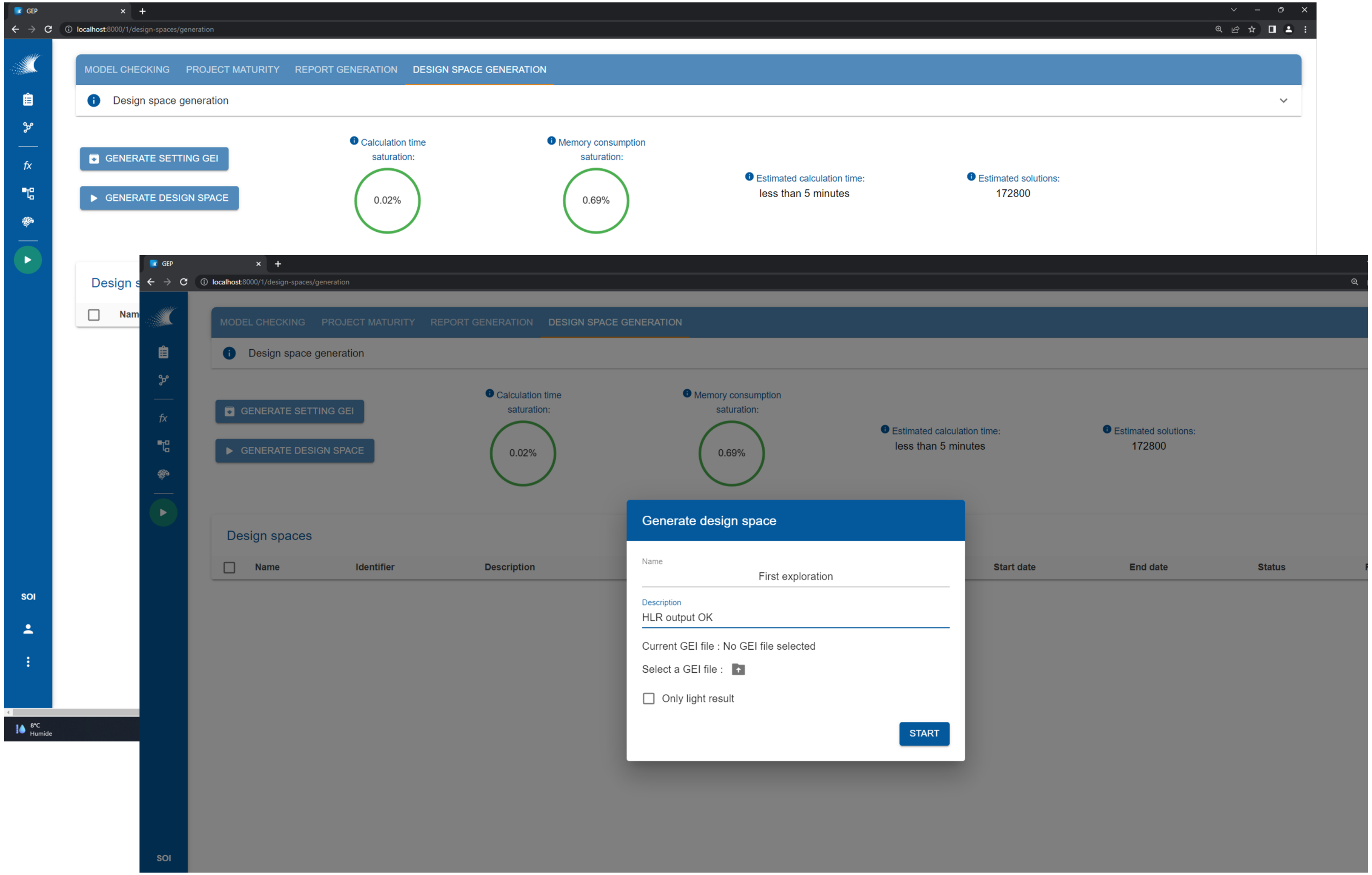
Step 21: Have a look into the model check

- ✓ No critical problems



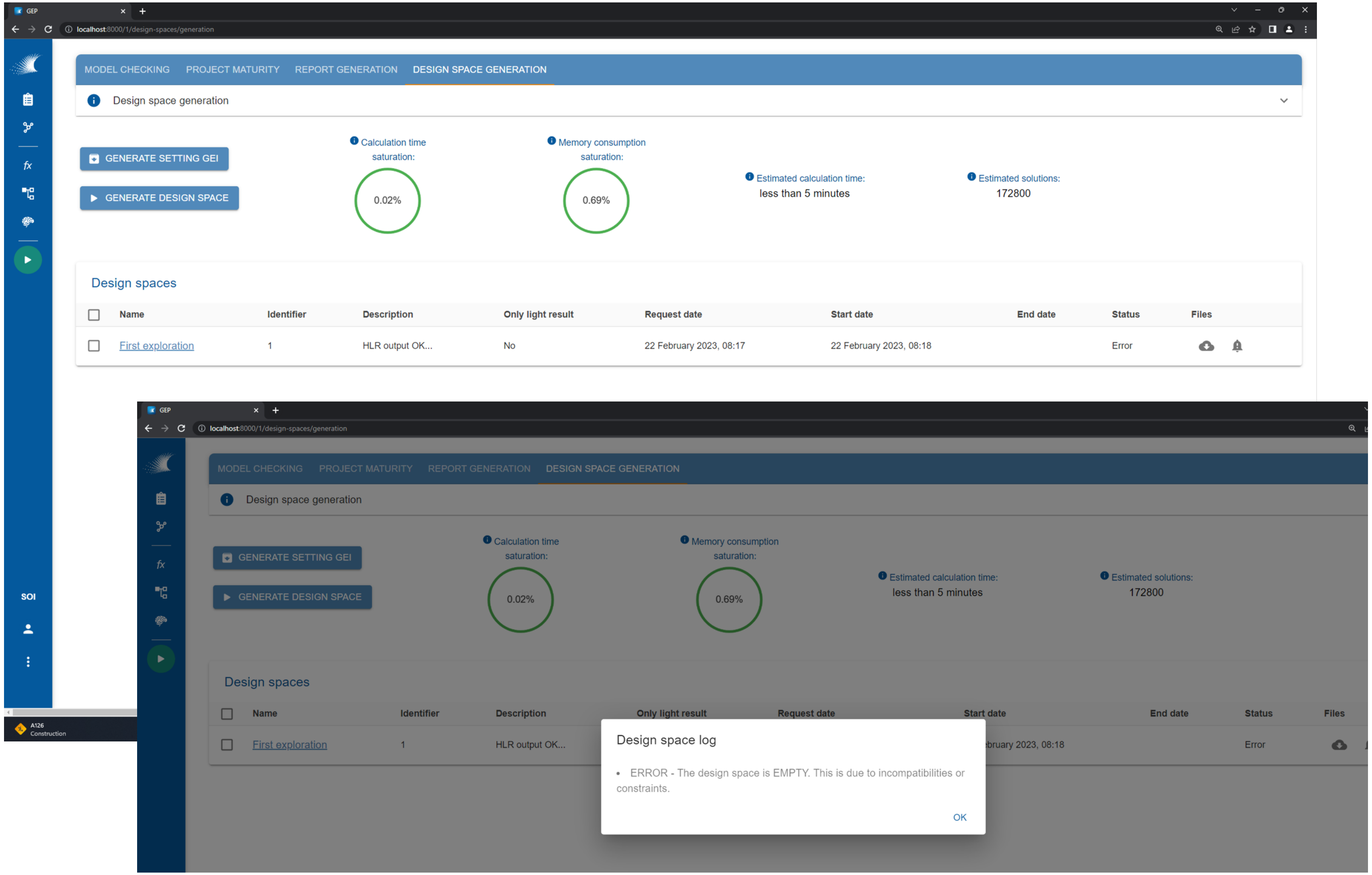
Step 22: Launch the exploration of the Decision Space

- ✓ Over hundrer thousand of configuration in our case!
- ✓ Name simulation for traceability



