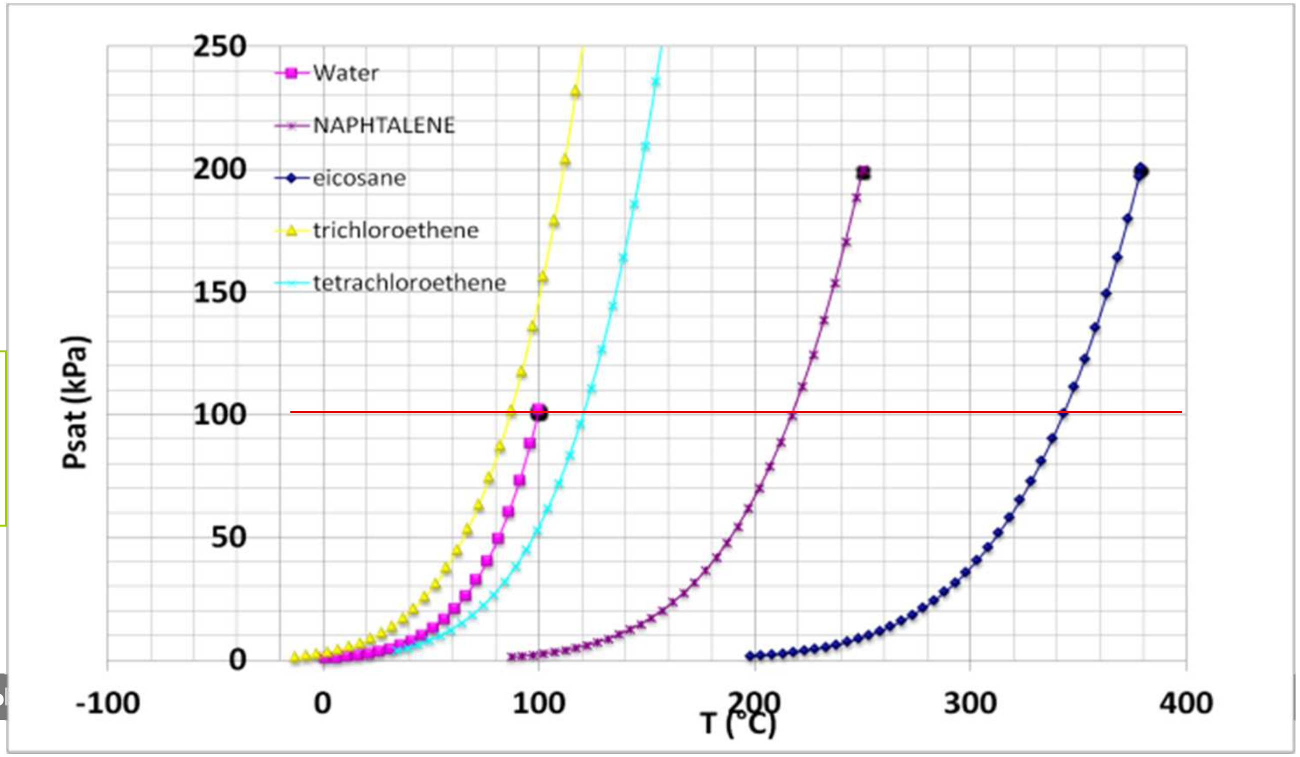
Thermal Desorption: A Solution for Insoluble Case

<u>Session C :</u> innovations techniques

Technical Principle

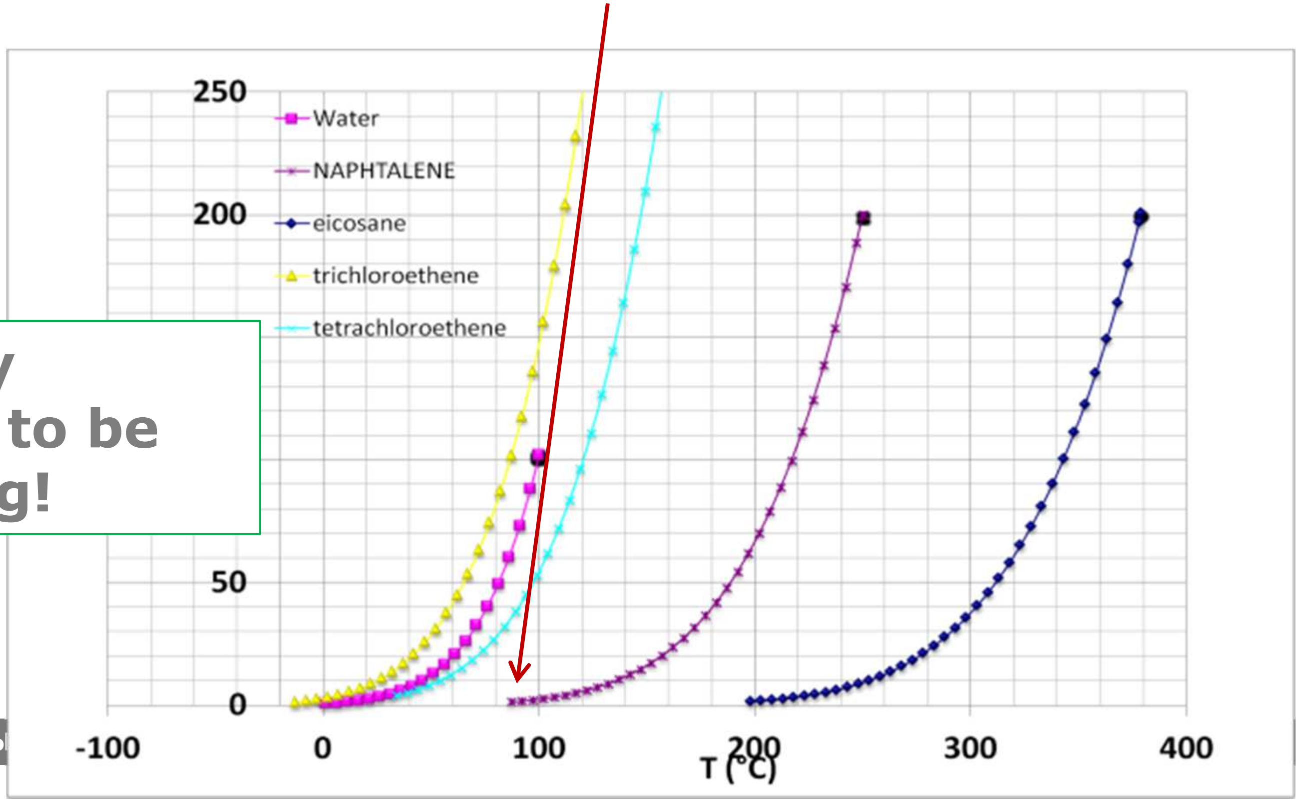
- Based upon **venting** principles
  - Only available for pollutants with a high vapor saturation pressure: P_{sat} > 100-150 Pa (1 mm Hg)
  - Now, P_{sat} is greatly influenced by temperature → given by Antoine's Equation



Curves of saturation pressure : for each compound, the vapor partial pressure grows with temperature
100 kPa = BP under 1 atm pressure

Technical Principle

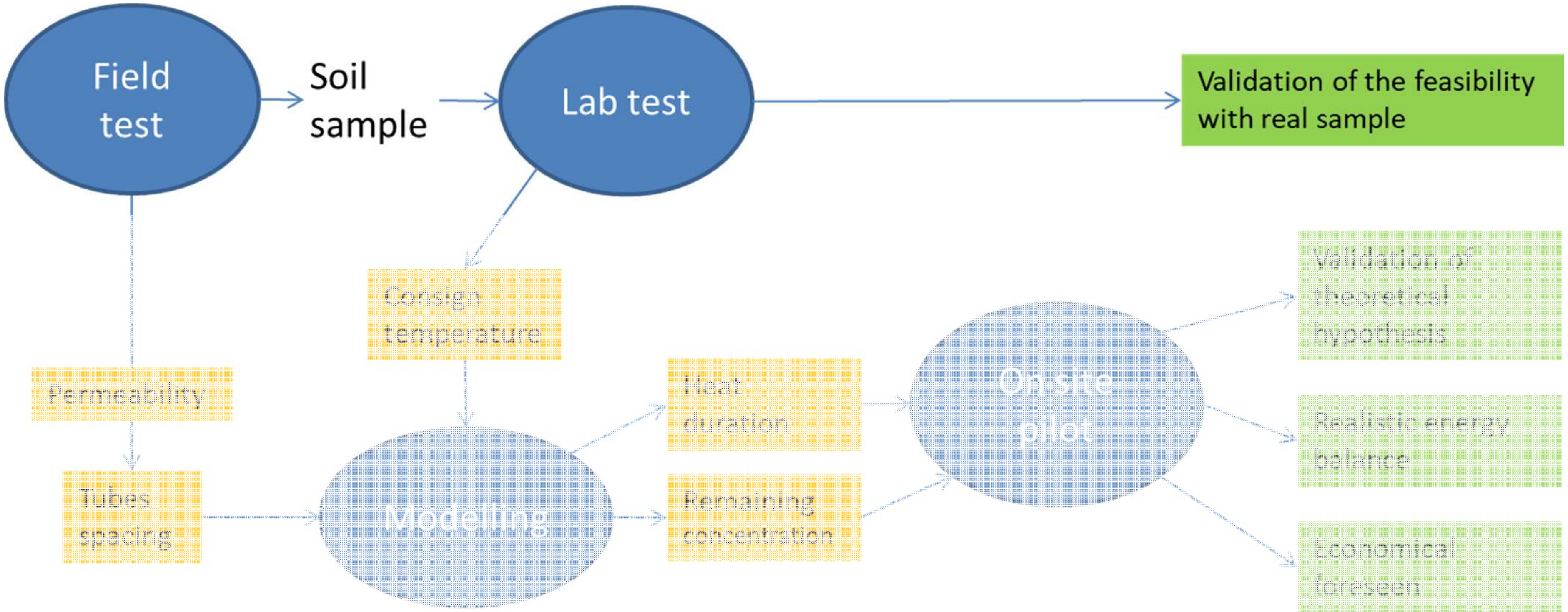
- P_{sat} for naphthalene at 20°C is about 7,2 Pa (too low to be drawn). We reached an average temperature of 87°C → P_{sat} raises to 1,37 kPa
- It is 190 times more; it means remediation should go 190 times faster



