SIFT DESK

SDRP Journal of Computer Science

STUDY AND MODELING OF A HEAT EXCHANGER FOR THE PURPOSE OF AIR CONDITIONING A SPACE BY A CANADIAN WELL USING GEO-THERMAL ENERGY

Research

AUTHOR: Didi Faouzi

May 2017

Didi Faouzi[*1], Messaouden Bilel[1], Saka Merouane[1], Bentchikou Mohamed[2]
[1*] Faculty of Science and Technology, Department of Physics, University of Abou-bakr Belkaïd, B.P. 119, Tlemcen, Algeria
[1] Faculty of Science and Technology, Department of Climate engineering, University of Yahia Fares, Médéa, Algeria
[1] Faculty of Science and Technology, Department of Climate engineering, University of Djilali Bounaama, Khemis Miliana, Algeria
[2]University of Yahia Fares, Médéa, Laboratory Director (LBMPT), Médéa Alegria

CORRESPONDENCE AUTHOR

Didi Faouzi

CONFLICTS OF INTEREST

There are no conflicts of interest for any of the authors.

Received Date: 05th May 2017
Accepted Date: 25th May 2017
Published Date: 31st May 2017

ABSTRACT

Air conditioning or heating a room designed to maintain a desired temperature. This comfort is not free because it uses energy. The latter not only is expensive and its price is increasing. It is not also cleaner, since often it is a fossil fuel. In this context, and to make our contribution to the development of renewable energies, we chose the study of cooling a room by a Canadian well. The work presented here is designed around five chapters. After a literature review of geothermal, the computing elements of the system are discussed and then the heat balance is exposed. Subsequently the design, regulation and maintenance of our facility are exposed.

Keywords: Geothermal Energy, Modelling, Thermal balance, heat exchanger, Conditioning, Canadian well.

INTRODUCTION

Housing and commercial buildings account for 19% of CO_2 emissions and consume 46% of final energy in Europe. Heating accounts for nearly two-thirds of these energy consumption and air-conditioning systems are experiencing strong growth. The improvement of the energy performance of buildings and the optimization of their design with regard to summer comfort are nowadays inescapable. The Canadian well or Provencal well is part of this.

Research into the use of geothermal upper soil in recent years has helped to develop systems for the use of this energy for housing. The ground becomes a fabulous reservoir of energies thanks to the solar energy which heats it by its radiation throughout the year to maintain it at constant temperatures according to the seasons. This energy can be used throughout the year on cloudy days or even at night when the sun is absent. Practice has shown that it is possible today to use this energy to bring heat to our homes in winter but also to refresh them in summer[10].

By passing air through a network of pipes placed horizontally in the ground before it enters a building, it can be reheated or refreshed with 30 times the energy required to maintain The system in operation. This principle will influence not only economic but also ecological, to reduce the amount of CO_2 released in the nature knowing that it will be one of the major stakes in the years to come.

Little known in Algeria, this principle, known as the "Canadian well" for winter preheating or "Provencal wells" for cooling in summer, is designed to minimize envelope energy losses. It becomes a good complement

to the heating and ventilation system in our homes[11].
In order to contribute to the development of renewable energies and in particular the development of geothermal energy, we have studied the air conditioning of a space by a Canadian well.
We have compiled essential elements of calculations necessary for the conduct of our study. Then the calculations of the energy requirements, heat inputs and losses[8], of the space and the air flows required after the Canadian well was sized, the method of laying the buried pipes and the balancing of the distribution network d 'air.

PARAMETRES GEOGRAPHIQUES:

In this chapter we will start by determining the various parameters related to air conditioning so that we can calculate the thermal balance so as not to oversize the equipment of the installation.
The house is located in the town of Médéa Algeria at an altitude of 900 m, latitude Æ=36,27 Nord and longitude 2.77 Est. in climatic zone B [4].

CLIMATE PARAMETERS:

1. External basic conditions

According to data provided by the meteorological center of Médéa we find that:

The lowest temperature (cold period) is T_{min} = 6.64 ° C.
The highest temperature (hot period) is T_{max} = 26.94 ° C.
The highest humidity value is φ = 81.6% [4].

2. Recommended internal conditions

Local	Periods	Temperature [° c]	Humidity [%]	Enthalpie [kcal/kg_{as}]	Specific volume [M^3/ kg_{as}]
Bedrooms	summer	24	50	47.5	0.853
	Winter	20	50	38.09	0.838
Kitchens	summer	24	50	47.5	0.853
	Winter	16	50	30	0.824
Exhibitions	summer	24	50	47.5	0.853
	Winter	20	50	38.09	0.838
Halls	summer	26	50	51.9	0.862
	Winter	18	50	34.28	0.832
bathroom	summer	26	50	51.9	0.862
	Winter	22	50	42.85	0.847

Table 1: Recommended indoor conditions

GEOMETRIC PARAMETERS

1 Ground floor

Designation	Local	S_L [m^2]	V_L [m^3]	S_M [m^2]				S_V [m^2]				S_P [m^2]	S_{env} [m^2]
				S	N	O	E	S	N	O	E		
R-B	Bedroom 1	16.78	51.51	13.04	13.04	10.44	10.22	-	-	1.68	-	1.9	83.88
R-B	Bedroom 2	14.02	43.04	10.89	10.89	10.22	10.44	-	-	-	1.68	1.9	74.06

R-B	Bed-room 3	13.66	41.93	10.89	9.21	9.91	11.81	-	1.68	-	-	1.9	72.72
R-R	Room	24.23	74.38	13.04	16.30	11.06	10.74	-	3.16	1.68	-	2	106.44
R-Bt	SDB	4.93	15.15	7.21	7.21	6.19	4.54	-	-	0.25	-	1.9	37.16

S_L: surface of the room, V_L: volume of the room, S_M: surface of the walls, S_V: surface of the windows
S_P: surface of doors, S_{env}: envelope surface.