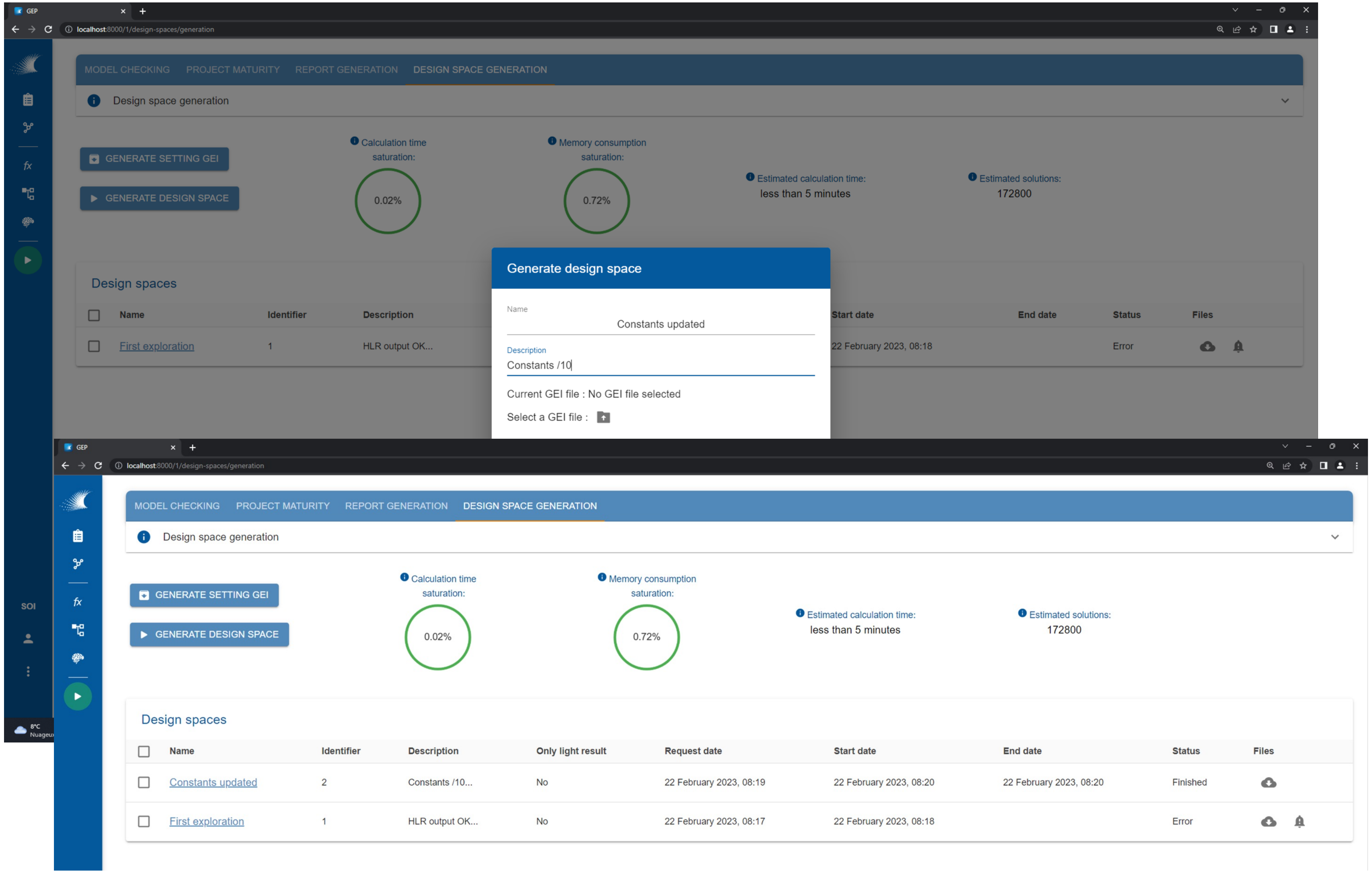
Step 23: if needed, correct error!