➢ **To allow a weakly volatile pollutant to be treated by venting!**

VALGO's Approach

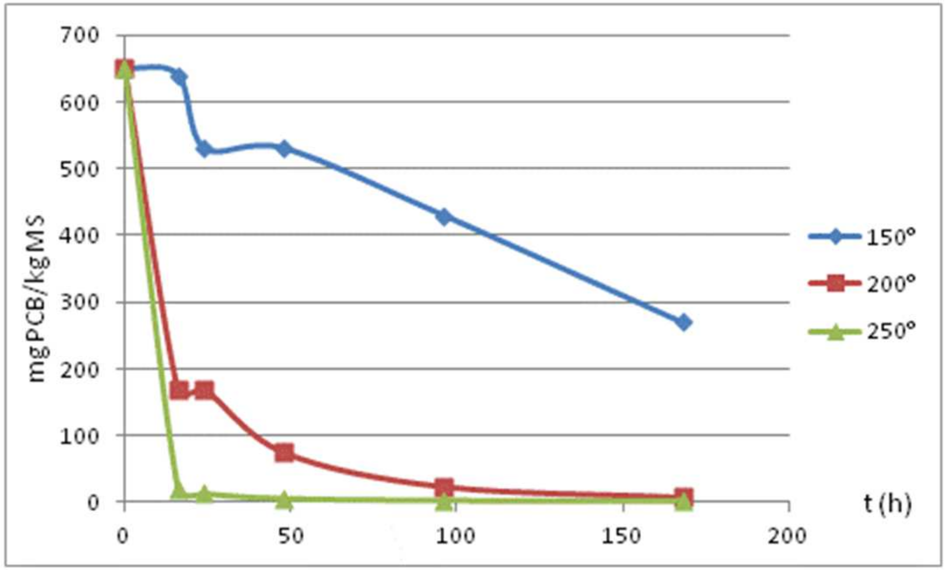
- A Strategy based upon modelling and pilots:



LAB PHASE

- Preliminary assays In VALGO's lab:

Contaminated soils are held in a desorption unit (oven), with a ventilation, at several temperatures. Heated soils are periodically sampled during desorption and remaining amount of pollutants is measured, to draw kinetics.

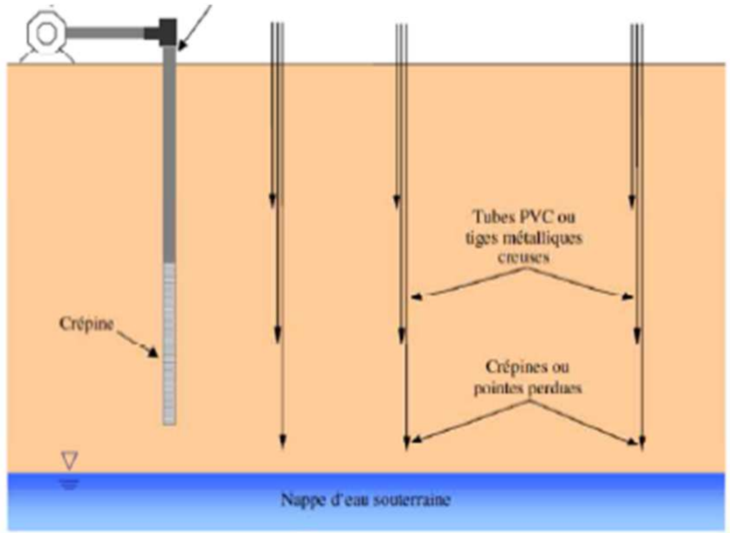


Validation of chemical interactions

ON SITE TESTS

- Air permeability assay

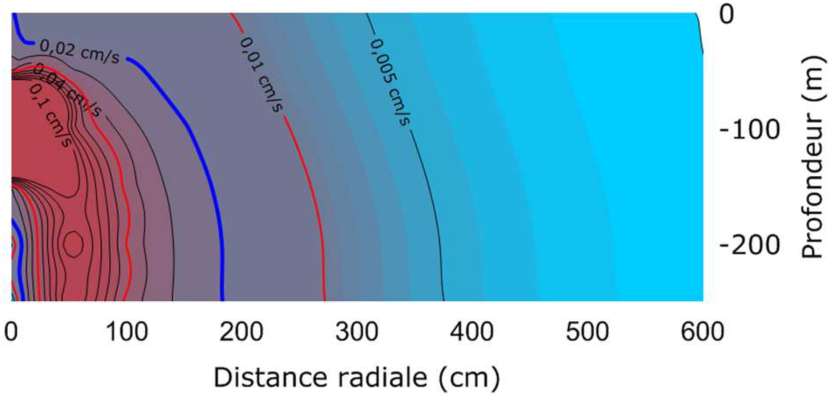
- Plot depressure data in soil and all other parameters used to adjust MFRKINV model:



Determine radial and vertical parameters of soil's permeability to air

ON SITE TESTS

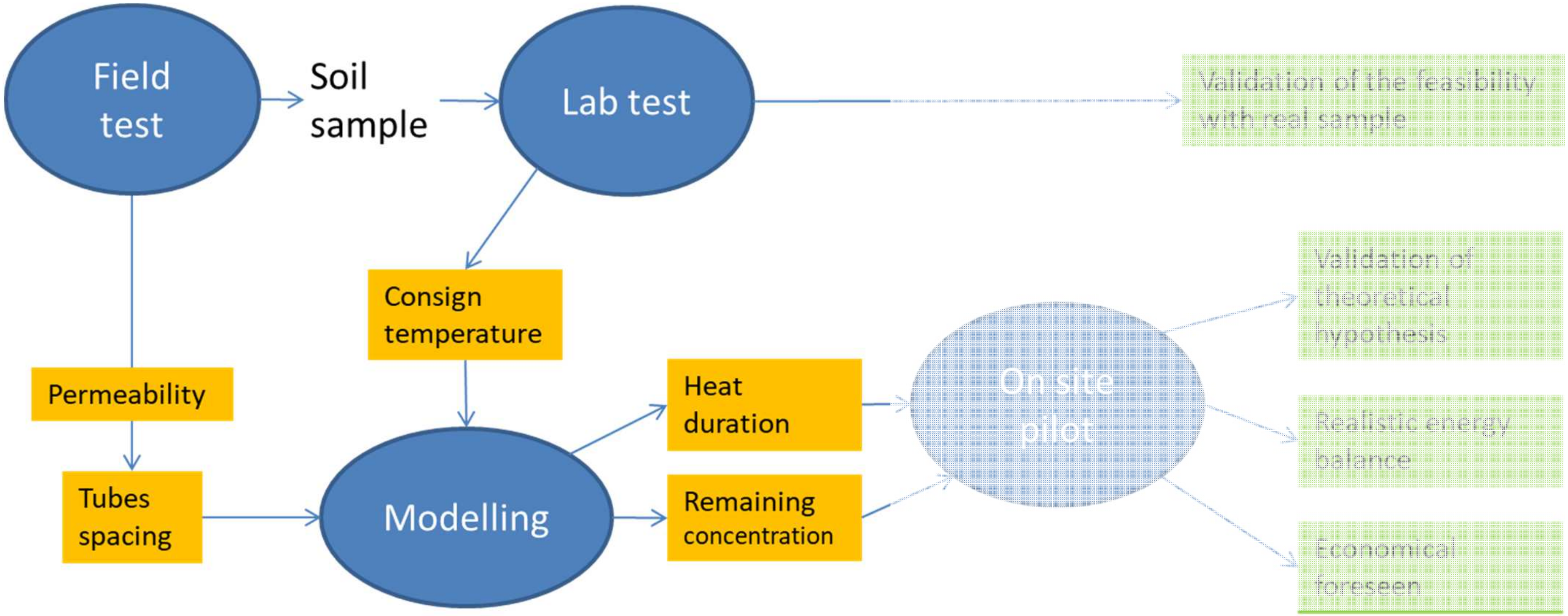
- Air permeability test



choose a pore flow speed over 0,01 cm/s

Determine the ROI (radius of influence) of the extraction needles

MODELLING



Field test
Soil sample
Lab test
Validation of the feasibility with real sample
Consign temperature
Validation of theoretical hypothesis
Permeability
Heat duration
On site pilot
Realistic energy balance
Tubes spacing
Modelling
Remaining concentration
Economical foreseen