Table 2: Geometric parameters on the ground floor

2. 1st floor:

Desi-gnation	Local	S_L [m^2]	V_L [m^3]	S_M [m^2]				S_V [m^2]				S_P [m^2]	S_{env} [m^2]
				S	N	O	E	S	N	O	E		
E1-Bed1	Bedroom 1	19.39	59.52	15.29	17.19	9.66	11.66	-	-	2	-	1.9	96.48
E1-Bed2	Bedroom 2	13.66	41.93	10.89	9.21	9.91	10.13	-	1.68	-	1.68	1.9	72.72
E1-R	Room	24.23	74.38	13.04	16.30	10.74	10.74	-	3.16	2	-	2	106.44
E1- Bath 1	Bath-room1	2.9	8.90	6.14	6.14	2.55	4.45	-	-	-	-	1.9	26.98
E1-Bath2	Bath-room2	3.12	9.57	7.36	5.46	3.99	3.99	-	-	-	-	1.9	28.94

Table 3: Geometric parameters on the 1st floor

3 2nd floor :

Designation	Local	S_L [m²]	V_L [m³]	S_M [m²]				S_V [m²]				S_P [m²]	S_{env} [m²]
				S	N	O	E	S	N	O	E		
E 2 - B1	Bedroom 1	16.57	50.86	13.04	11.04	9.92	10.07	-	2	2	-	1.9	83.11
E 2 - B2	Bedroom 2	15.82	48.56	12.95	10.95	9.61	9.51	-	2	-	2	1.9	80.56
E2-Bt	Bathroom	2.8	8.59	6.14	6.14	2.39	4.29	-	-	-	-	1.9	26.46

Table 4: Geometric parameters 2nd stage

THERMAL PARAMETERS

1 Thermal balance model

Heat is actually a physical phenomenon it is the unaccompanied energy exchange of overall movement. This exchange of energy (heat transfer) between several bodies is effected by three modes of transmission (conduction, convection and radiation) :

A. Conduction

The relation of conduction heat flux is:

$Q_c = (\lambda/\delta).S.(T_i - T_e)$ (1)

Where :

λ : thermal conductivity coefficient [w / m.°c].

δ : thickness of the wall [m].

S: exchange surface [m2].

(Ti - Te): temperature difference between the faces [° c].

B. Convection

The relation of convection heat flux is:

$Q_v = h.S.(T_p - T_e)$ (2)

C. Radiation

A typical example of this mode of transfer is the heating of the Earth by sunlight.

$Q_v = \sigma.S.(t^4_1 - t^4_2)$ (3)

σ: radiation coefficient [w / m². ° c⁴].

2 Surface Transfer coefficient

To determine the coefficients αi and αe we have to take into account the nature, the position of the wall and the direction of the heat flux.

Position of the wall and direction of the heat flux		α_i[kcal/h.m^2.°c]	α_e[kcal/h.m^2.°c]
Vertical Wall	Int → Out	7	20
Horizontal Wall	Out / Ind (flux downward)	5	20
Horizontal Wall	Ind / Out (flux upward)	7	20
Vertical Wall	Ind Out →	7	7

Table 5: Surface transfer coefficient

3 Total heat transfer coefficient

The overall heat transfer coefficient of several layers of a wall is given by the formula:

$k = 1/(1/\alpha_i + \sum e_i/\lambda_i + 1/\alpha_e) = 1/R_{th}$ (4)

K: overall heat transfer coefficient [w / m^2.° c].

R_{th}: thermal resistance of the wall [m^2.° c / w].

α_i , α_e: interior and exterior surface exchange coefficients [w / m2. ° c].

e_i: Thick layer thickness [m].

λ_i : thermal conductivity of the first layer [w / m.°c] (TAB N°1).