- ✓ Here bell is ringing!
- ✓ Click on it to check the error



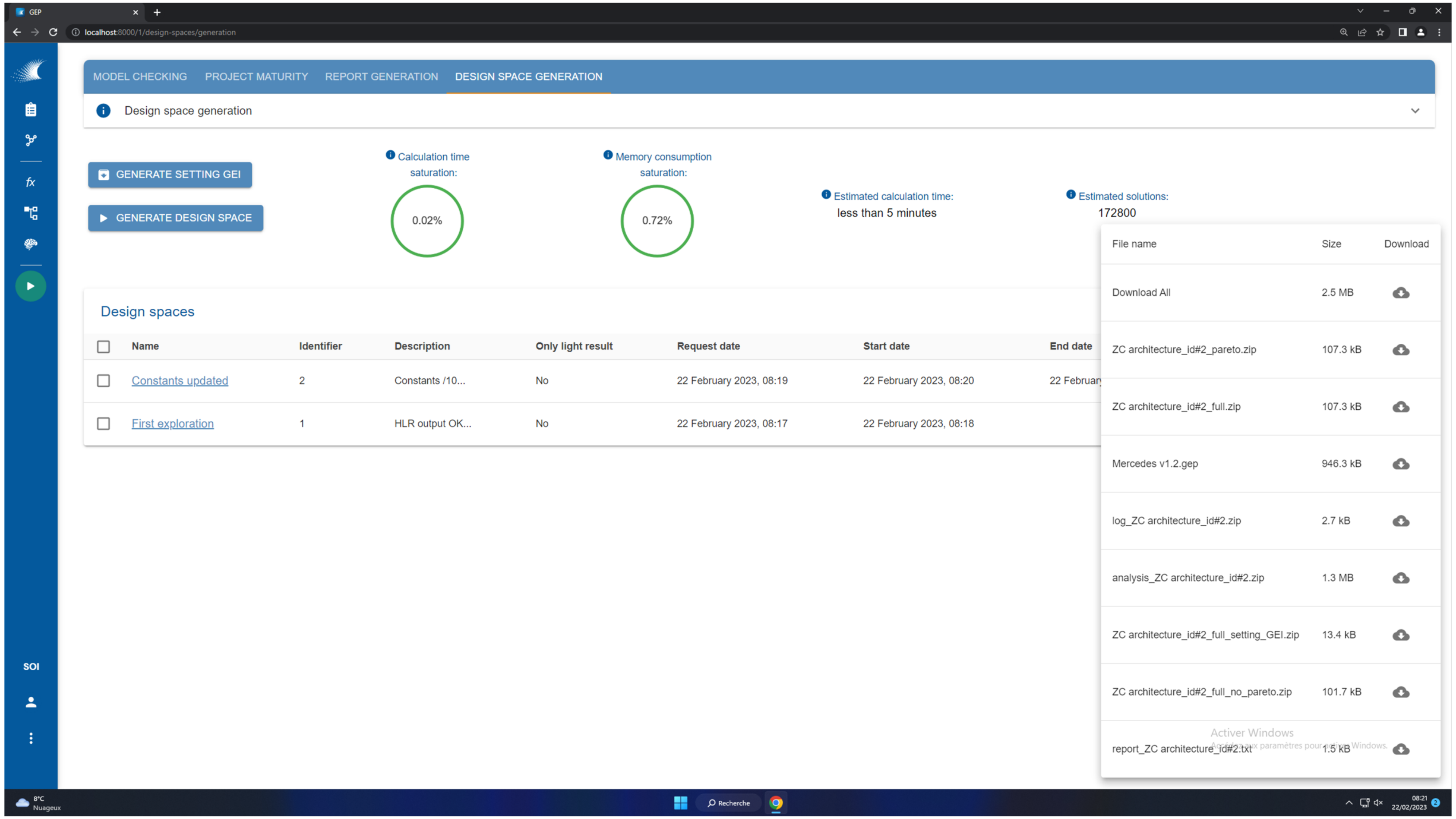
Step 24: Correct and run again

- ✓ Simulate your project again

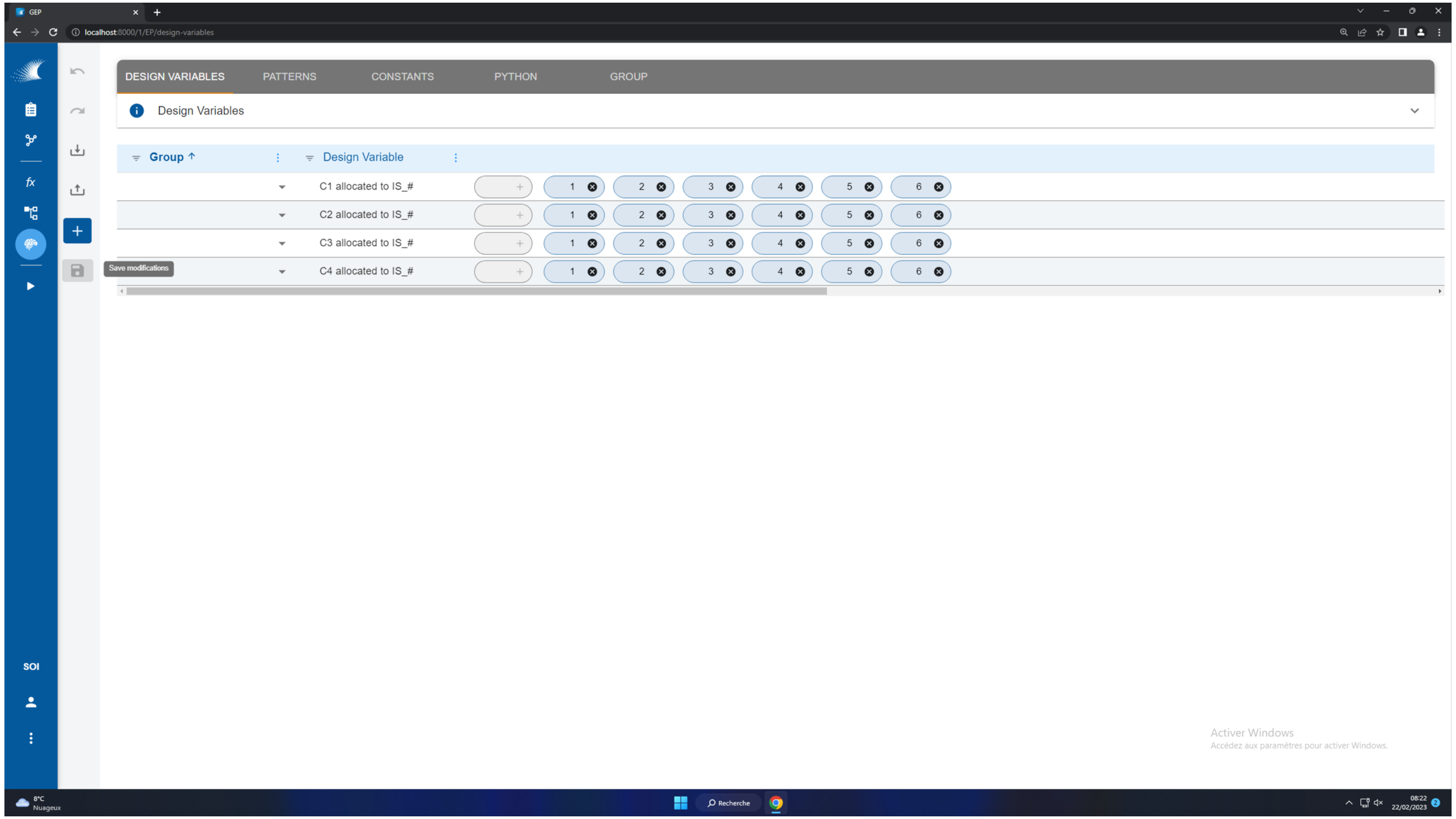


Step 25: Download file for GEI

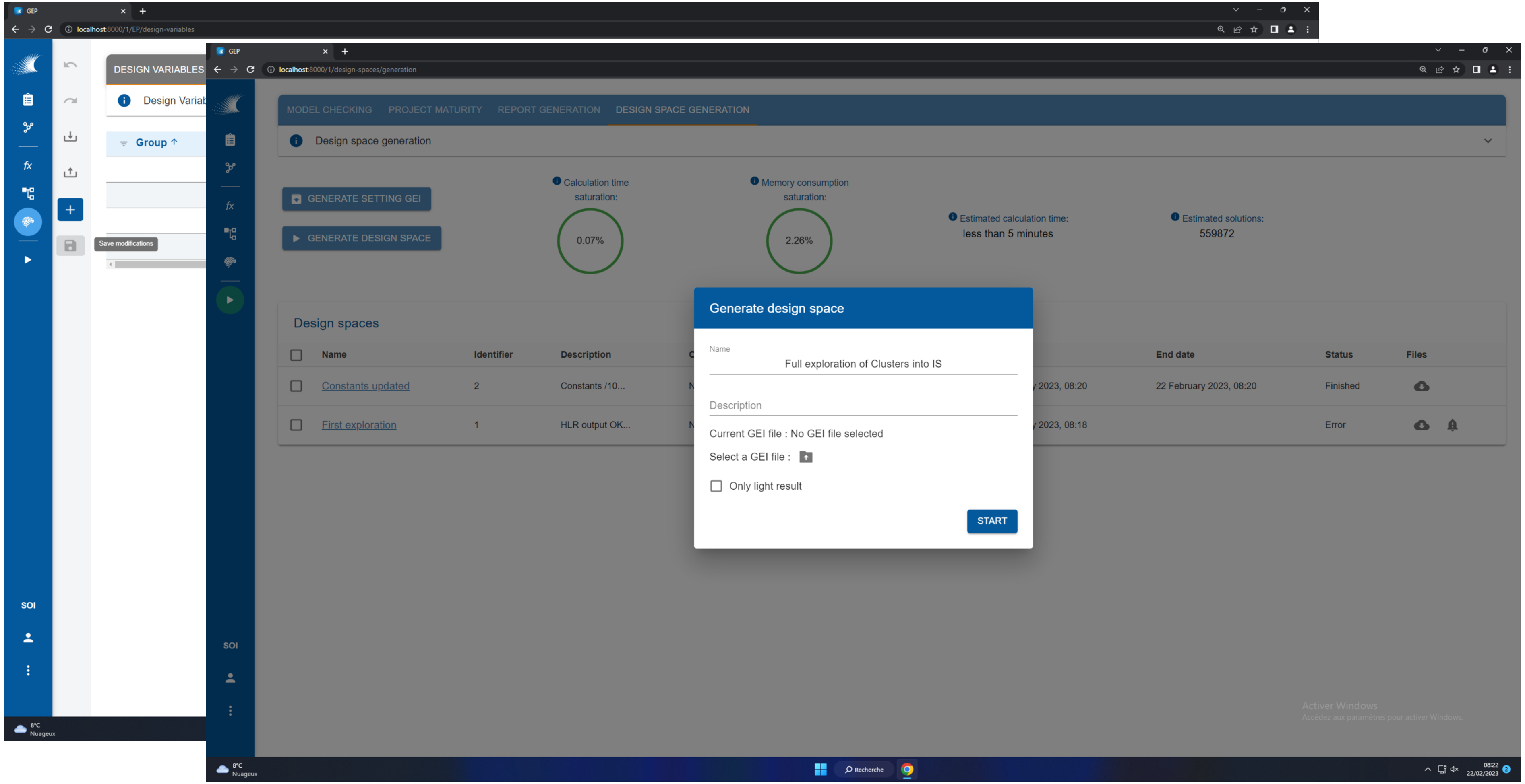
- ✓ Get the results ;-)



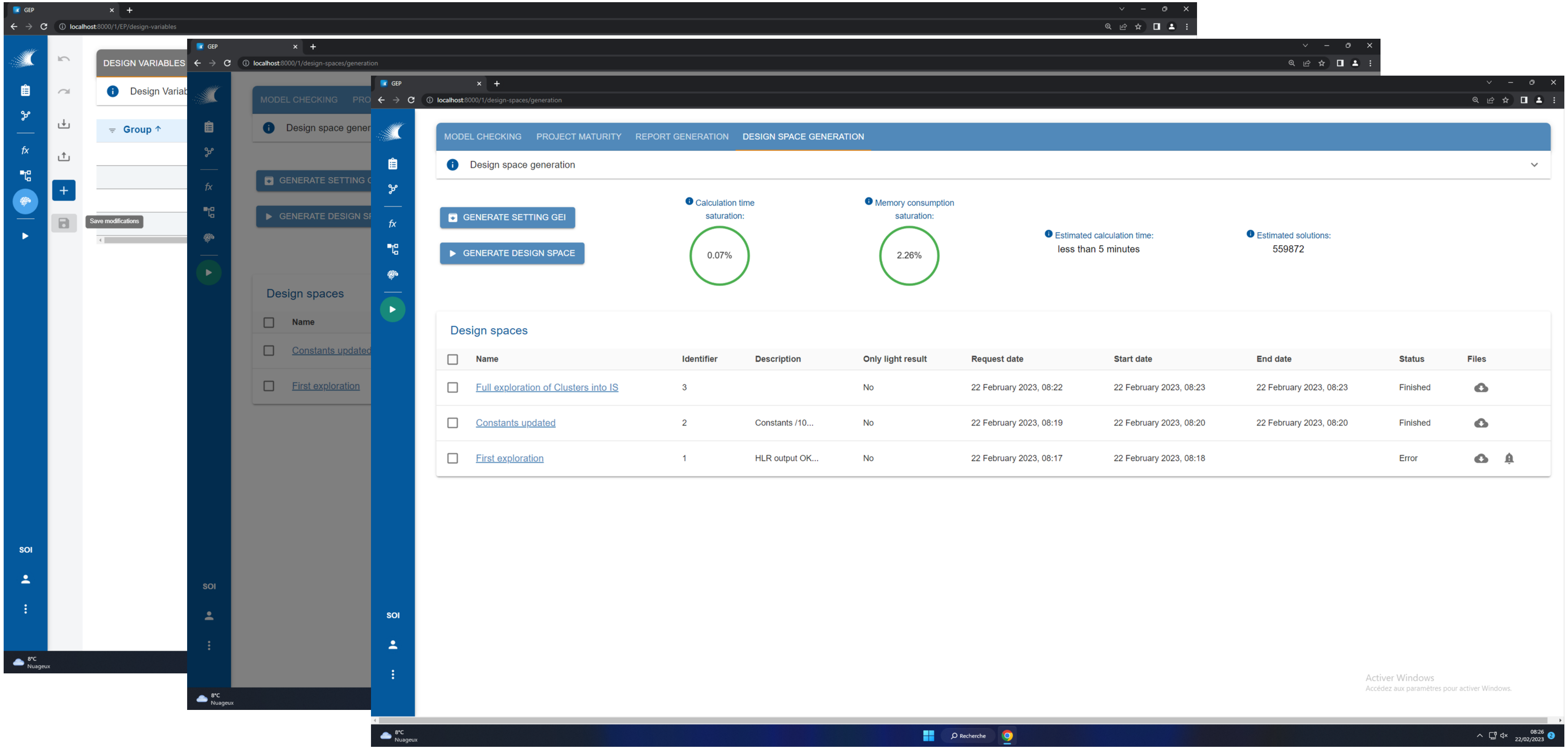
Step 26: Make it more complex/improve your model!



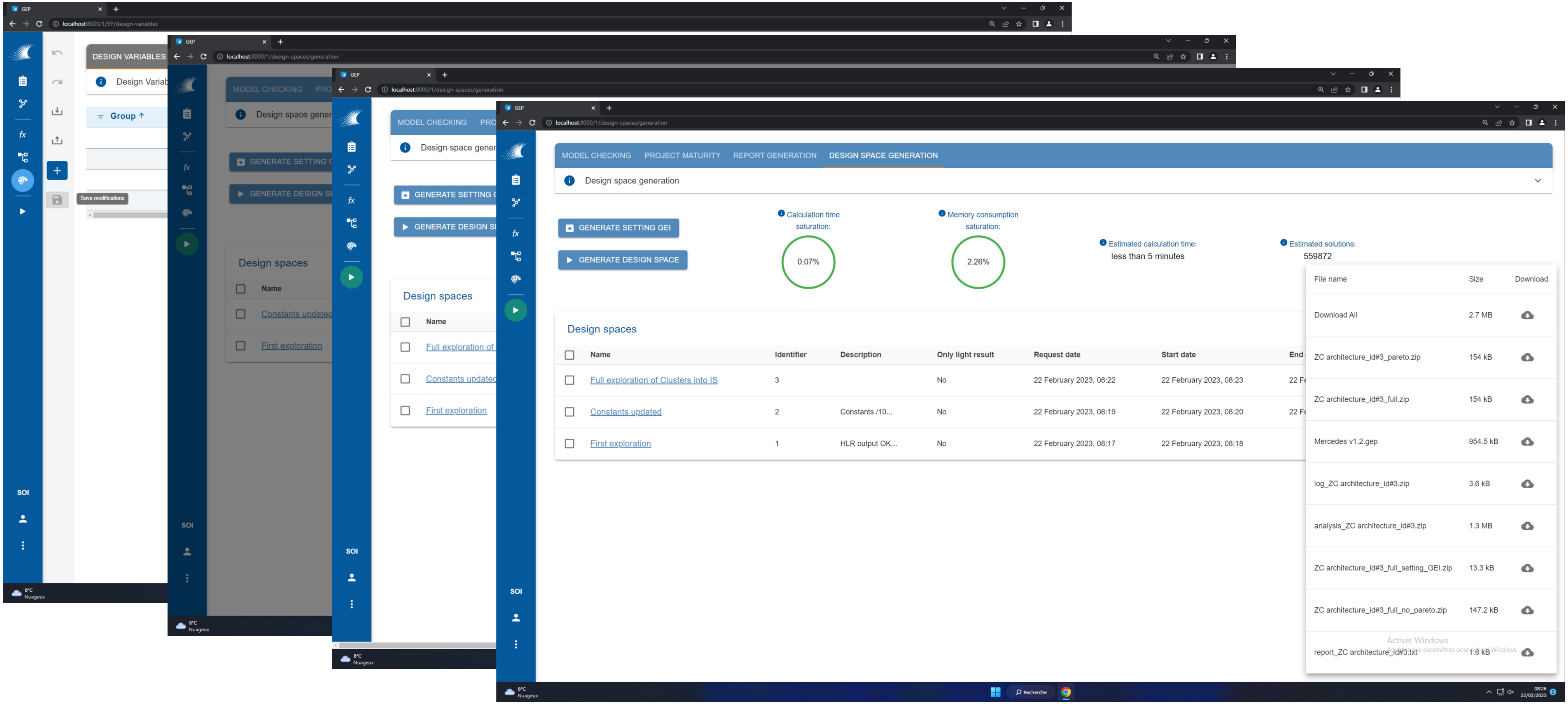
Step 27: Make it more complex/improve your model!