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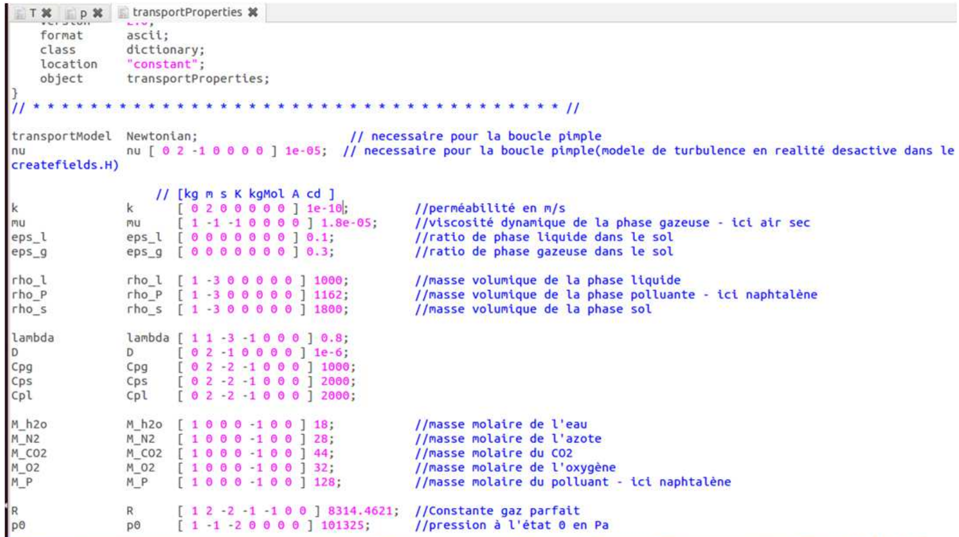
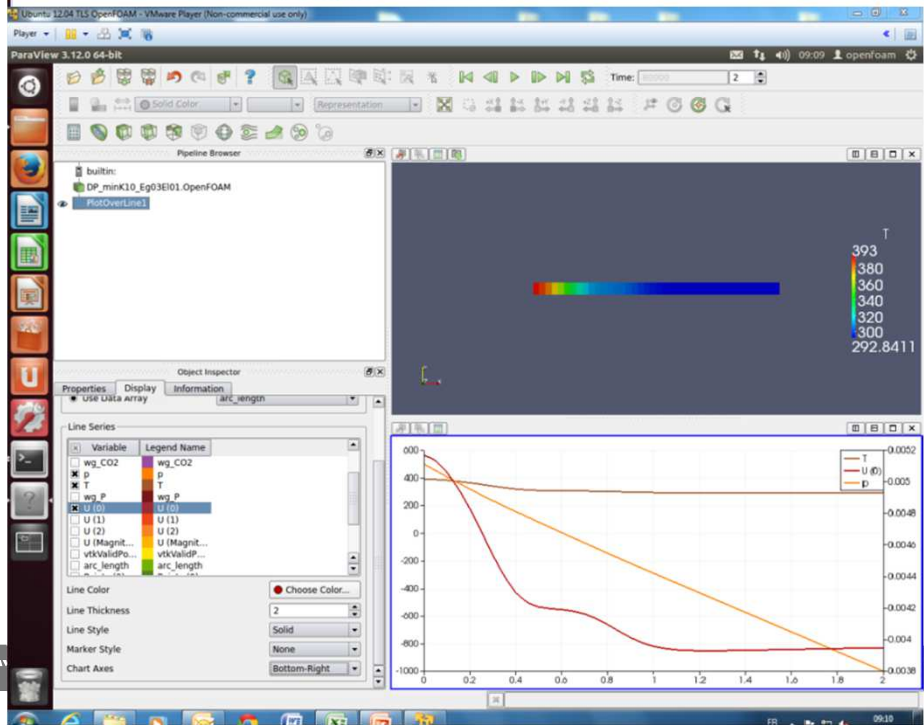
MODELLING PHASE

- Partnership with IMFT

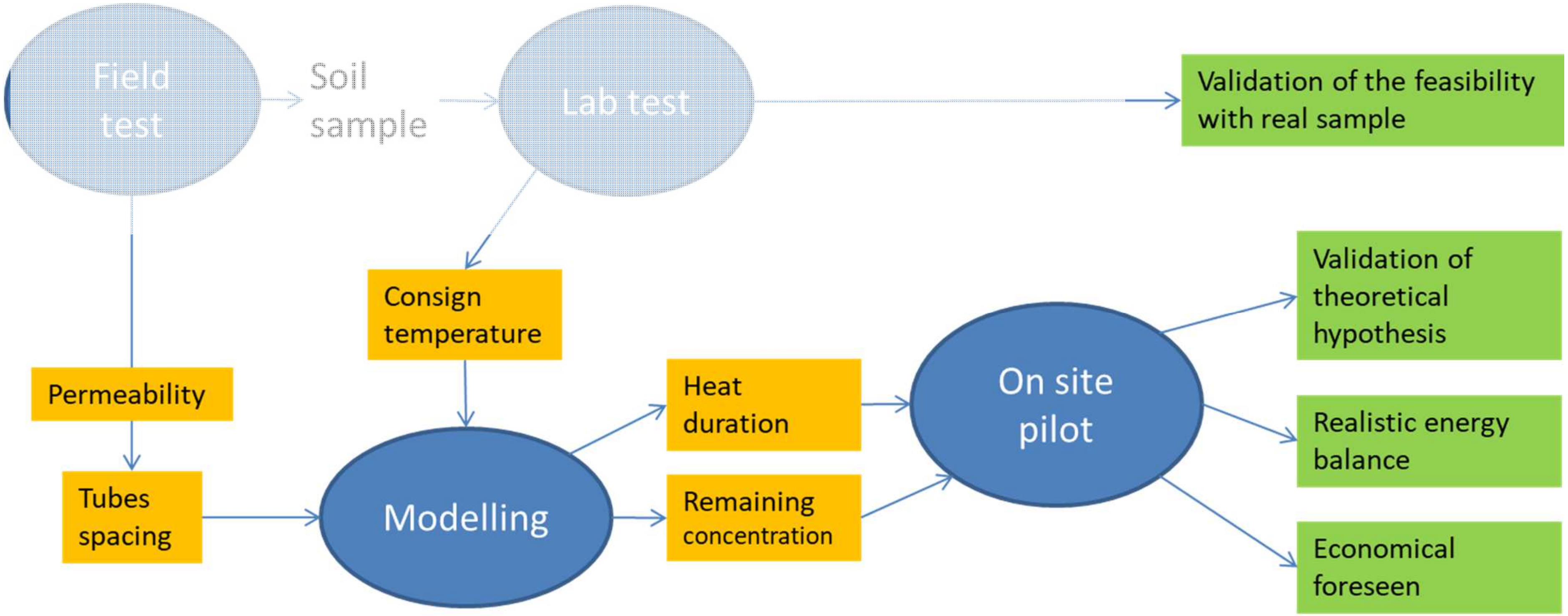
- The multi-physical model (OpenFoam) for the flow in porous medium is taking account of air gases, water and a pollutant.
- Soil’s matrix is defined by several dimensions, including permissivity
- Calculation starts when applying a temperature and a pressure differences between 2 points
- The program calculates flow and pressure vectors and their place-to-place evolution during time



```
    format      ascii;
    class       dictionary;
    location    "constant";
    object      transportProperties;
}
// * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * //

transportModel  Newtonian;                    // necessaire pour la boucle pimple
nu              nu [ 0 2 -1 0 0 0 0 ] 1e-05;  // necessaire pour la boucle pimple(modele de turbulence en realité desactive dans le
createfields.H)

                // [kg m s K kgMol A cd ]
k               k      [ 0 2 0 0 0 0 0 ] 1e-10;      //perméabilité en m/s
mu              mu     [ 1 -1 -1 0 0 0 0 ] 1.8e-05;  //viscosité dynamique de la phase gazeuse - ici air sec
eps_l           eps_l  [ 0 0 0 0 0 0 0 ] 0.1;        //ratio de phase liquide dans le sol
eps_g           eps_g  [ 0 0 0 0 0 0 0 ] 0.3;        //ratio de phase gazeuse dans le sol

rho_l           rho_l  [ 1 -3 0 0 0 0 0 ] 1000;      //masse volumique de la phase liquide
rho_P           rho_P  [ 1 -3 0 0 0 0 0 ] 1162;      //masse volumique de la phase polluante - ici naphtalène
rho_s           rho_s  [ 1 -3 0 0 0 0 0 ] 1800;      //masse volumique de la phase sol

lambda          lambda [ 1 1 -3 -1 0 0 0 ] 0.8;
D               D      [ 0 2 -1 0 0 0 0 ] 1e-6;
Cpg             Cpg    [ 0 2 -2 -1 0 0 0 ] 1000;
Cps             Cps    [ 0 2 -2 -1 0 0 0 ] 2000;
Cpl             Cpl    [ 0 2 -2 -1 0 0 0 ] 2000;

M_h2o           M_h2o  [ 1 0 0 0 -1 0 0 ] 18;        //masse molaire de l'eau
M_N2            M_N2   [ 1 0 0 0 -1 0 0 ] 28;        //masse molaire de l'azote
M_CO2           M_CO2  [ 1 0 0 0 -1 0 0 ] 44;        //masse molaire du CO2
M_O2            M_O2   [ 1 0 0 0 -1 0 0 ] 32;        //masse molaire de l'oxygène
M_P             M_P    [ 1 0 0 0 -1 0 0 ] 128;       //masse molaire du polluant - ici naphtalène

R               R      [ 1 2 -2 -1 -1 0 0 ] 8314.4621;  //Constante gaz parfait
p0              p0     [ 1 -1 -2 0 0 0 0 ] 101325;      //pression à l'état 0 en Pa
```