4 Opaque walls

A. Exterior walls (35 cm)

N°	Designation	e	λ	R
		m	Kcal/h.m.°c	h.m^2.°c/kcal
-	Indoor Air	-	-	0.142
1	Coating With plaster	0.01	0.3	0.033
2	Cement plaster	0.02	.099	0.02
3	Hollow brick	0.10	0.4	0.25
4	Air blade	0.05	-	0.08
5	Hollow brick	0.15	0.4	0.375
6	Cement plaster	0.02	0.99	0.02
-	Outdoor air	-	-	0.05
∑R	-	-	-	1.27
K[kcal/h.m^2.°c]	-	-	-	0.787

Table 6: Construction characteristics of external walls 35 cm

B. Internal walls (14 cm)

N°	Désignation	e	λ	R
		m	Kcal/h.m.°c	h.m².°c/kcal
-	Indoor Air	-	-	0.142
1	Coating With plaster	0.01	.03	0.033
2	Cement plaster	0.01	0.99	0.01
3	Hollow brick	0.10	0.4	0.25
4	Enduit en ciment	0.01	0.99	0.01
5	Cement plaster	0.01	0.3	0.033
-	Outdoor air	-	-	0.142
∑R	-	-	-	0.62
K[kcal/h.m².°c]	-	-	-	1.61

Table 7: Construction characteristics of interior walls 14cm

C. Slab between floors 25cm

N°	Designation	e	λ	R
		m	Kcal/h.m.°c	h.m².°c/kcal
-	Indoor Air	-	-	0.142
1	Floor tile	0.02	0.9	0.022
2	Cement mortar	0.02	0.99	0.020
3	Concrete	0.04	1.5	0.026
4	Socks	0.16	1.06	0.15
5	Cement plaster	0.01	0.99	0.010
6	Area Blade	0.50	2.4	0.21
7	False ceiling	0.013	-	1.27
-	Indoor Air	-	-	0.142
∑R	-	-	-	1.992
K[kcal/h.m².°C]	-	-	-	0.502

Table 8: Characteristics of deck construction (roofing) 25cm

D. Terrace tile 25cm

N°	Désignation	e	λ	R
		m	Kcal/h.m.°C	h.m².°C/kcal
-	Outdoor air	-	-	0.05
1	Floor tile	0.02	0.9	0.022
2	Cement mortar	0.02	0.99	0.020

3	Concrete	0.04	1.5	0.026
4	Socks	0.16	1.06	0.15
5	Cement plaster	0.01	0.99	0.010
6	Area Blade	0.50	2.4	0.21
7	False ceiling	0.013	-	1.27
-	Indoor Air	-	-	0.142
∑R	-	-	-	1.9
K[kcal/h.m^2.°C]	-	-	-	0.526

Table 9: Characteristics of deck construction (roofing) 25cm

E. Roof tile 21cm

N°	Désignation	e	λ	R
		m	Kcal/h.m.°C	h.m^2.°C/kcal
-	Indoor Air	-	-	0.142
1	Concrete	0.04	1.5	0.026
2	Socks	0.16	1.06	0.15
3	Cement mortar	0.010	0.99	0.010
5	Area Blade	0.5	2.4	0.21
6	False ceiling	0.013	-	1.27
-	Indoor Air	-	-	0.142
∑R	-	-	-	1.95
K[kcal/h.m^2.°C]	-	-	-	0.512

Table 10: Roof slab construction characteristics 21cm

F. Floor on soil

N°	Désignation	e	λ	R
		m	Kcal/h.m.°C	h.m^2.°C/kcal
-	Indoor Air	-	-	0.142
1	Floor tile	0.02	1.2	0.026
2	Cement mortar	0.015	0.99	0.015
3	Concrete	0.04	1.5	0.026
4	Porous Natural stone	0.1	0.47	0.21
5	soil	0.5	1.8	0.27
∑R	-	-	-	0.689
K[kcal/h.m^2.°C]	-	-	-	1.451

Table 11: Construction characteristics of floor on soil

V.5 The windows
Single glazing with: k = 4.9 kcal / h.m^2. ° C.
V.6 The doors
For the rooms the doors are in simple wood with:
λ = 1.12 kcal / h.m. °C, e = 0.03 m So k = 3.76 kcal / h.m2 ° C.
V.7 The occupants

Local	Number of occupants	Duration of occupation
Bedrooms	2 à 4	8h
Living room	4 à 8	4h

Table 12: Occupants and their tenure

V.8. Lighting

Local	Power [w/m^2]	Lighting time
Bedrooms	16	5h
Living room	16	5h

Table 13: Power levels and lighting times

V.9. The machine

Local	Apparatus	Power [w]
R-Bedroom1	TV	100
R-S	TV	100
E1-Bedroom1	Micro computer	90
E1-S	TV	100
E2-Bedroom1	TV	100

Table 14: The power of the machines

VI. CONDENSATION STUDY
We will first define the phenomenon and its basic technical criteria, then we will distinguish the different ways in which the condensations are likely to affect the walls of a dwelling [6]. A physical phenomenon for changing the state of matter from a vapor (gas) to a condensed (liquid) state. One can experience this change of state in a shower where, in contact with the cold mirror, the humidity of the air turns into droplets[5].
VI.1 Surface Condensation
In buildings, surface condensation first appears on windows, metal frames without thermal break, cold water pipes, and on cold parts of the envelope.
VI.3. Condensations in the mass
Water vapor is likely to migrate through the wall from the inner to the outer environment. On the one hand, masonry materials (concrete, terracotta) have a certain porosity; on the other hand, water vapor, like any gas, has a pressure in the medium that contains it, and in the situation Which is ours, the pressure is stronger on the inside.
VI.4. Superficial Condensation Checks
To avoid this type of condensation, the internal surface temperature "T_{Si}" of the wall must remain higher than the dew point temperature of the indoor air "T_R".
Since the heat flux density is constant, the exchange between an interior atmosphere and the outer wall surface is given by the following relation[4]:

$Q = \alpha_i.(T_i - T_p) = K.(T_i - T_e)$ (5)

So :

$T_{si} = T_i - (1/\alpha_i).(T_i - T_e).K$ (6)

In the above formula it is noted that:

If K is decreasing then T_{si} is increasing and the risk of condensation decreases.