Step 28: Make it more complex/improve your model!



Step 29: Make it more complex/improve your model!



16^{th} ex

The Wind Farm

The Wind Farm PROJECT

OBJECTIVES

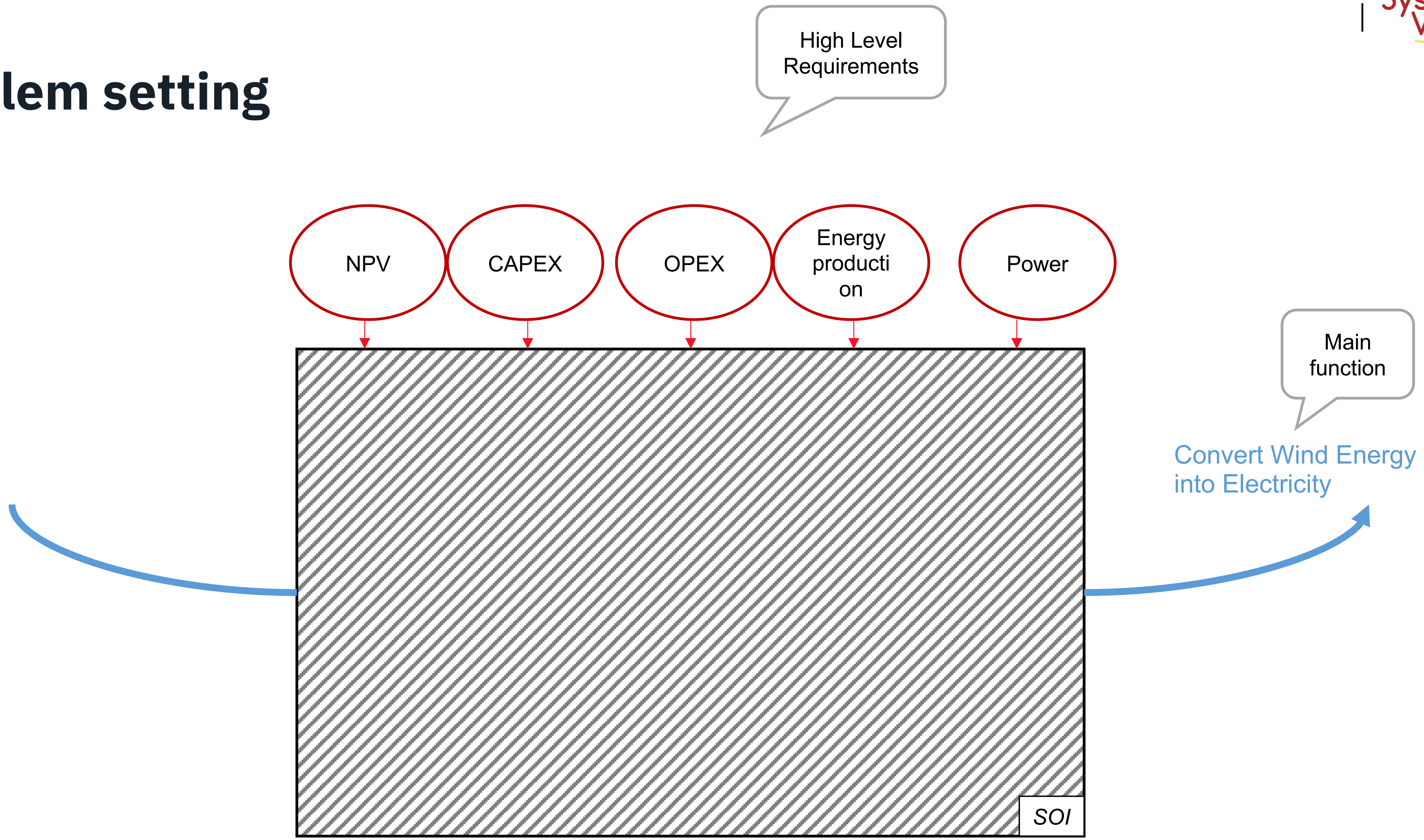
Creating the model of a wind farm in **Geeglee Pattern**

- Focus on:
  - Power
  - Energy production
  - Project's Economics

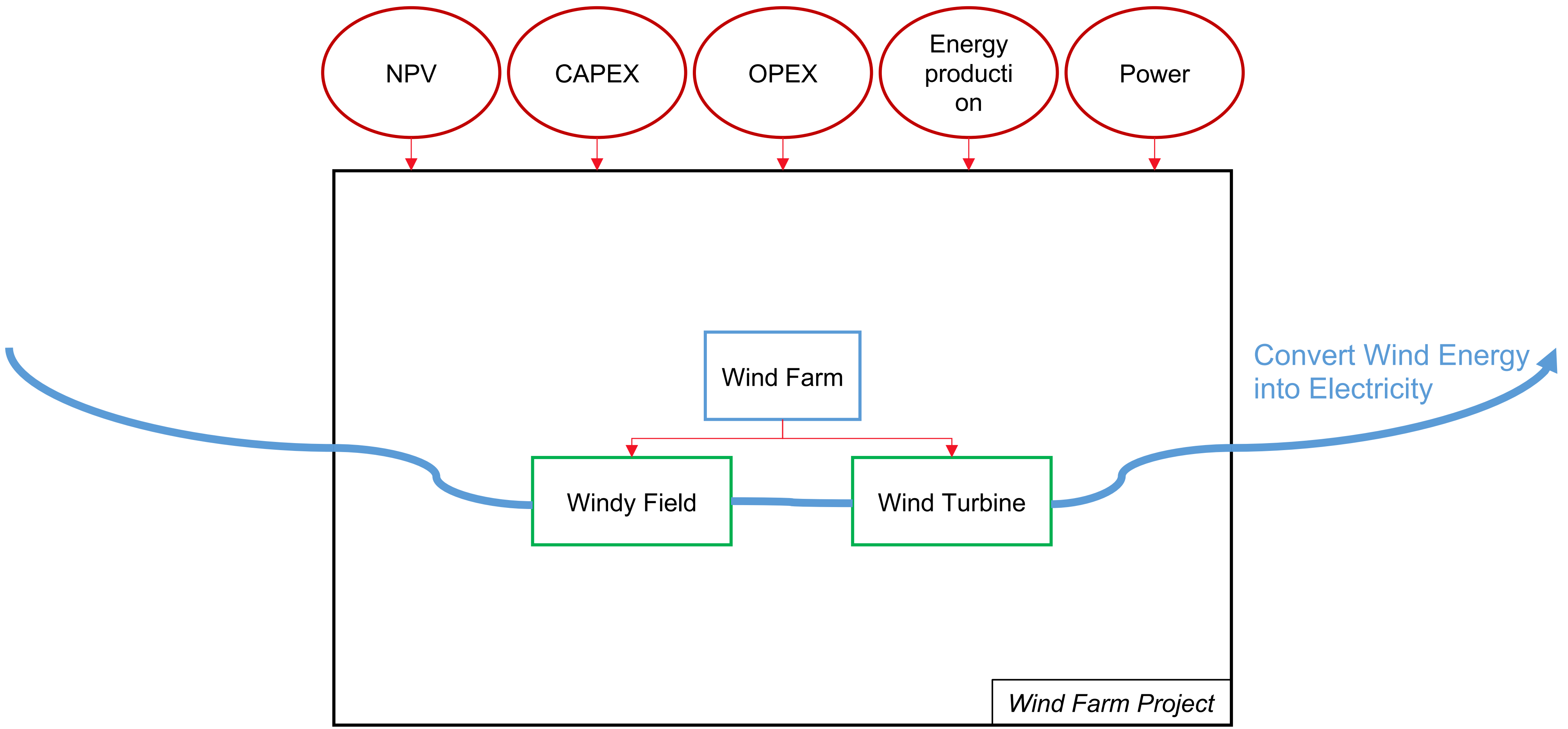
Choosing the best solution in **Geeglee Intelligence**

- Creating a datapage to be able to choose
- Playing a scenario to take a decision

Problem setting



Functional BreakDown (FBS) down to Product (PBS)



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Some relevant data for the project

Field – Dimensions & Price

Field Area:

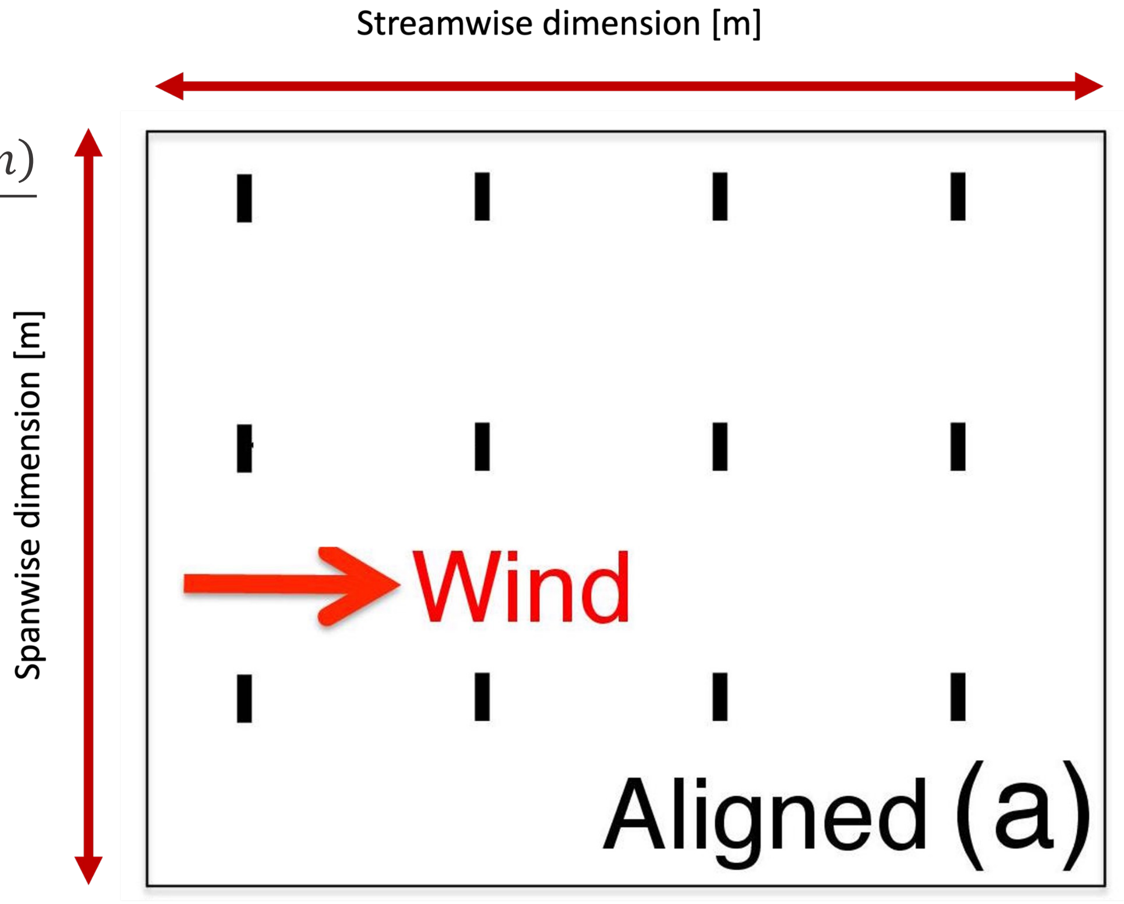
$$Area\ [ha] = \frac{(Streamwise\ dimension * Spanwise\ dimension)}{10000}$$

Economics:

Per-hectare price [€/ha]

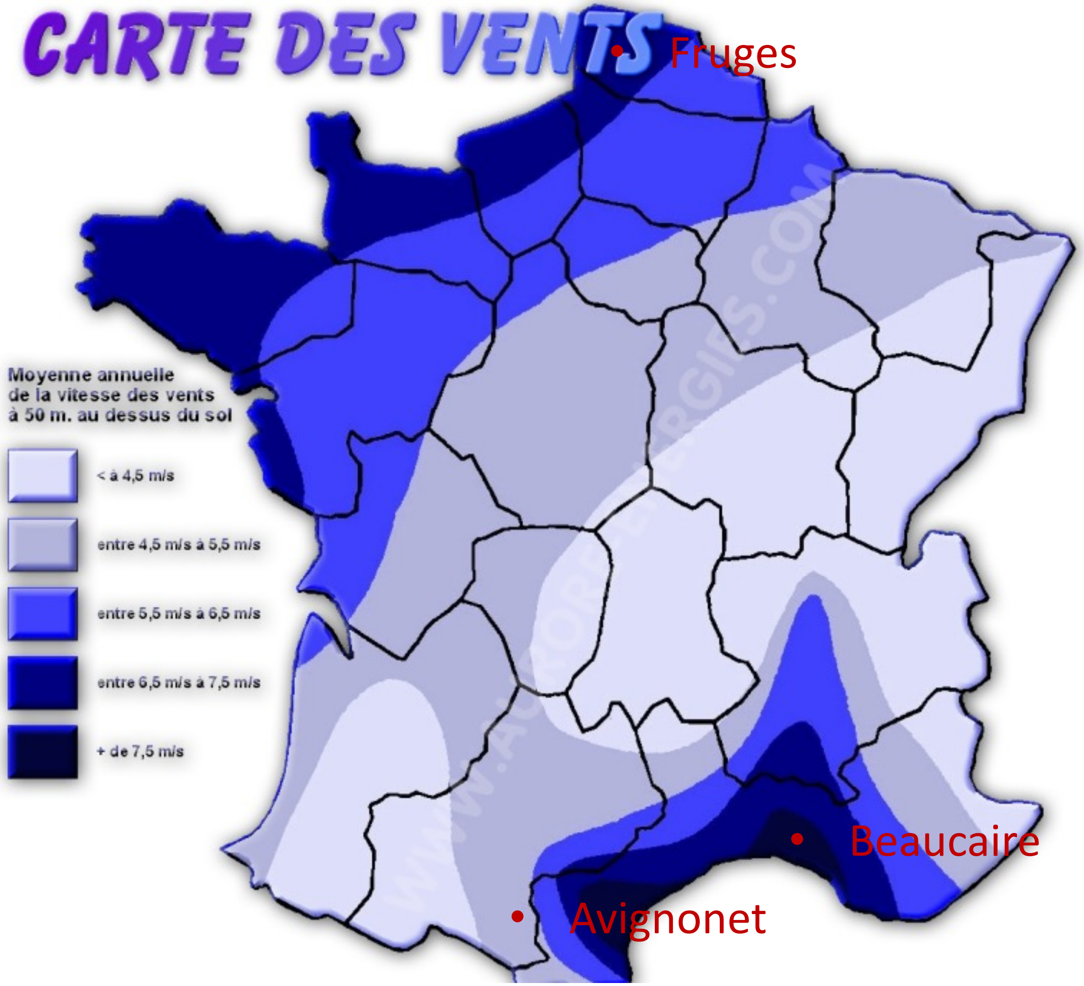
Field CAPEX:

$$CAPEX\ [M€] = Area * \frac{(Per\ hectare\ price)}{10^6}$$

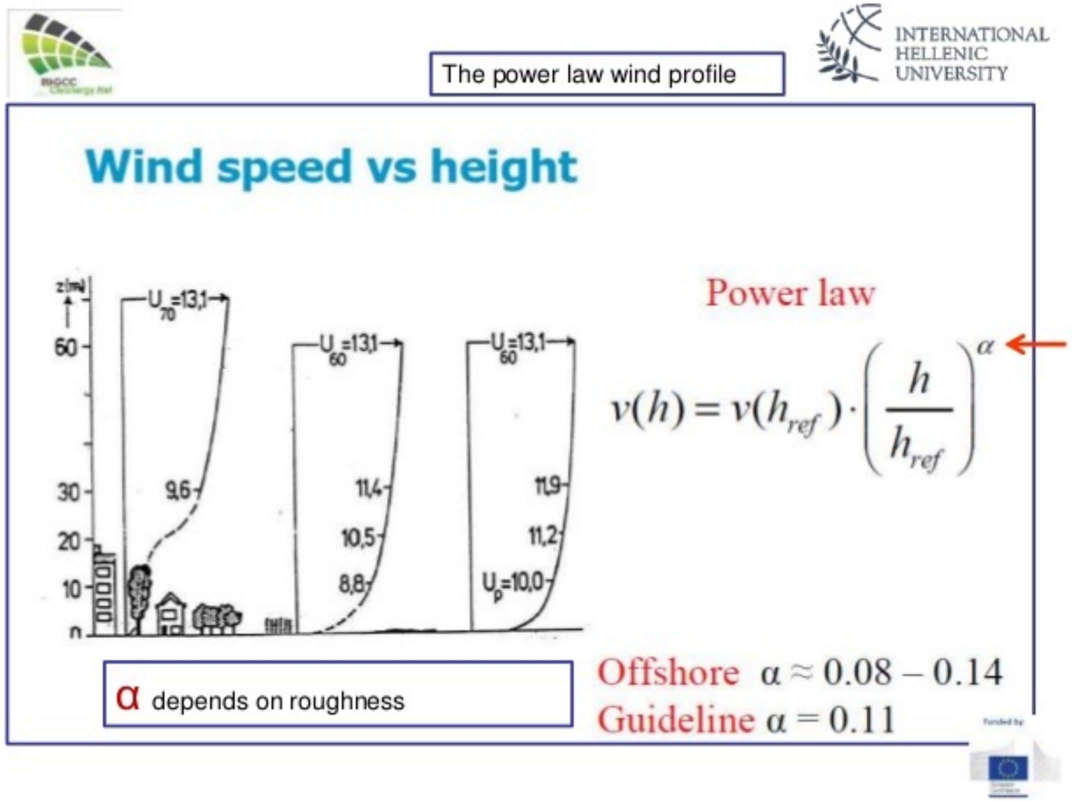


Field - Wind

Mean Wind Speed at 50m [m/s]