PILOT PHASE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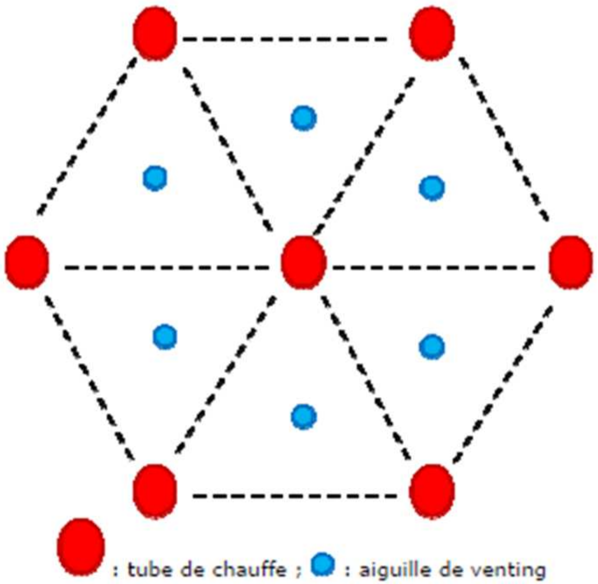


PILOT PHASE

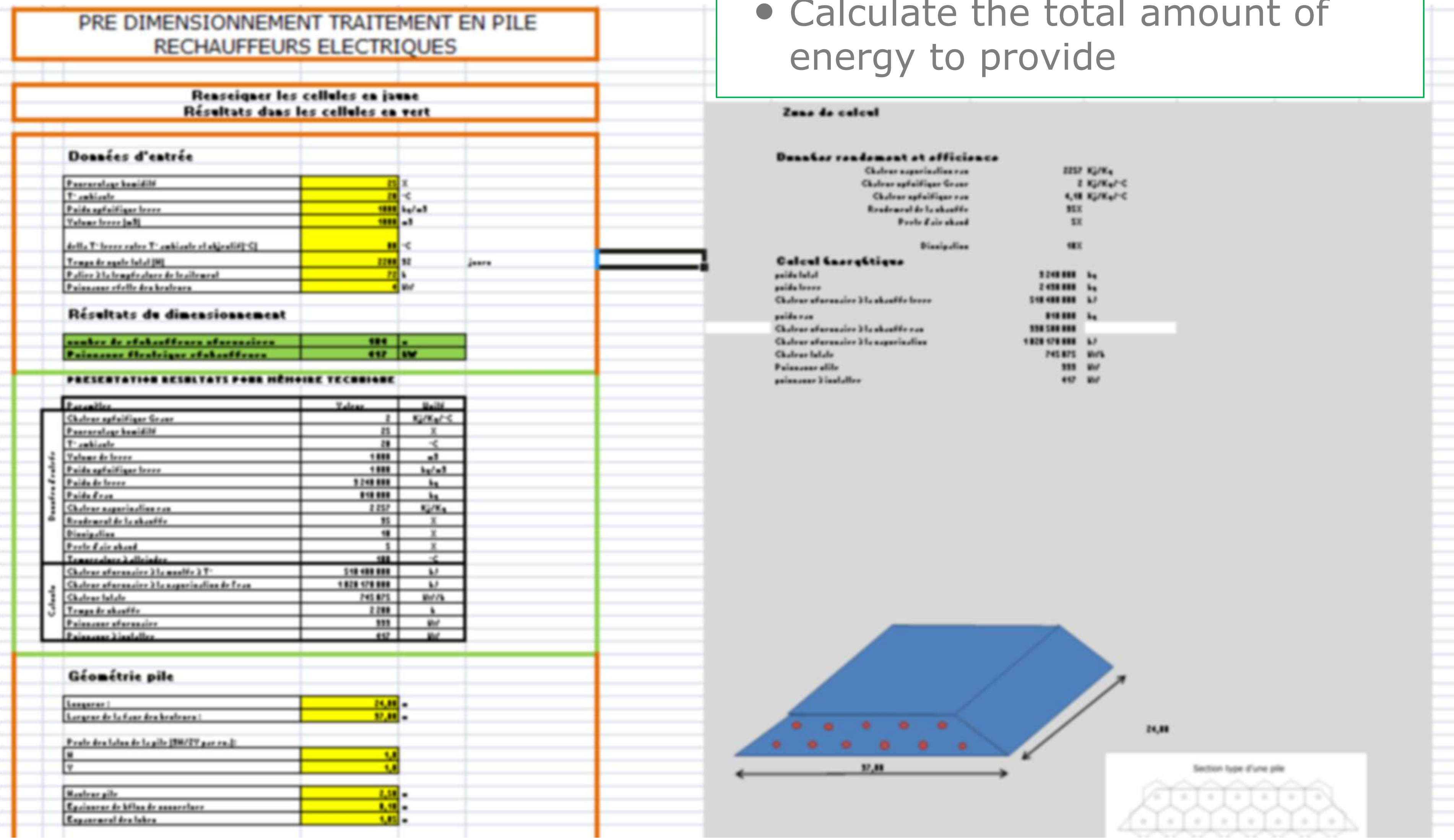
→ validation of choice

FULL SCALE – VALGO’S OFFER

- Optimize each step of the process
  - **Heating**
  - **Gases collection**
  - **Cooling**
  - **Implementation & treatment**

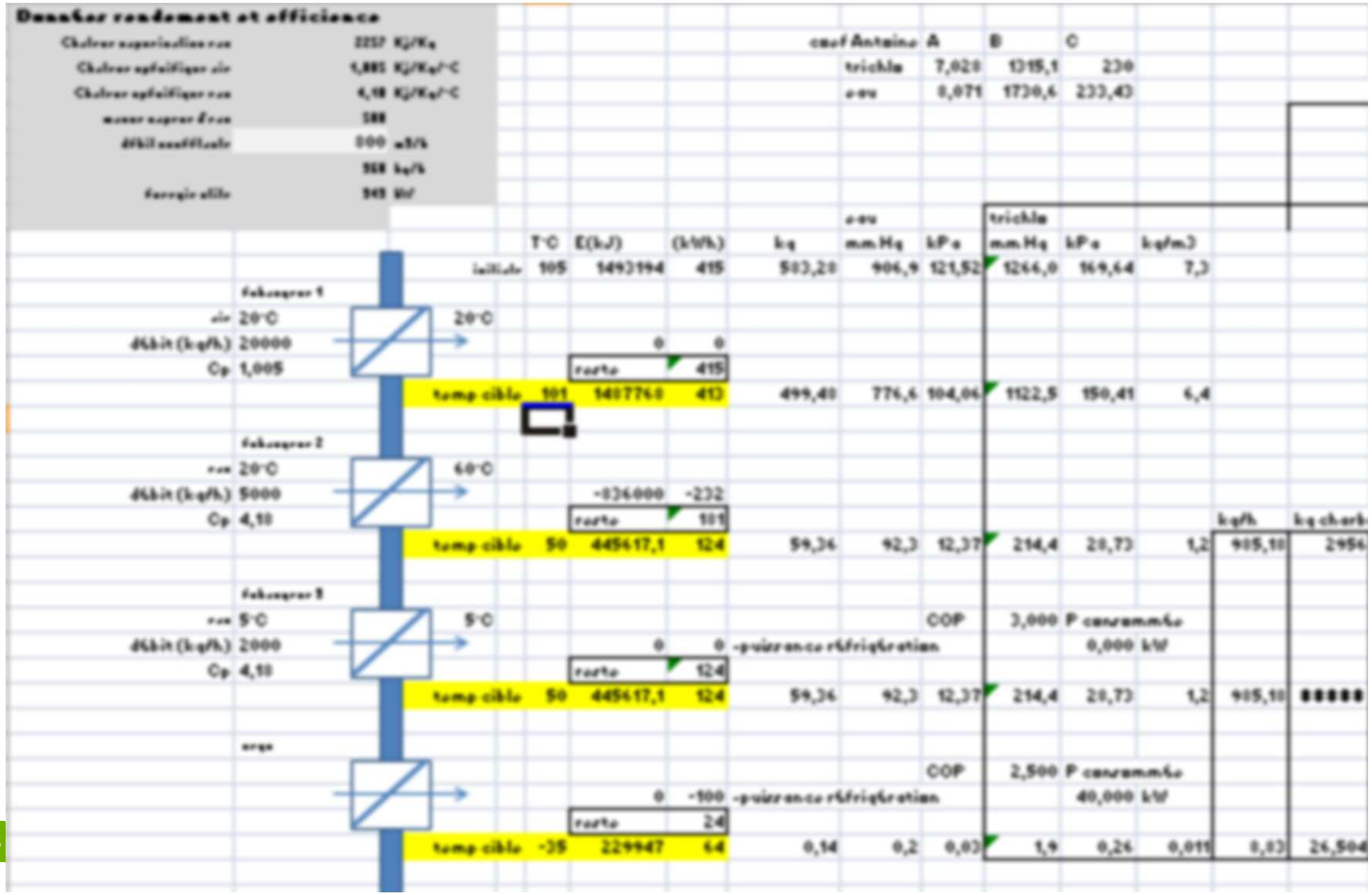
HEATING

- Calculate the total amount of energy to provide



COLLECTING GASES

- Similar to "classical" venting but with heat resistant materials (steel, stainless steel, suited piping…)
- + cooling exchangers