α_i : Inner surface heat transfer coefficient [kcal / h.m². ° C].

K: Total heat transfer coefficient [Kcal / h.m². ° C].

T_i: inside temperature [° C].

T_e: temperature of the inside face of the wall [° C].

Q: The density of the heat flux in [kcal / h.m²]

The row temperature "T_R" is determined graphically according to the diagram H-X for the internal calculation conditions φ_i and T_i

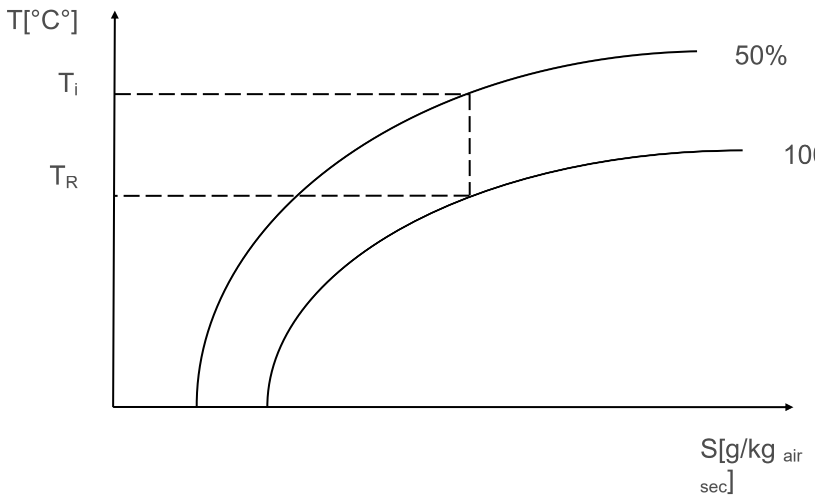


Figure (1): Obtaining the rosé temperature from the H-X diagram

IV.4.1 Application to the project

To avoid a risk of surface condensation : $T_{si} > T$

A. Outside wall 35 cm (bedroom, living room / outdoor)

Of: $T_i = 20$ °C and $T_e = 6.64$ °C

$T_i = 20$ °C
H-X → $T_R = 9.1$ °C
$\varphi_i = 50$ %

We have: K = 0,787 Kcal / h.m².°C, R = 1,27 h.m².°C/ Kcal, $\alpha_i = 7$ Kcal / h.m².°C.

$Ts_i = 20 - (0{,}787 / 7) * (20 - 6.64)$ g $T_{si} = 18.49$ °C.

T_{si} > T_R : Which means that there is no superficial condensation.

B. Outdoor Wall 35 cm (Bathroom / Outdoor)

Of: $T_i = 22$ °C and $T_e = 6.64$ °C

$T_i = 22$ °C
H-X $T_R = 11$ °C
$\varphi_i = 50$ %

We have : K = 0,787 Kcal / h.m².°C, R = 1,27 h.m².°C/ Kcal, $\alpha_i = 7$ Kcal / h.m².°C.

$Ts_i = 22 - (0{,}787 / 7) * (22 - 6.64)$ g $Ts_i = 20.27$ °C.

Tsi> T_R : which means that there is no surface condensation.

C. Outdoor wall 35 cm (kitchen / outdoor)

Of: $T_i = 16$ °C and $T_e = 6.64$ °C .

$T_i = 16$ °C
H-X → $T_R = 5$ °C
$\varphi_i = 50$ %

We have : K = 0,787 Kcal / h.m².°C, R = 1,27 h.m².°C/ Kcal, α_i = 7 Kcal / h.m².°C.
Ts_i = 16 – (0,787 / 7) * (16 – 6.64) g Ts_i = 14.94 °C.

T_{si}> T_R : which means that there is no surface condensation.

D. Floor on soil

Of: T_i = 16 °C and T_e = 6.64 °C

T_i = 16 °C
H-X → T_R =5 °C
φ_i= 50 %

We have : K = 1.451 Kcal / h.m².°C, R = 0.689 h.m².°C/ Kcal, α_i = 7 Kcal / h.m².°C.
Ts_i = 16 – (1.451 / 7) * (16 – 6.64) g Ts_i = 14.04 °C.
Ts_i > T_R : Which means that there is no superficial condensation.

E. Shed 58.8cm

Of: T_i = 20 °C and T_e = 6.64 °C

T_i = 20 °C
H-X → T_R =9.1 °C
φ_i= 50 %

We have : K = 0.526 Kcal / h.m².°C, R = 1.9 h.m².°C/ Kcal, α_i = 7 Kcal / h.m².°C.
Ts_i = 20 – (0.526 / 7) * (20 – 6.64) g Ts_i = 18.99 °C.
Ts_i > T_R : Which means that there is no superficial condensation.