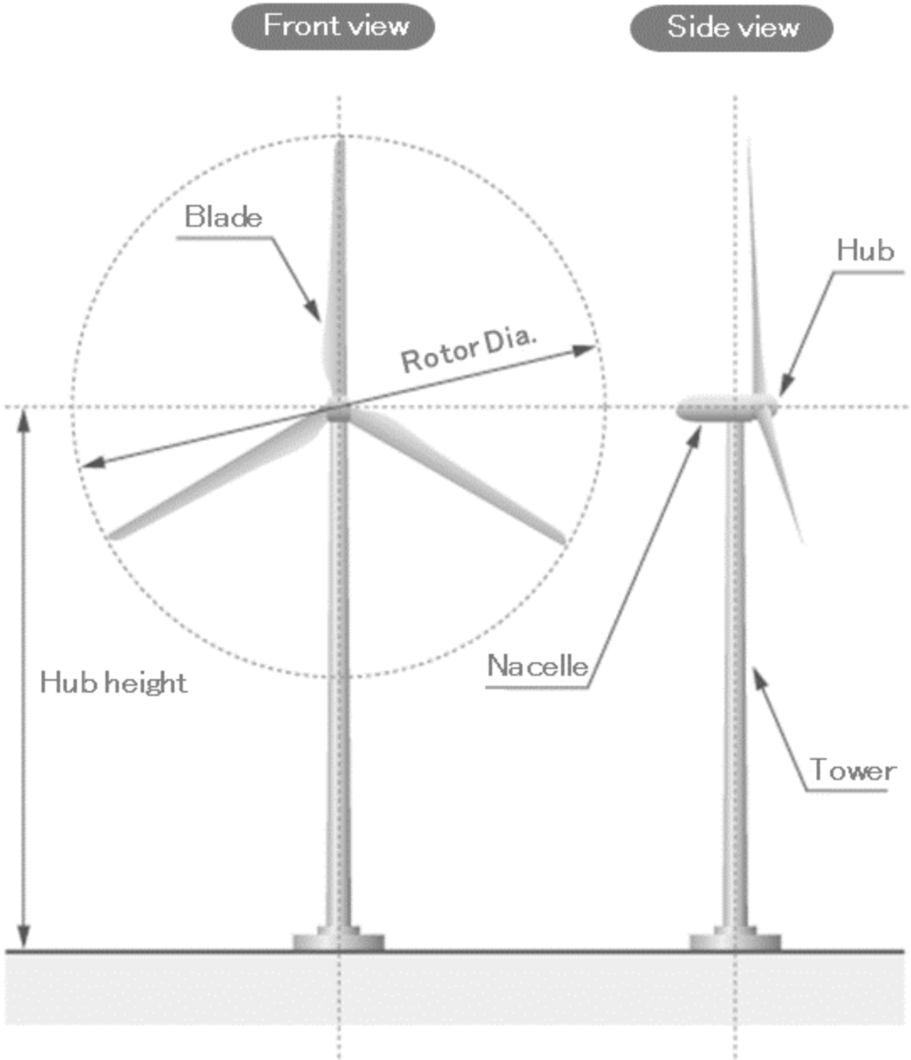
Wind Shear exponent [-]



Field - Data

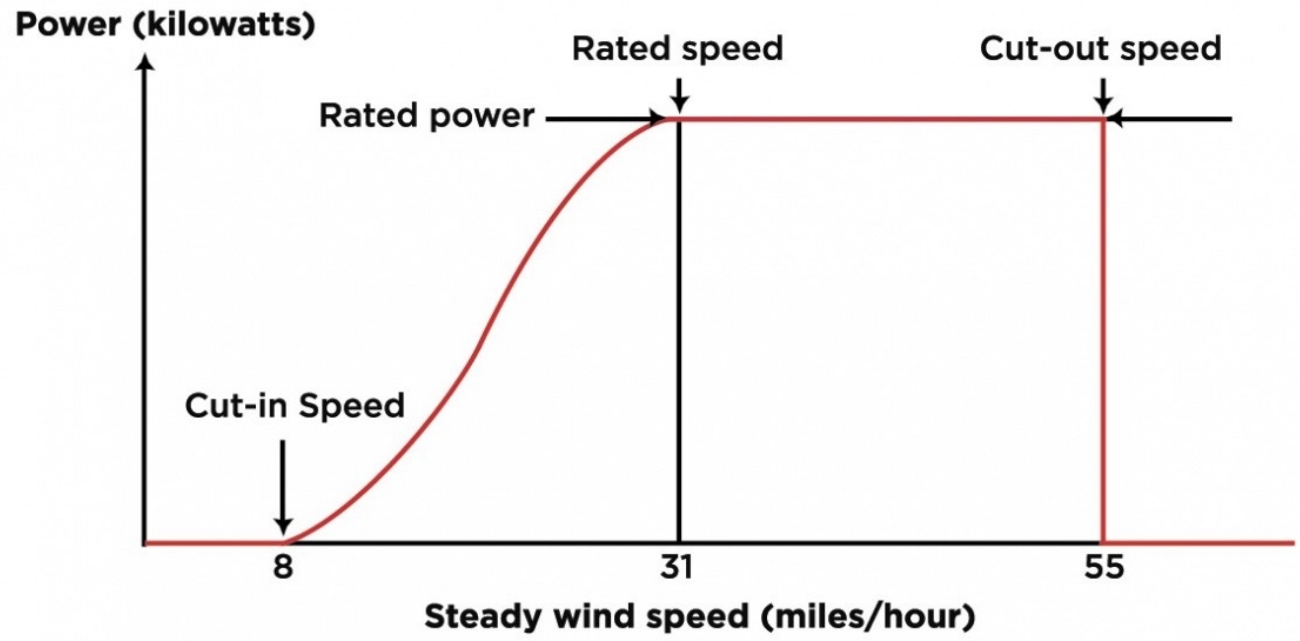
	Streamwise dimension [m]	Spanwise dimension [m]	Per-hectare Price [€/ha]	Mean wind speed at 50 m [m/s]	Wind shear exponent [-]
Avignonet-1	300	3000	10000	5	0,11
Avignonet-1+2	600	3000	15000	5	0,11
Fruges-1	600	1500	16000	7	0,04
Fruges-1+2	1200	1500	20000	7	0,04
Beaucaire-1	300	3000	30000	9	0,25
Beaucaire-1+2	1200	1500	40000	9	0,25

Wind Turbine – Physical dimensions



	Rotor diameter [m]	Hub height [m]
1.5-93 (Envision)	93	100
1.85-87 (GE Energy)	87	80
100 (Alstom Power)	100,8	100
V20/100 (Vestas)	20	24
V42/600 (Vestas)	42	53
M5000 (Multibrid)	116	102

Wind Turbine – Power Curves



Typical wind turbine power with steady wind speed

	Cut-in Wind Speed [m/s]	Cut-out Wind Speed [m/s]	Rated Power [kW]	Rated Wind Speed [m/s]
1.5-93 (Envision)	3	20	1500	9,5
1.85-87 (GE Energy)	3	25	1850	13
100 (Alstom Power)	3	25	3000	12
V20/100 (Vestas)	5	25	100	17,5
V42/600 (Vestas)	4,5	25	600	16
M5000 (Multibrid)	4	25	5000	13

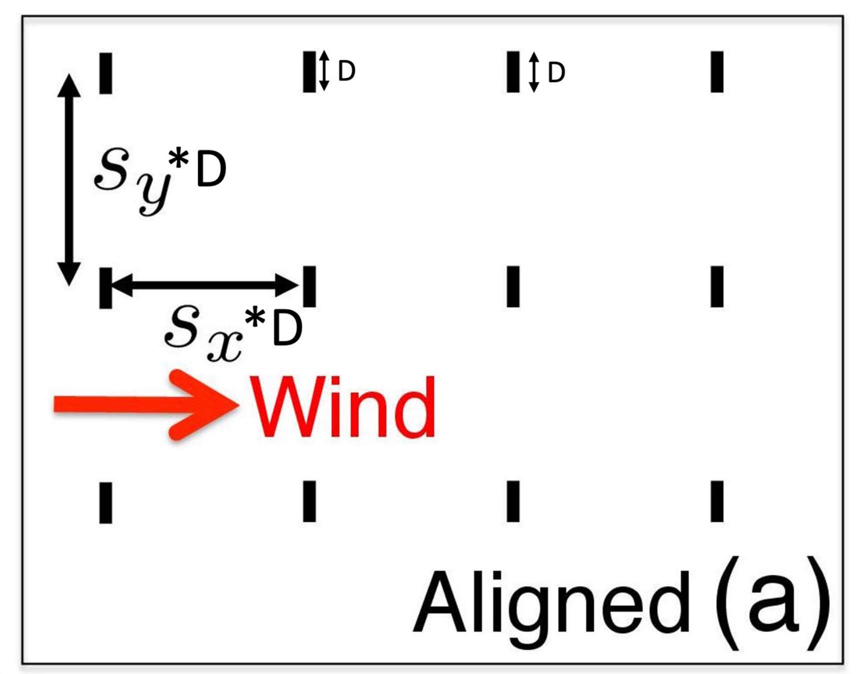
Wind Turbine – OPEX & CAPEX

	CAPEX [M€]	Maintenance yearly cost [M€]	Operation yearly cost [M€]
1.5-93 (Envision)	1,946	0,0226	0,0494
1.85-87 (GE Energy)	2,133	0,025	0,056
100 (Alstom Power)	3,48	0,0454	0,0991
V20/100 (Vestas)	0,119	0,0013	0,0035
V42/600 (Vestas)	0,668	0,0083	0,0198
M5000 (Multibrid)	5,444	0,0734	0,1689