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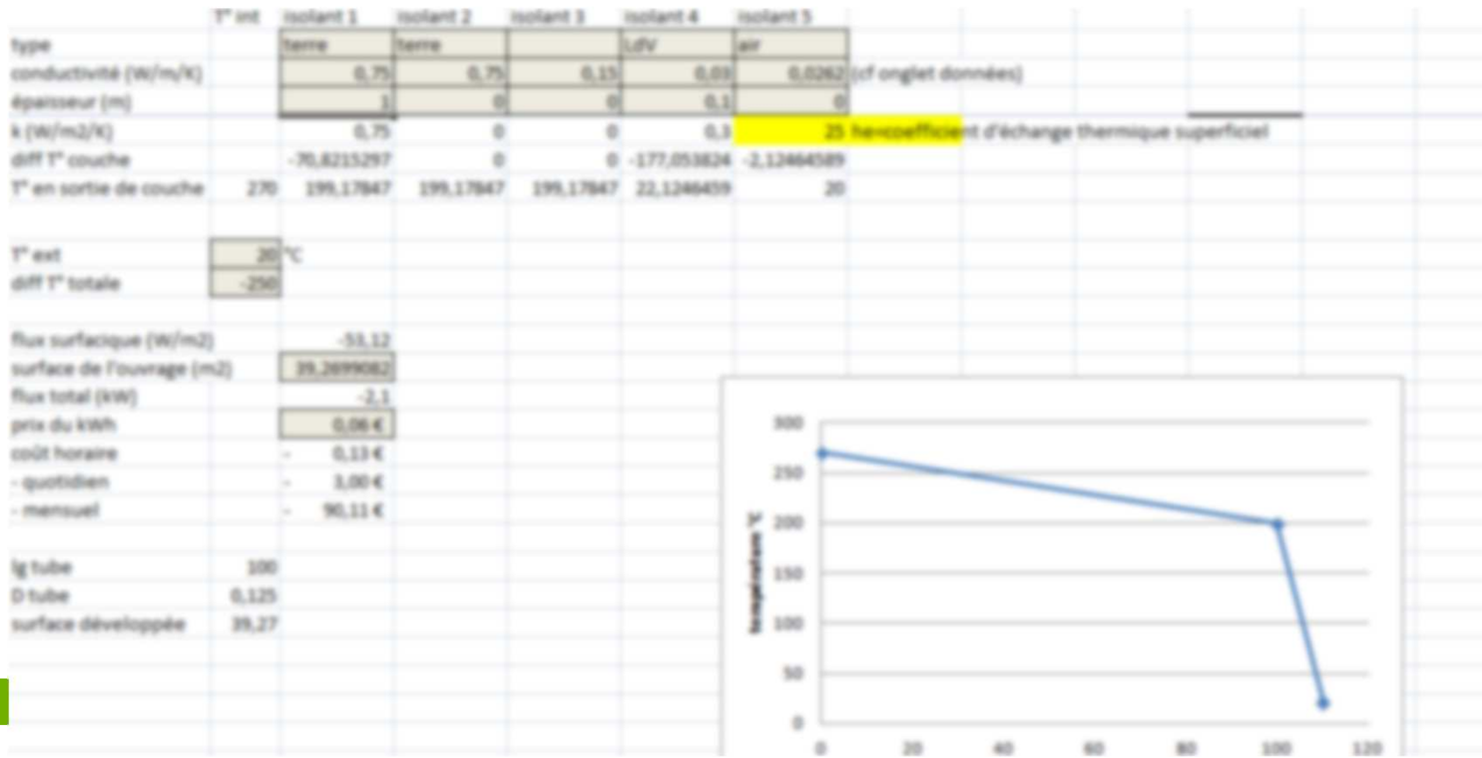
IMPLEMENTATION

- Building pile or in-situ?
  - pile: classical leveling engines
  - in-situ → needs drilling works
- Insulating → hunting losses, spare money
  - Depending of implementation, several solutions are available: rockwool panels, cellular concrete, clean earth



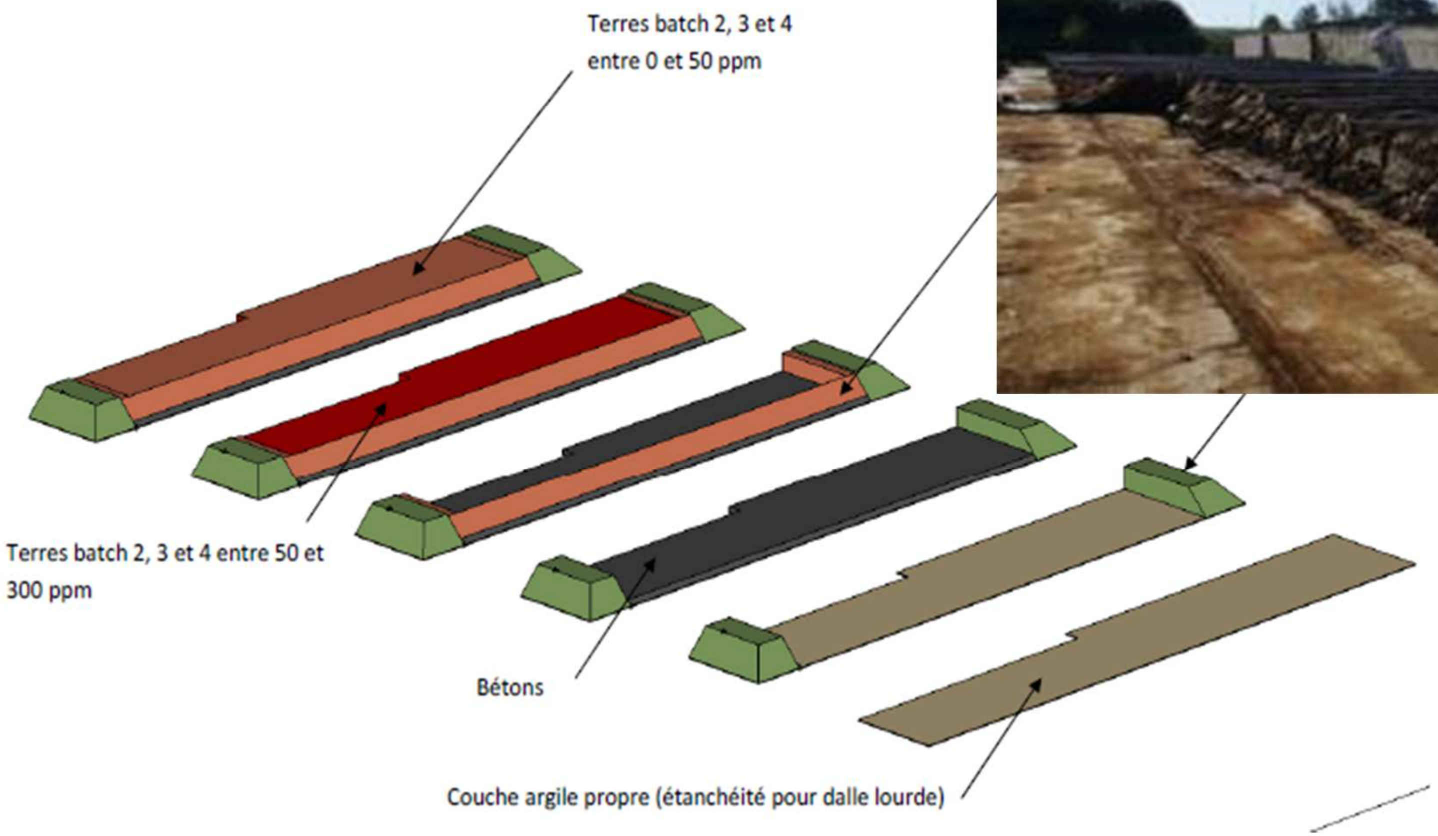
	T° int	isolant 1	isolant 2	isolant 3	isolant 4	isolant 5	
type		terre	terre		LdV	air	
conductivité (W/m/K)		0,75	0,75	0,15	0,03	0,0262	(cf onglet données)
épaisseur (m)		1	0	0	0,1	0	
k (W/m2/K)		0,75	0	0	0,3	25	he=coefficient d'échange thermique superficiel
diff T° couche		-70,8215297	0	0	-177,053824	-2,12464589	
T° en sortie de couche	270	199,17847	199,17847	199,17847	22,1246459	20	
T° ext	20	°C					
diff T° totale	-250						
flux surfacique (W/m2)		-53,12					
surface de l'ouvrage (m2)		39,2699082					
flux total (kW)		-2,1					
prix du kWh		0,06 €					
coût horaire		- 0,13 €					
- quotidien		- 3,00 €					
- mensuel		- 90,11 €					
lg tube	100						
D tube	0,125						
surface développée	39,27						