F. Roofing

Of: T_i = 20 °C et T_e = 6.64 °C

T_i = 20 °C
H-X → T_R =9.1 °C
φ_i= 50 %

We have : K = 0.512 Kcal / h.m².°C, R = 1.95 h.m².°C/ Kcal, α_i = 7 Kcal / h.m².°C.
Ts_i = 20 – (0.512 / 7) * (20 – 6.64) g Ts_i = 19.02 °C.
Ts_i > T_R : Which means that there is no superficial condensation.

VI.4.2 In-Ground Condensation Checks

To verify the existence of condensation in the mass, it is necessary to go through the following steps:

- Calculation of the temperatures of the wall interfaces.
- determination of the saturation pressures of each layer.
- determination of the partial pressures of each layer.
- GLASER chart

Note

The GLASER diagram allows us to determine the presence or absence of the condensation in the mass, because the partial pressure must remain lower than that of saturation.

VI.4.3 Application to the project

A. Outside wall 35 cm

Of T_i = 20 °C et T_e = 6.64 °C

1- Calculation of temperature of the layer couches

$$T_{sn} = T_i - K.\ R_n.\ (T_i - T_e) \quad (7)$$

Or:

$$Ts_n = T_e + K.\ R_n.\ (T_i - T_e) \quad (8)$$

With :

$R_n = (1/\alpha_e) + \sum (e_i / \lambda_i)$ et K = 0,787 Kcal / h.m.°c, α_e = 20 Kcal / h.m².°C, T_e = 6.64 °C

Where :

$Ts_e = T_e + (1/\alpha_e).K.(T_i - T_e)$ = 7.16 °C

$Ts_1 = T_e + ((1/\alpha_e) + (e_1/\lambda_1)).K.(T_i - T_e) = 7.37$ °C
$Ts_2 = T_e + ((1/\alpha_e) + (e_1/\lambda_1) + (e_2/\lambda_2)).K.(T_i - T_e) = 11.31$ °C
$Ts_3 = T_e + ((1/\alpha_e) + (e_1/\lambda_1) + (e_2/\lambda_2) + (e_3/\lambda_3)).K.(T_i - T_e) = 12.16$ °C
$Ts_4 = T_e + ((1/\alpha_e) + (e_1/\lambda_1) + (e_2/\lambda_2) + (e_3/\lambda_3) + (e_4/\lambda_4)).K.(T_i - T_e) = 14.78$ °C
$Ts_5 = T_e + ((1/\alpha_e) + (e_1/\lambda_1) + (e_2/\lambda_2) + (e_3/\lambda_3) + (e_4/\lambda_4) + (e_5/\lambda_5)).K.(T_i - T_e) = 15$ °C
$Ts_6 = T_e + ((1/\alpha_e) + (e_1/\lambda_1) + (e_2/\lambda_2) + (e_3/\lambda_3) + (e_4/\lambda_4) + (e_5/\lambda_5) + (e_6/\lambda_6)).K.(T_i - T_e) = 18.50$ °C

2- Determination of saturation pressures

T [°C]	6.64	7.16	7.37	11.31	12.16	14.78	15	18.5	20
P_s [mm Hg]	7.38	7.59	7.7	10.05	10.62	12.60	12.78	15.97	17.52

Table 15: Determination of saturation pressures for the external wall of 35 cm

3-Determination of partial pressures

Construction	Thickness [m]	π [g/ m.h.mmHg]	e ⁄ π [g/h.mmHg]
Coating With plaster	0.01	0.009	1.11
Cement plaster	0.02	0.004	5
Hollow brick	0.10	0.0093	10.71
Air blade	0.05	0.045	1.11
Hollow brick	0.15	0.014	10.71
Cement plaster	0.02	0.004	5
$\sum(e_i/\pi_i)$	-	-	33.64

Table 16: Determination of permeances for the outer wall of 35 cm

$$\begin{cases} P_{vn} = P_{ve} + (e_n/\lambda_n).(P_{vi} - P_{ve})/\sum(ei/\pi i) \\ \varphi = P_v/Ps \Rightarrow P_v = \varphi.\, Ps \end{cases}$$

$$\begin{cases} P_{vi} = \varphi_i.\, P_{si} \\ P_{ve} = \varphi_e.\, P_{se} \end{cases} \xrightarrow[\varphi_e = 81.6\ \%]{\varphi_i = 50\ \%} \begin{cases} P_{vi} = 8.76 \text{ mm Hg} \\ P_{ve} = 6.02 \text{ mm Hg} \end{cases}$$