Wind Turbine – Data Recap

	Rotor diameter [m]	Hub height [m]	CAPEX [M€]	Maintenance yearly cost [M€]	Operation yearly cost [M€]	Cut-in Wind Speed [m/s]	Cut-off Wind Speed [m/s]	Rated Power [kW]	Rated Wind Speed [m/s]
1.5-93 (Envision)	93	100	1,946	0,0226	0,0494	3	20	1500	9,5
1.85-87 (GE Energy)	87	80	2,133	0,025	0,056	3	25	1850	13
100 (Alstom Power)	100,8	100	3,48	0,0454	0,0991	3	25	3000	12
V20/100 (Vestas)	20	24	0,119	0,0013	0,0035	5	25	100	17,5
V42/600 (Vestas)	42	53	0,668	0,0083	0,0198	4,5	25	600	16
M5000 (Multibrid)	116	102	5,444	0,0734	0,1689	4	25	5000	13

ARRAY Arrangement



Spacing:

$$Streamwise\ spacing\ ratio\ (Sx)[-] = \{6; 9\}$$

$$Spanwise\ spacing\ ratio\ (Sy)\ [-] = \{4; 5; 6\}$$

Number of turbines:

$$Number\ of\ rows\ -Spanwise\ [\#] = \left\lceil \frac{Spanwise\ dimension\ [m] - 2 * Rotor\ diameter\ [m]}{Sy * Rotor\ diameter} \right\rceil$$

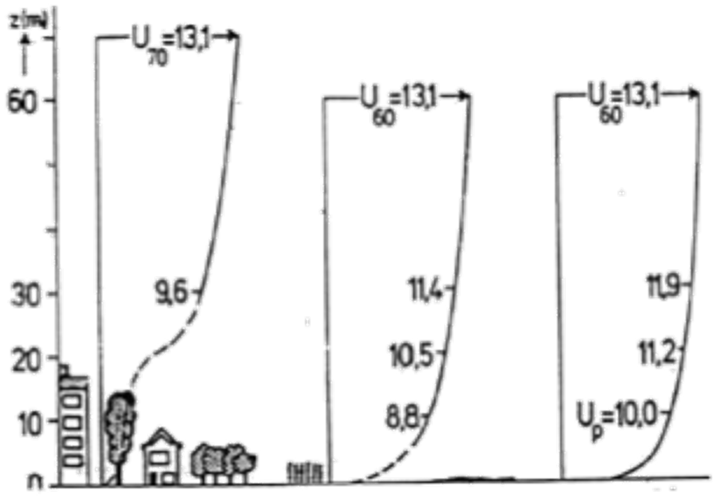
$$Number\ of\ rows\ -Streamwise\ [\#] = \left\lceil \frac{Streamwise\ dimension\ [m] - 2 * Rotor\ diameter\ [m]}{Sx * Rotor\ diameter} \right\rceil$$

$$Number\ of\ Wind\ Turbines\ [\#] = Number\ of\ rows\ -Streamwise\ [\#]^{*}\ Number\ of\ rows\ -Spanwise\ [\#]$$

Wind Speed at Hub height [m/s]

The power law wind profile

Wind speed vs height



Power law

$$v(h) = v(h_{ref}) \cdot \left(\frac{h}{h_{ref}} \right)^{\alpha}$$

α depends on roughness

Offshore $\alpha \approx 0.08 - 0.14$

Guideline $\alpha = 0.11$

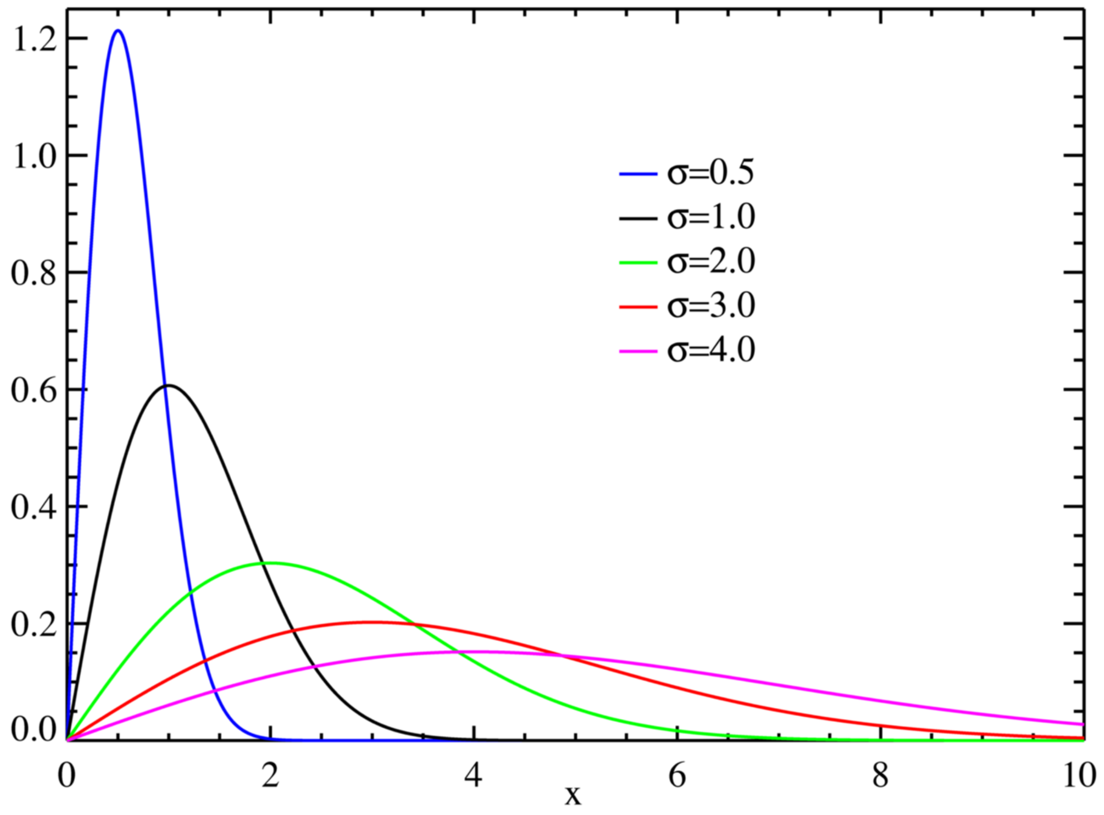
Wind distribution At Hub height

Distribution of wind speed at hub height approximated using Rayleigh distribution

One parameter: σ

σ determined using mean wind speed at hub height:

$$\sigma = \overline{U}_{hub} * \sqrt{\frac{2}{\pi}}$$



Rayleigh distribution – Probability density function

Wind distribution – Obtaining Representative Wind Speed values

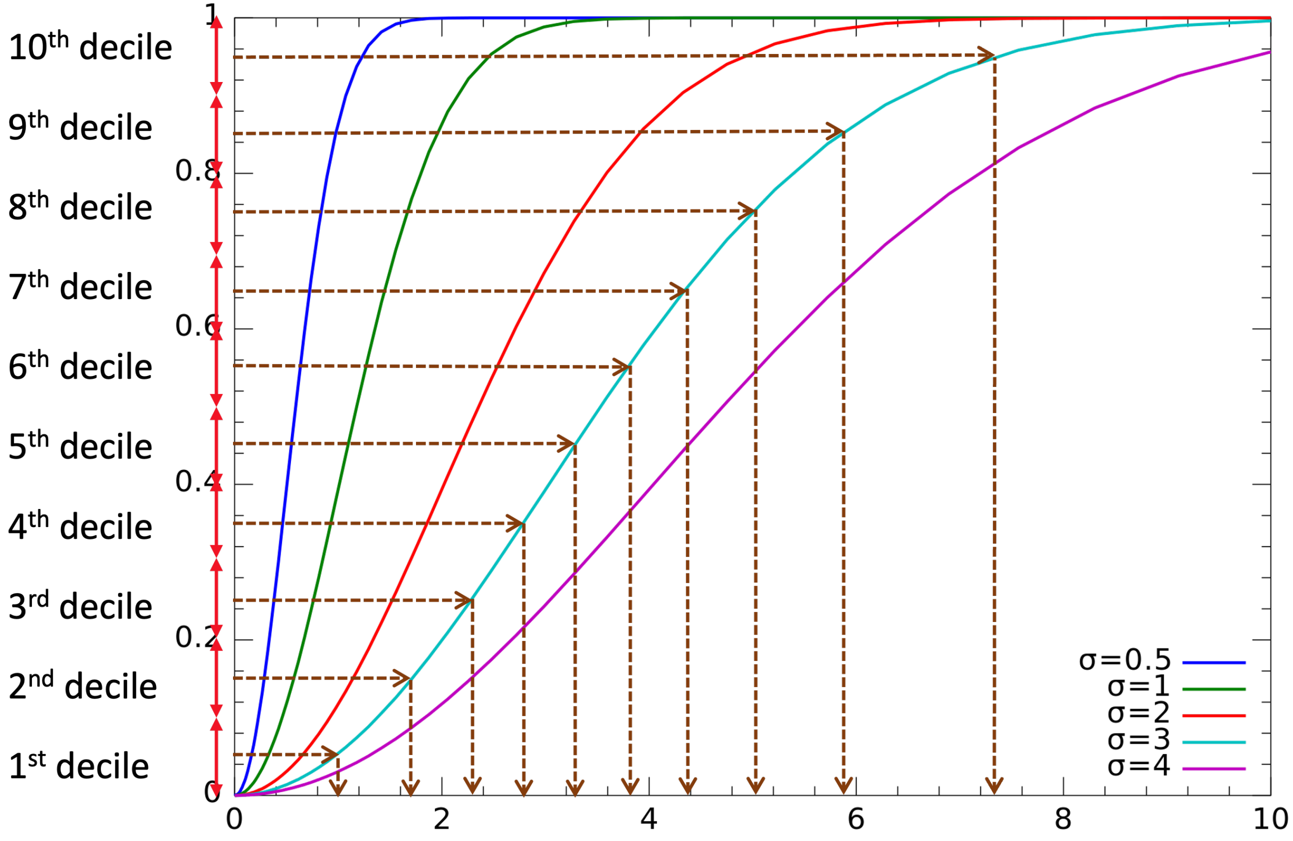
Obtention of representative wind speed values, using the cumulative distribution function