CASE STUDY

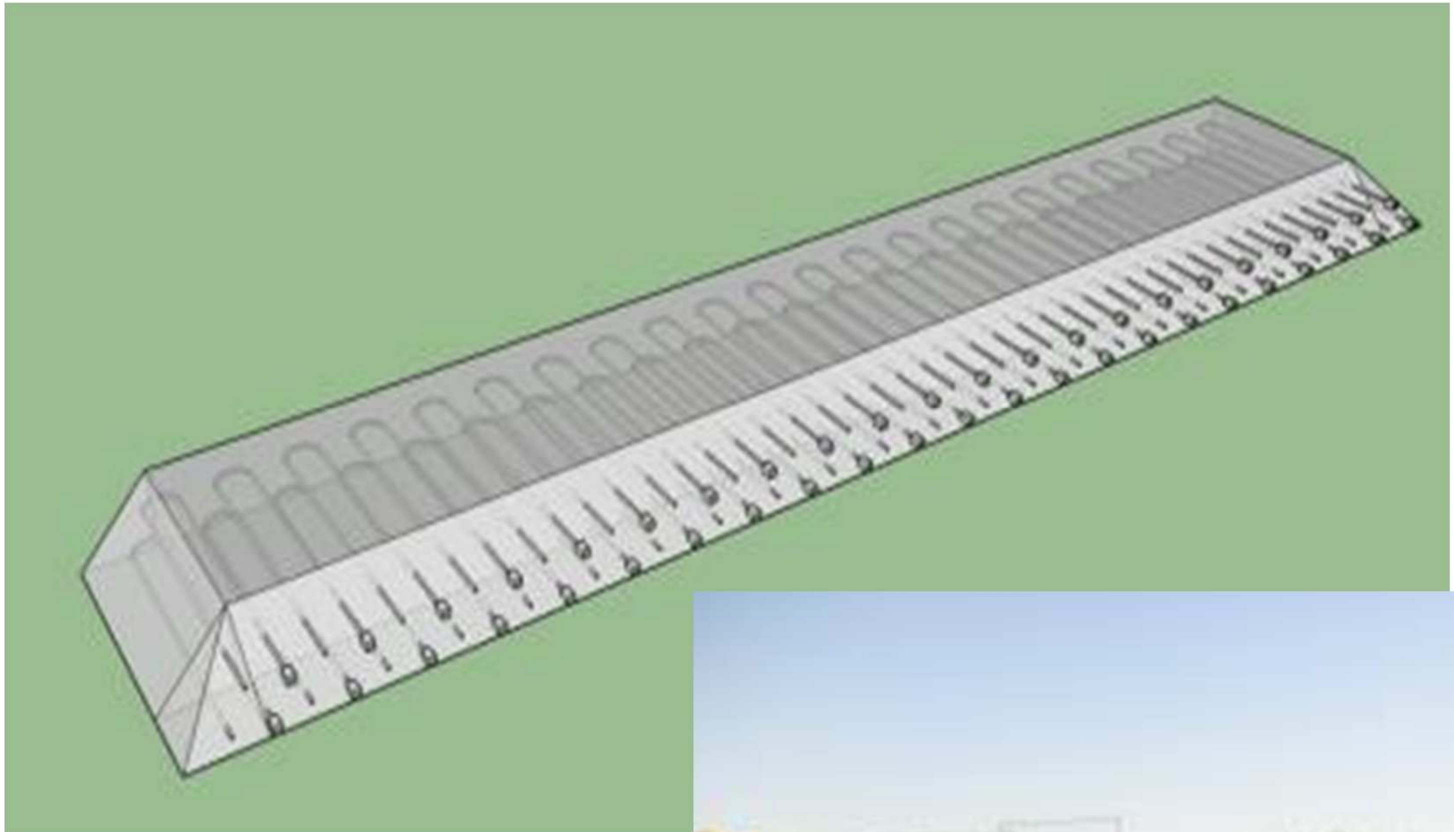
- Aluminium industry – Southwestern France
  - Electrical station → PCB spillage on the floor
  - Reported amounts between 20 and 200ppm.
  - About 3000m^3 of polluted soils to be treated

CASE STUDY: implementation

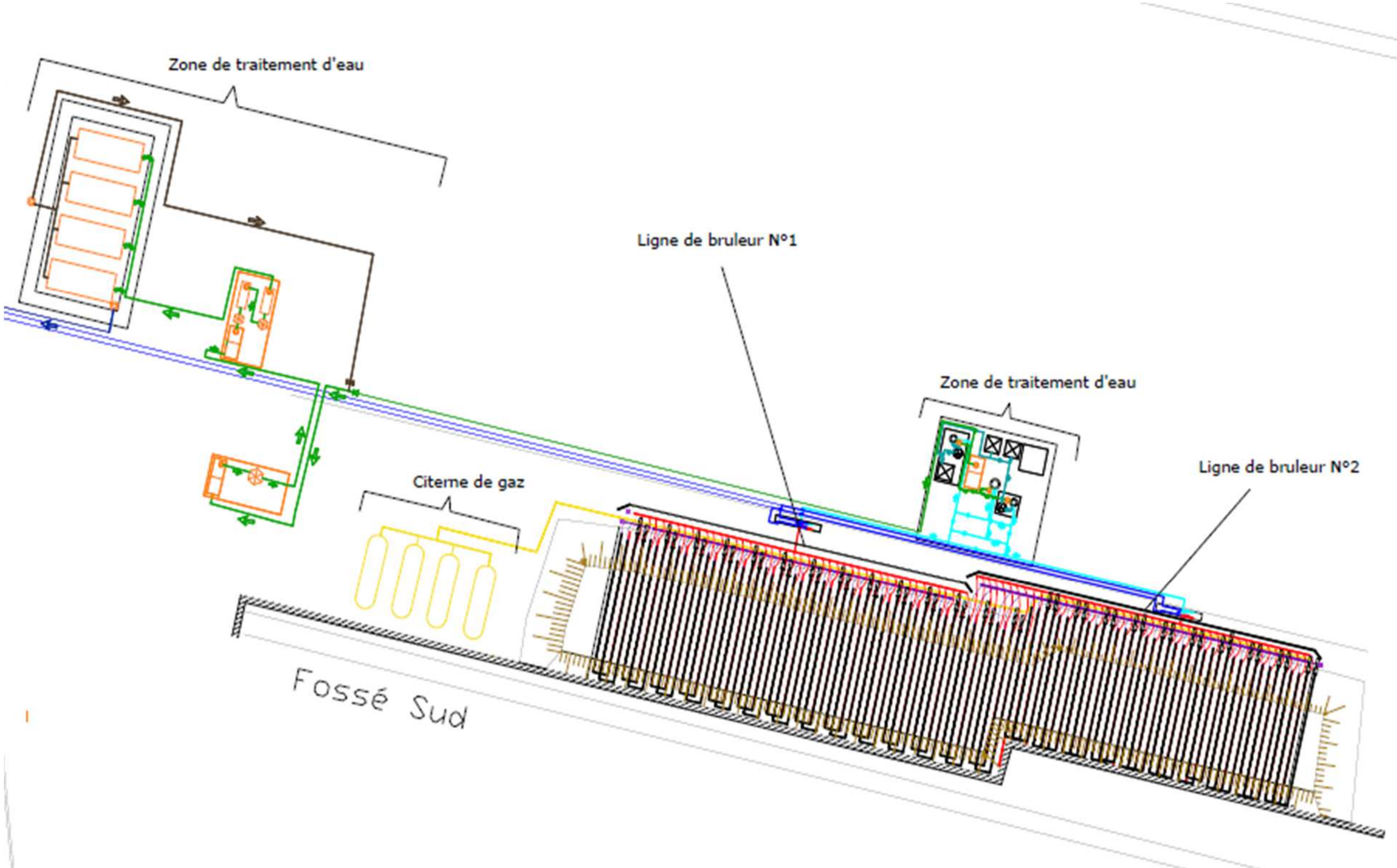
Optimizing parameters
→ Led to pile building