$(P_{vi} - P_{ve}) = 8.76 - 6.02 = 2.74$ mm Hg
$\sum(e_i/\pi_i) = (e_1/\pi_1) + (e_2/\pi_2) + (e_3/\pi_3) + (e_4/\pi_4) + (e_5/\pi_5)$
Where :
$P_{v1} = P_{ve} + (e_1/\pi_1).\ 0.081$ $Pv_1 = 6.109$ mm Hg
$P_{v2} = P_{ve} + (e_1/\pi_1 + e_2/\pi_2).\ 0.081$ $Pv_2 = 6.514$ mm Hg
$P_{v3} = P_{ve} + (e_1/\pi_1 + e_2/\pi_2 + e_3/\pi_3).\ 0.081$ $Pv_3 = 7.382$ mm Hg
$P_{v4} = P_{ve} + (e_1/\pi_1 + e_2/\pi_2 + e_3/\pi_3 + e_4/\pi_4).\ 0.081$ $Pv_4 = 7.472$ mm Hg
$P_{v5} = P_{ve} + (e_1/\pi_1 + e_2/\pi_2 + e_3/\pi_3 + e_4/\pi_4 + e_5/\pi_5).\ 0.081 Pv_5 = 8.339$ mm Hg
$P_{v6} = P_{ve} + (e_1/\pi_1 + e_2/\pi_2 + e_3/\pi_3 + e_4/\pi_4 + e_5/\pi_5 + e_6/\pi_6).\ 0.081 Pv_5 = 8.744$ mm Hg

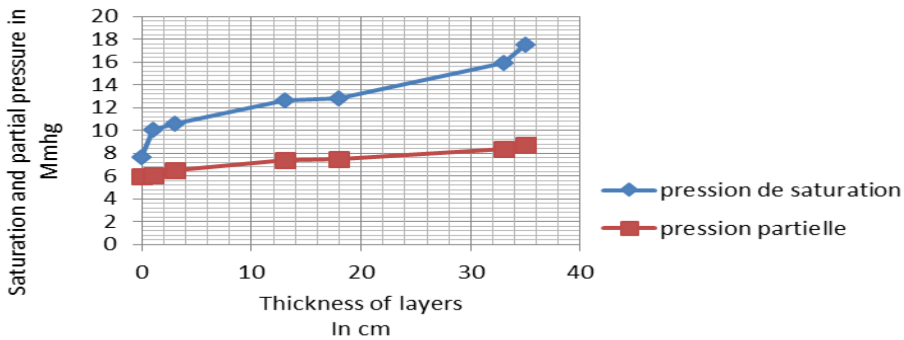


Figure 2: Diagram of GLASER (External wall 35 cm) T_i=20 °C

Note

It is noted that the curve of the saturation pressure is higher than that of partial pressure, which means the absence of condensation in the mass.

A. Outdoor wall of 35 cm

Of: $T_i = 22$ °C and $T_e = 6.64$ °C

1- Calculation of the temperature of the layers

$$R_{sn} = T_i - K.\ R_n.\ (T_i - T_e) \quad (9)$$

Or :

$$T_{sn} = T_e + K.\ R_n.\ (T_i - T_e) \quad (10)$$

With :

$R_n = (1/\alpha_e) + \sum(e_i / \lambda_i)$ et K = 0,787 Kcal / h.m².°C, α_e = 20 Kcal / h.m².°C, t_e = 6.64 °C

Where :

$T_{se} = T_e + (1/\alpha_e).K.(T_i - T_e) = 7.24$ °C

$T_{s1} = T_e + ((1/\alpha_e) + (e_1/\lambda_1)).K.(T_i - T_e) = 7.48$ °C

$T_{s2} = T_e + ((1/\alpha_e) + (e_1/\lambda_1) + (e_2/\lambda_2)).K.(T_i - T_e) = 12.01$ °C

$T_{s3} = T_e + ((1/\alpha_e) + (e_1/\lambda_1) + (e_2/\lambda_2) + (e_3/\lambda_3)).K.(T_i - T_e) = 12.98$ °C

$T_{s4} = T_e + ((1/\alpha_e) + (e_1/\lambda_1) + (e_2/\lambda_2) + (e_3/\lambda_3) + (e_4/\lambda_4)).K.(T_i - T_e) = 16$ °C

$T_{s5} = T_e + ((1/\alpha_e) + (e_1/\lambda_1) + (e_2/\lambda_2) + (e_3/\lambda_3) + (e_4/\lambda_4) + (e_5/\lambda_5)).K.(T_i - T_e) = 16.25$ °C

2. Determination of saturation pressures

T [°C]	6.64	7.24	7.48	12.01	12.98	16	16.25	20.27	22
P_s [mm Hg]	7.38	7.63	7.76	10.52	11.21	13.62	13.85	17.83	19.82

Table 17: Determination of saturation pressures for the external wall of 35 cm

3- Determination of partial pressures

Construction	Thickness [m]	π [g/ m.h.mmHg]	e /π [g/ h.mmHg]
Coating With plaster	0.01	0.009	1.11
Cement plaster	0.02	0.004	5
Hollow brick	0.10	0.0093	10.71
Air blade	0.05	0.045	1.11
Hollow brick	0.15	0.014	10.71
Enduit en ciment	0.02	0.004	5
$\sum(e_i/\pi_i)$	-	-	33.64

Table 18: Determination of permeances for the outer wall of 35 cm

$$\begin{cases} P_{vn} = P_{ve} + (e_n/\lambda_n).(P_{vi} - P_{ve})/\sum(ei/\pi i) \\ \varphi = P_v/Ps \Rightarrow P_v = \varphi .\ Ps \end{cases}$$

$$\begin{cases} P_{vi} = \varphi_i .\ P_{si} \\ P_{ve} = \varphi_e .\ P_{se} \end{cases} \xrightarrow[\varphi_e = 81.6\ \%]{\varphi_i = 50\ \%} \begin{cases} P_{vi} = 8.76 \text{ mm Hg} \\ P_{ve} = 6.02 \text{ mm Hg} \end{cases}$$