$$CDF(x) = 1 - e^{-\frac{x^2}{2\sigma^2}}\ with\ x \geq 0$$

Therefore:

$$CFD^{-1}(y) = \sigma\sqrt{-2 * \ln(1-y)}\ with\ y \in [0;1[$$

Rayleigh distribution – Cumulative distribution function



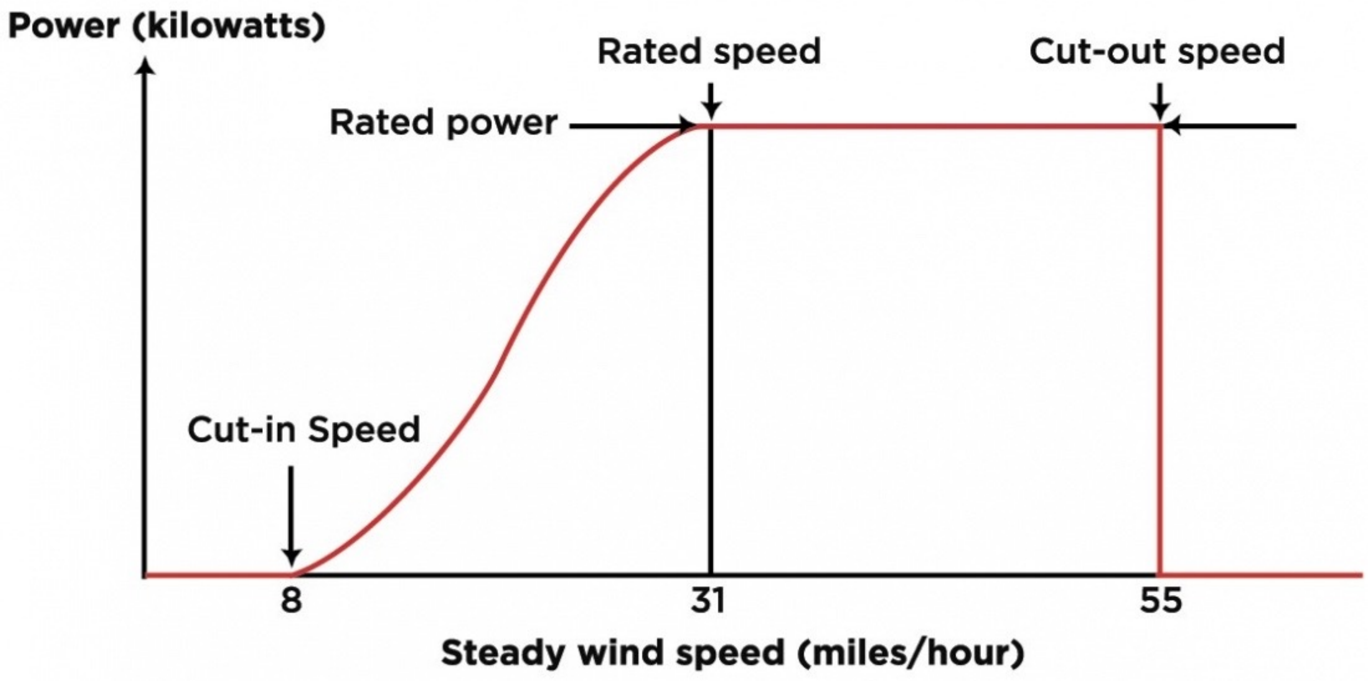
Mean Power Computation – Single Turbine

Wind Power is given by the following formula:

$$P(u) = \begin{cases} 0, & u < u_{cut-in} \\ P_r * \dfrac{u^3 - u_{cut-in}^3}{u_{rated}^3 - u_{cut-in}^3}, & u \leq u_{rated} \\ P_r, & u \leq u_{cut-out} \\ 0, & u \geq u_{cut-out} \end{cases}$$

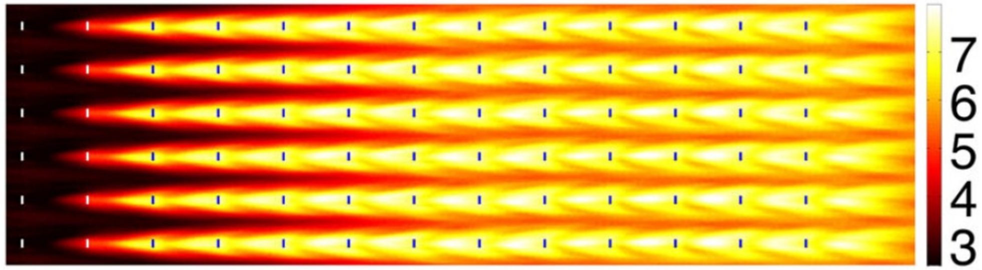
Mean Wind Power for one turbine:

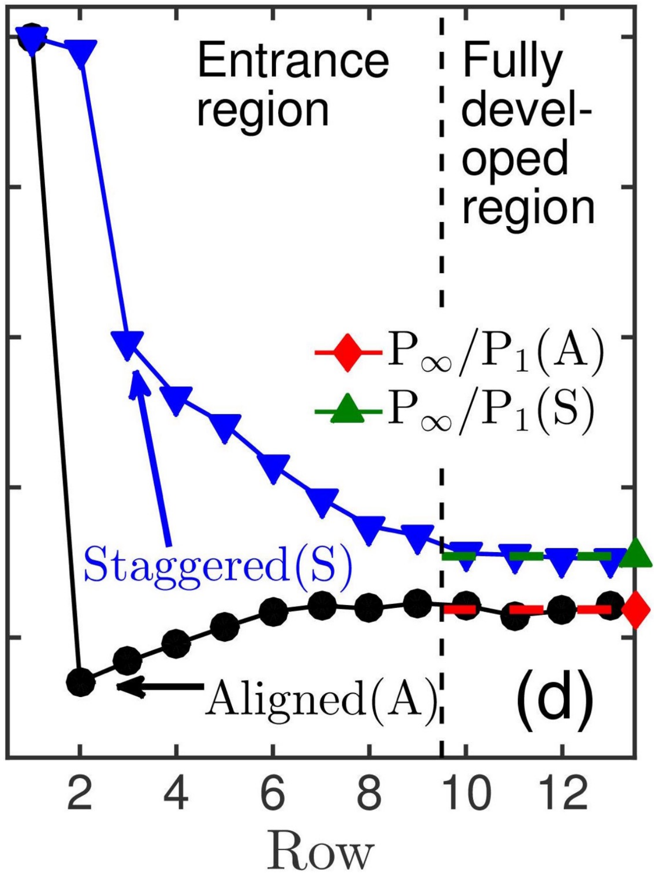
$$\overline{P_1} = \frac{1}{10} \sum_{i=1}^{10} P(u_{i-th\ decile})$$



Typical wind turbine power with steady wind speed

Mean Power Computation – Array





Array efficiency:

$$Eff_{array} = \frac{1 + (Number\ of\ rows\ - Streamwise\ - 1) * \frac{P_\infty}{P_1}}{Number\ of\ rows\ - Streamwise}$$

Fully developed region power ratio:

$$\frac{P_\infty}{P_1}(S_x, S_y) = \begin{cases} -0.0089 * S_x{}^2 + 0.1549 * S_x - 0.0421 - 0.08 * \frac{S_y - 5.24}{3{,}49 - 5{,}24}, S_y < 5.24 \\ -0.0089 * S_x{}^2 + 0.1549 * S_x - 0.0421, S_y \geq 5.24 \end{cases}$$

Array Mean Power:

$$\bar{P}_{array} = \overline{P_1} * Eff_{array}$$

Mean Power Computation – SOME KPI

KPIS RELATED TO POWER & ENERGY:

- ✓ Total Installed Power [kW]
- ✓ Total Mean Power [kW]
- ✓ Capacity factor [%]
- ✓ Power density [kW/ha]
- ✓ Field yearly energy production [kWh]

Economics of the project

KPIS RELATED TO ECONOMIC ANALYSIS OF THE PROJECT:

- CAPEX [M€]
- Yearly OPEX [M€/y]
- Yearly Revenue [M€/y] (function of Electricity Price [€/kWh])
- Yearly Depreciations [M€] (function of Operations duration [y])
- Yearly Free Cash Flows during Operations [M€]: (function of Tax rate [%])

$$FCF = (1-\tau) * (Revenue - OPEX) + \tau * Depreciations, where\ \tau\ is\ the\ tax\ rate$$

- Annuity Present Value Factor [-]: (function of Discount rate [%])

$$APVF = \frac{(1+r)^{operations\ duration} - 1}{r * (1+r)^{operations\ duration + construction\ duration}}$$

- NPV [M€]:

$$NPV = -CAPEX + APVF * FCF$$

Model perspectives

PERSPECTIVES TO ENRICH THE MODEL:

- ✓ Schedule of the Wind Turbines construction
- ✓ Improving CAPEX and OPEX estimation
  - ✓ Wind Turbines transportation
  - ✓ Distance to construction plants
  - ✓ Connection to grid
  - ✓ …
- ✓ Off-shore Architecture
- ✓ Variable selling price
- ✓ Site accessibility limitations
- ✓ Project Portfolio