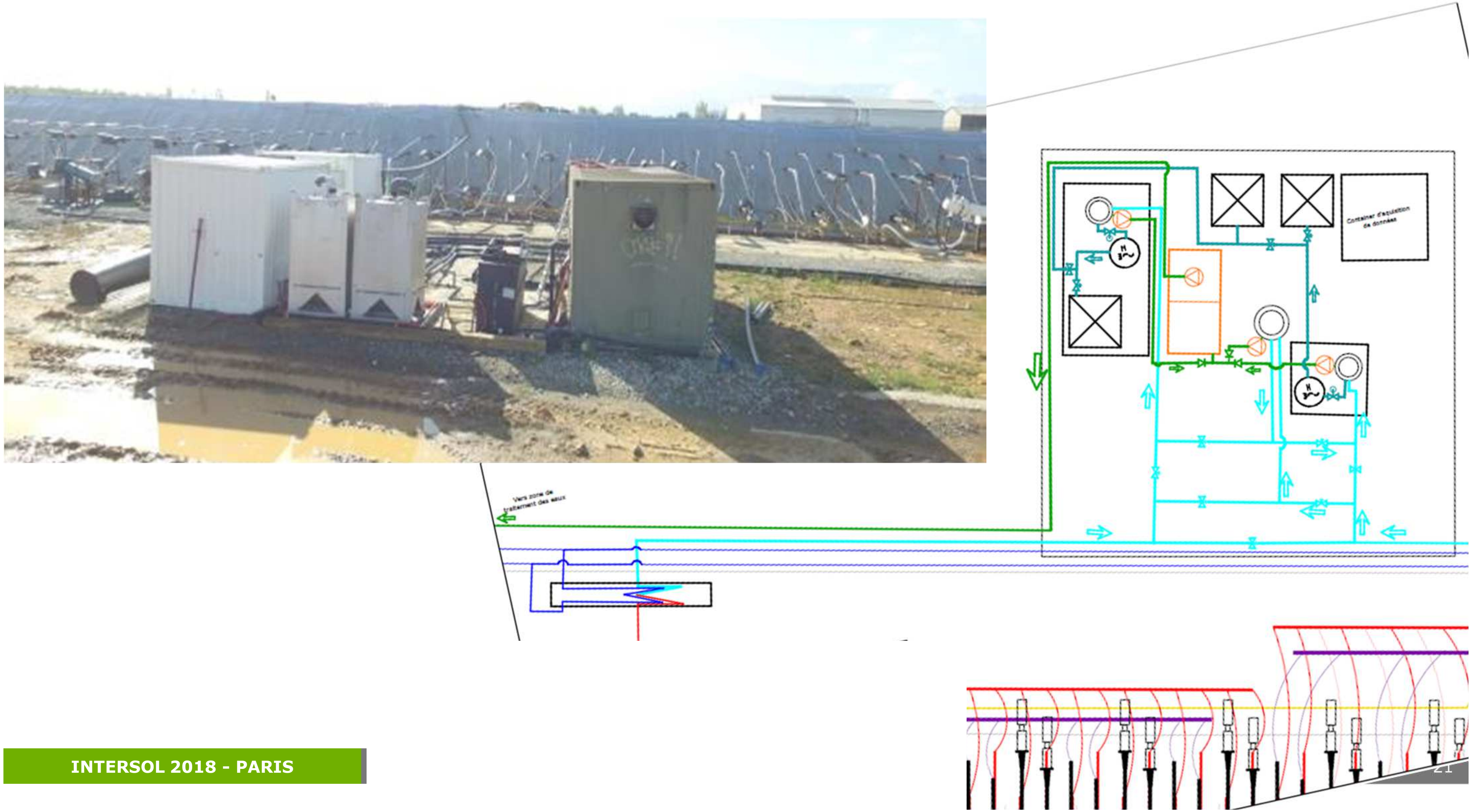
CASE STUDY: heating



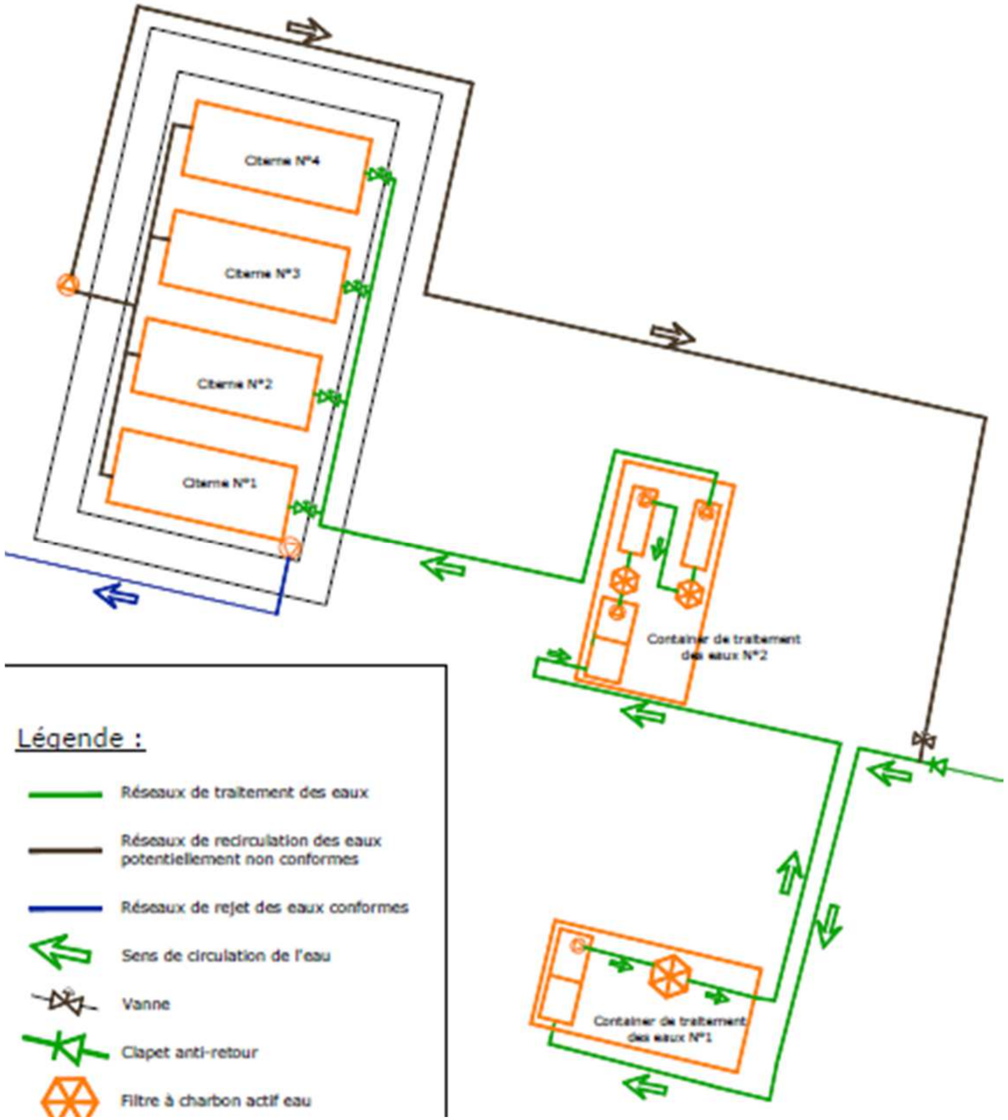
CASE STUDY: whole plant



EXTRACTION & TREATMENT OF VAPORS



TREATING CONDENSATES



STORAGE FOR CONDENSATES

VERY INDUSTRIAL IMPLEMENTATION

- 47 heating tubes and burners.
- 94 Venting tubes
- 4 electrical panels
- 4 propane tanks
- 2 condensation skids
- 2 water and air treatment units
- monitoring unit + data acquirement