$(P_{vi} - P_{ve}) = 8.76 - 6.02 = 2.74$ mmHg.
$\sum(e_i/\pi_i) = (e_1 / \pi_1) +(e_2 / \pi_2) +(e_3 / \pi_3) +(e_4 / \pi_4) +(e_5 / \pi_5)$
$(Pv_i - Pv_e)/\sum(ei/\pi i) = 0.081$.
Where :
$P_{v1} = P_{ve} + (e_1 / \pi_1).\ 0.081 \quad P_{v1} = 6.109$ mmHg
$P_{v2} = P_{ve} + (e_1 / \pi_1 +e_2 / \pi_2).\ 0.081\ P_{v2} = 6.514$ mmHg
$P_{v3} = P_{ve} + (e_1 / \pi_1 +e_2 / \pi_2 +e_3 / \pi_3).\ 0.081\ P_{v3} = 7.382$ mmHg
$P_{v4} = P_{ve} + (e_1 / \pi_1 +e_2 / \pi_2 +e_3 / \pi_3 +e_4 / \pi_4).\ 0.081\ P_{v4} = 7.472$ mmHg
$P_{v5} = P_{ve} + (e_1 / \pi_1 +e_2 / \pi_2 +e_3 / \pi_3 +e_4 / \pi_4 +e_5 / \pi_5).\ 0.081 P_{v5} = 8.339$ mmHg
$P_{v6} =P_{ve} + (e_1 / \pi_1 +e_2 / \pi_2 +e_3 / \pi_3 +e_4 / \pi_4 +e_5 / \pi_5+ e_6 / \pi_6).\ 0.081 P_{v5} = 8.744$ mmHg

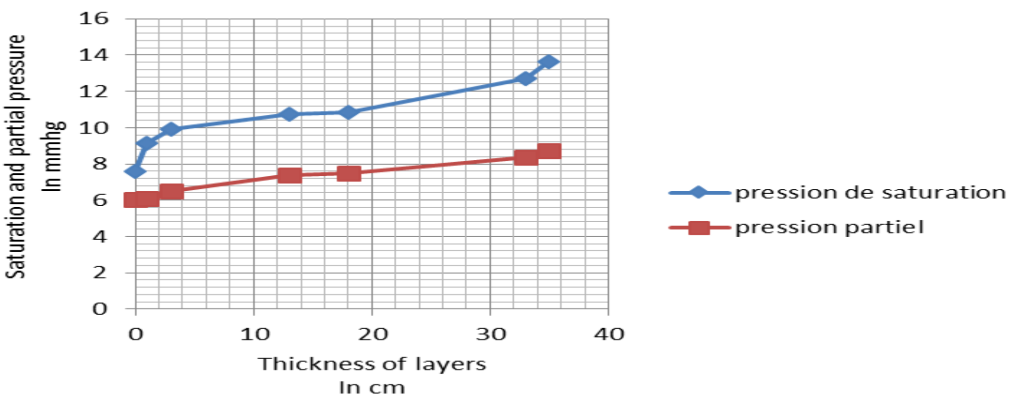


Figure 3: GLASER Diagram (Exterior wall 35 cm) Ti=22 °C

Note
It is noted that the curve of the saturation pressure is higher than that of partial pressure, which means the absence of condensation in the mass.

VII. CANADIAN WELL DIMENSIONS

The sizing of a Canadian well is somewhat difficult due to the number of parameters to be optimized: soil quality, length, diameter and number of tubes, depth of burial, distance between tubes, ventilation rate[7-8].

VII.1. The installation of a Canadian well

VII.1.1. Soil quality

1- The pipes are installed in trenches at a depth of 1.5 to 2 m, if the house is built on rock, or if the water table is too shallow, it seems unlikely to do such work.
2- If the land used is planted with trees or shrubs, they will have to be pulled out and dissolved, which is a big job [2].

VII.1.2. The quality of the land

Some types of terrain carry heat better than others. Clay-soaked earth has better "thermal conductivity" than sand, unless the sand is wet. The more the earth has the capacity to gorge itself with water and keep this water, the better it will carry heat, and the better the Canadian well will function. The advantage is that the length of the pipe may be smaller, the disadvantage is that the lands with better thermal conductivity cool more quickly in winter and that the pipes have to be buried at a greater depth [9] .
In the diagram below, the minimum conductivity to be expected is dark. According to the exact elements of the soil, the exact number of conductivity is the zone in clear.
It is noted that the most conductive soil is the wet soil, especially if it is quite clayey, followed by wet sand, then clay, and peat. Dry soils are the least conductive: their temperature varies more according to atmospheric

conditions [2-13].