VERY INDUSTRIAL IMPLEMENTATION

SURVEY PROTOCOL

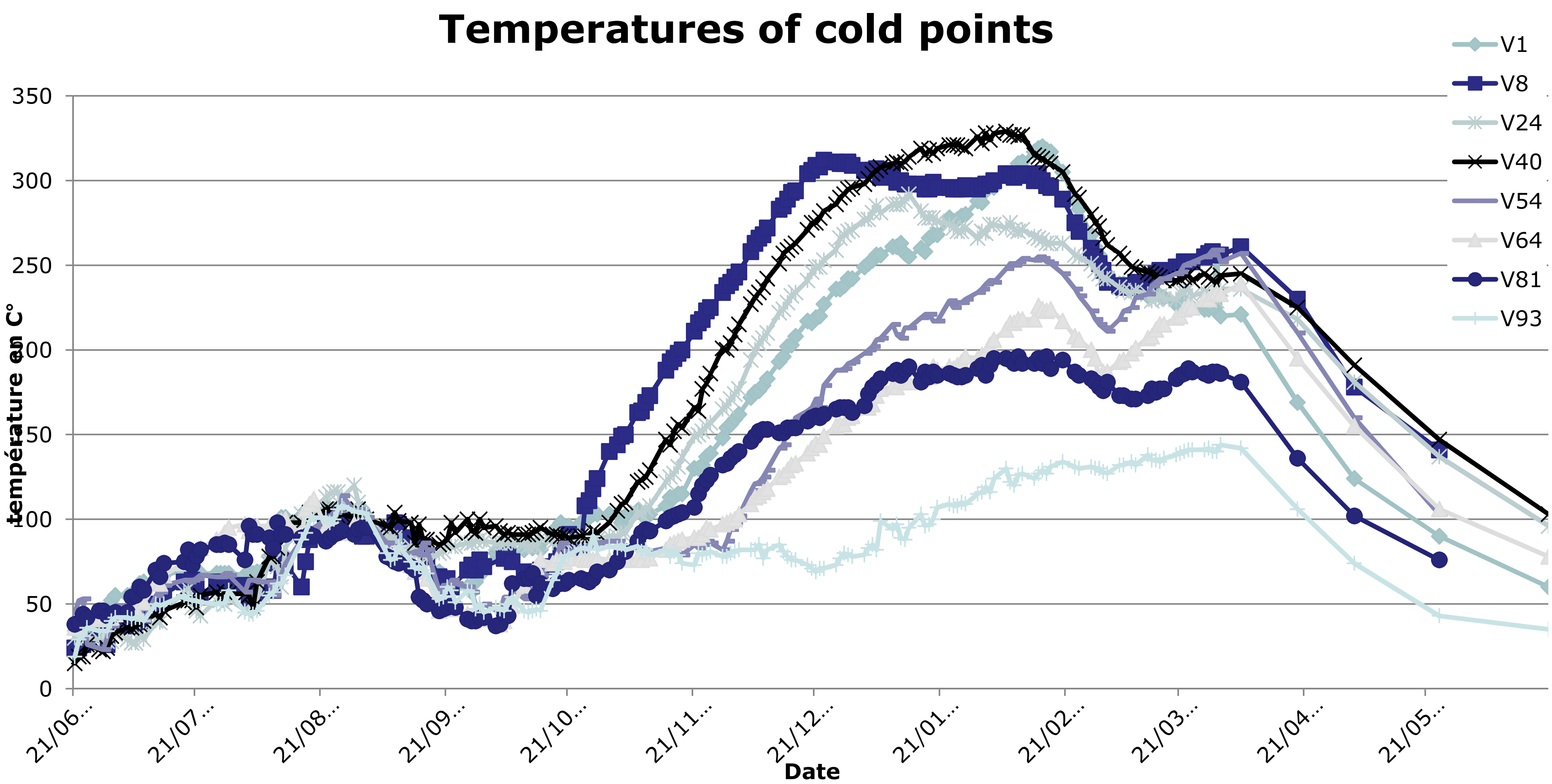
- Temperature

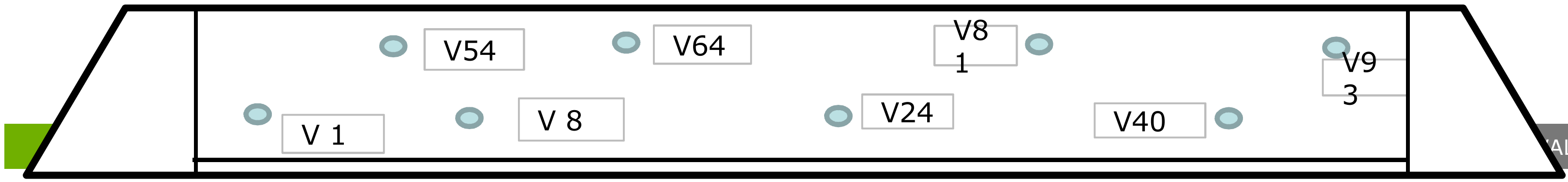
  T° <200°C : light survey

  T° >200°C : heavy survey

  - Full survey of emissions: PCBs, HCl, (H)VOCs, Dioxins & Furanes
  - combustion Exhausts : unburned compounds, CO, SO2, Nox
  - Automated security management with GSM reports

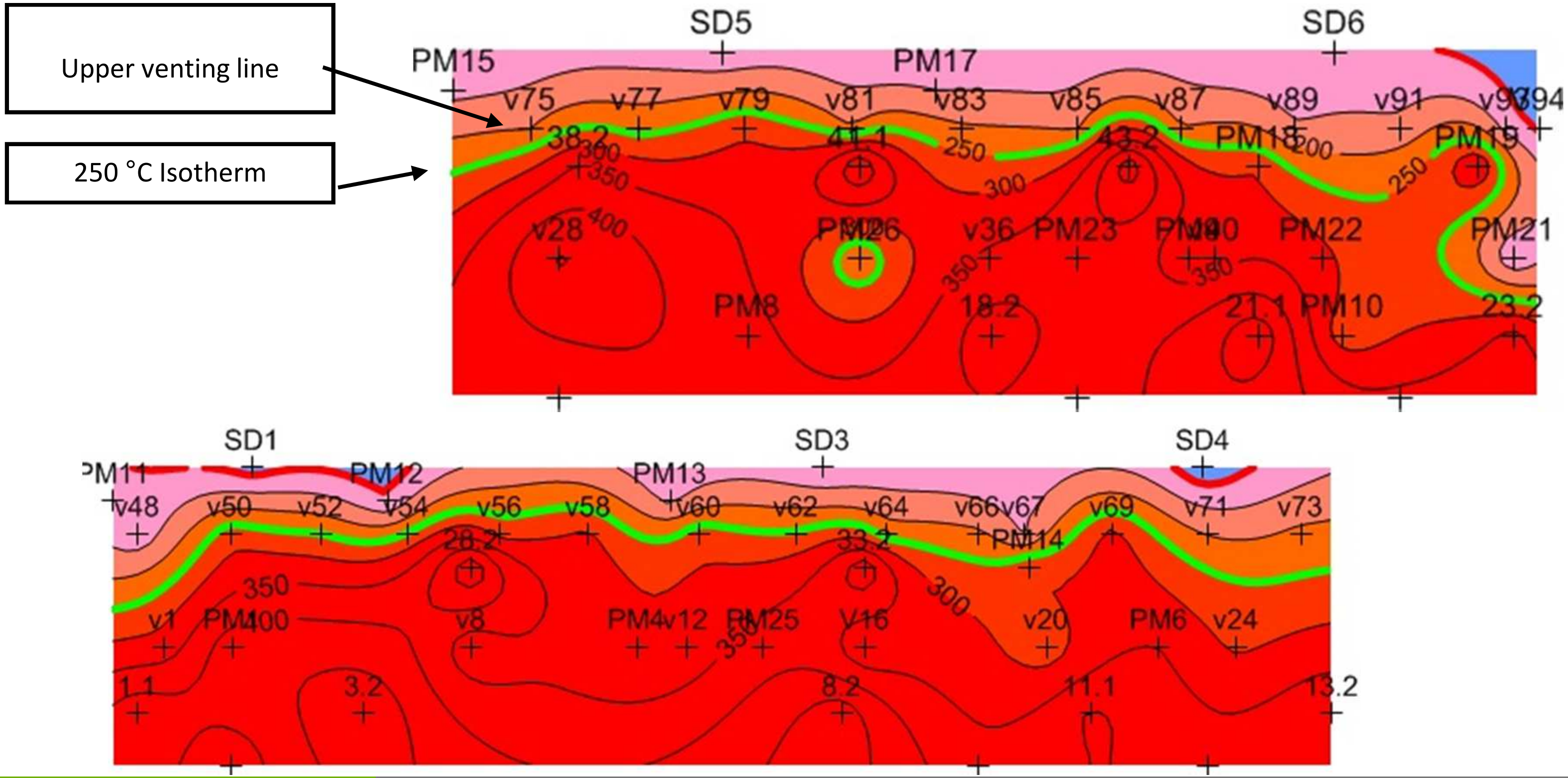
TEMPERATURE SURVEY





TEMPERATURE MAPPING

- Results



ANALYTICAL RESULTS

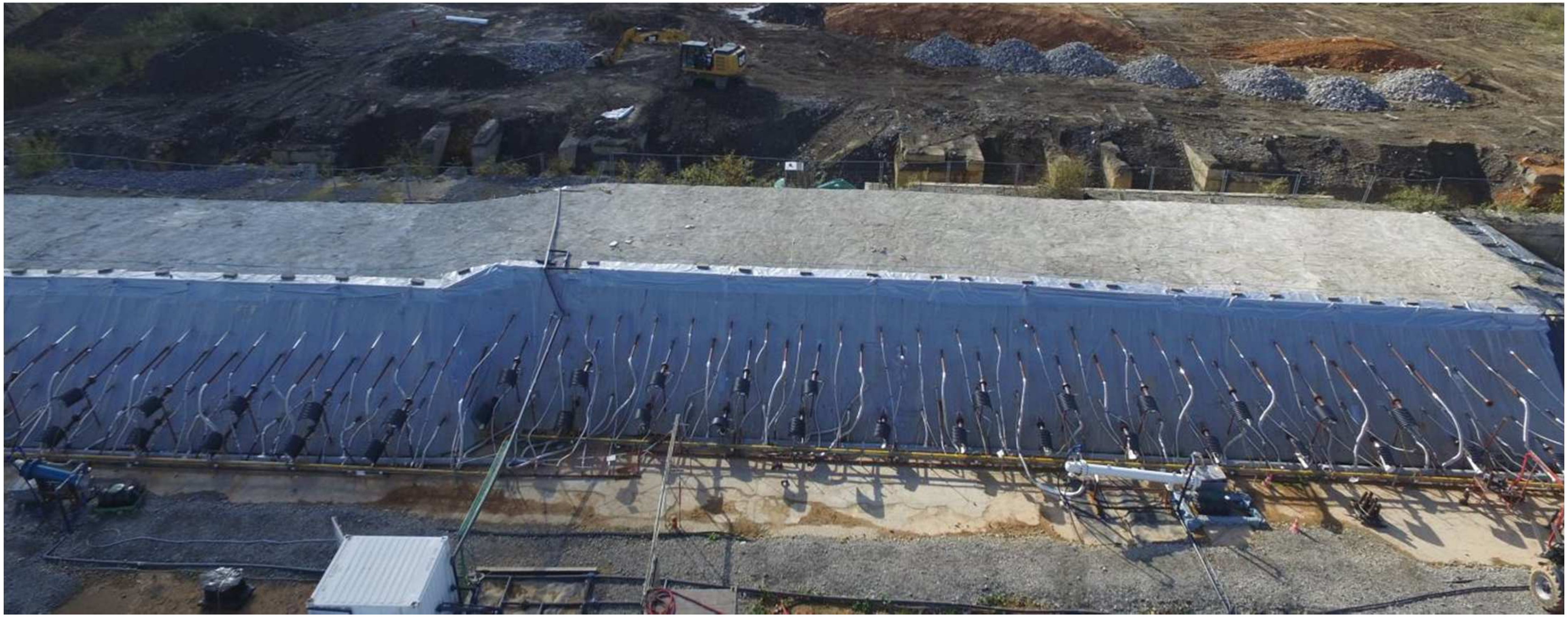
Final analysis

Maille	L2-1	L2-2	L2-3	L2-4	L1-1	L1-2	L1-3	L1-4
[PCB] mg/Kg	3,10	8,78	2,31	2,76	1,79	0,84	2,25	5,10

For a 10 mg/kg threshold

+ no impact in environment

MERCI DE VOTRE ATTENTION



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