VII.1.3. Geothermal exchange

The earth at a depth of two meters has a practically constant temperature throughout the year, it varies between 10 and 23 ° C according to the seasons whereas the outside air can vary from -1 ° C to + 37 ° C in Médéa Algeria. A Canadian well will exploit this constant temperature: air, instead of being brought directly from outside, will circulate in a buried collector in contact with the ground to exchange its calories. The objective is that the air at the outlet of the collector is at the temperature of the ground [2-14].

VII.2. Technical and mechanical characteristics

VII.2.1. The pipe

The air flow rate is linked to the need for renewal of fresh air in the dwelling.

A. The air circulation in the housing

First of all, it is important to determine the air exchange rates of the dwelling, and establish a ventilation plan. Once the air flows heated, it must circulate in the housing and be evacuated. To avoid the premature use of mechanical controlled ventilation (CVV) to pump air from the well, there are now CMVs available for coupling with the Canadian well.

If only one room is air-conditioned, a single-flow VMC is sufficient. In this system, fresh air is extracted from the Canadian well by the CMV and heated and then enters the room before being evacuated by an extraction unit with a fan

If the housing is composed of several rooms and several floors, it will be necessary to plan the passage of the air. This is especially true for a new construction. As the other air intakes of the housing will be closed to avoid cold air inlets, a double flow VMC will be more interesting. Its heat exchanger will allow the use of heat from the air extracted from the dwelling to heat the air coming from the Canadian well. The air temperature can thus be reduced by 50 to 80%.

The ventilator sends this heated air into the main rooms (living room, bedrooms) by blowouts. The air will then circulate in the service rooms (kitchen laundry room bathroom) or it will charge moist air before being discharged by extraction vents (more noisy than the insufflations vents) [14].

The air circulation can be done through false ceilings in the basement or attic not installed. The pipes will be insulated in order not to cool in the attic or the basement. In the case of an old building, another solution is possible: the VMR (distributed mechanical ventilation). It is made up of individual aerators placed in the different rooms.

Advantages: There are no ducts or ducts to maintain, everything is easily accessible. There are different aerator powers depending on the volume of the room. They may be mutinous and programmable. There are low-energy silent aerator models for extracting stale air, there are different types of helical extractors for direct discharge windows or walls, and centrifugal extractors for long ducts.

B. The air flow rate in the pipes

The lower the air velocity, the more time it has to warm up. The larger the area of the tube, the better the heat exchange and the more warm the air will be.

All the studies show that the air must not circulate too much (it would not have time to reach the right temperature), nor too slowly (the stagnant air can be charged in miasma).

It was calculated that the air had to remain at least 15 seconds in the pipe to reach the desired temperature.

It is therefore generally considered that 2 m / s is a good speed if the pipe is at least 30 m.

C. The diameter of the pipe

Twenty centimeters in diameter seem to be a good average. If the tube is narrower, more pump power is required to circulate it (and profitability is no longer sufficient), and if it is wider, air flows inside and The air does not have the same temperature at the outlet (the air circulating in the center circulates faster, it is therefore colder than the air which has circulated along the walls).

D. The material of the pipe

The hose must have the specified characteristics

- He must resist in time.
- It must resist corrosion, since it is always in contact with earth and water (avoid metal tubes).
- It must be rigid enough not to deform due to the weight of the earth that is above. One must also be able to pass on the ground above the tube with a lord gear without breaking it. It must also be flexible and deform with the ground if the latter slightly (in case of flood for example).
- It must not be porous or permeable, in order to avoid infiltration

- It must be good thermal conductor (avoid the concrete that is bad conductor).
- It must have a smooth and antistatic interior.

We will therefore avoid:

- The too porous concrete whose inner surface is not smooth enough is Poor thermal conductivity
- Steel and stainless steel are too difficult to work (risk of loss of Welding).
- It is extremely heavy to implement especially in long length.
- The protective conduits for electric cables. Although they are easy to install and long, they are unsuitable because they can be crushed by the weight of the earth and their inner layer is PVC which releases toxic compounds

The tubes generally used are:

- Either the polypropylene tubes with a coextruded inner layer which exhibits bactericidal and antifungal properties by means of agent ions
- Either unglazed vitrified sandstone tubes.

These tubes are quite expensive, but it must not be forgotten that the air that will circulate in it will then arrive in your house. They must not be polluted!

E. The installation depth of the pipes

As we have seen, the ideal depth is about 4 m deep. It is however enough to dig at this depth. if you are building, you can enjoy a trench connection (water, electricity ...). In most cases, the tubes are bundled at 1.5 m or 2 m. The pipes must be placed on a bed of sand or in a backfill to avoid "punching" the tube which could be damaged by contact with pebbles. If there are several pipes, they must be spaced at least 80 cm or 4 to 5 times the diameter of the duct. If they are located along the house, it is also necessary to stay about 1 m away from the house to avoid heat exchanges that would produce an effect to the desired one.

F. The length of the pipes

In general, a length of 40 to 50 m is sufficient for a good heat exchange. However, if the soil is sandy or the area is dry,
5 m of additional tubes are added to the calculations. The air circuit can be closed by capturing air in a cold room of the house, and forming a loop in the garden to return to the house. The advantages: hands of problems of humidity, even in rainy weather, it is necessary therefore to provide another circuit of air to ventilate the house.

VII.3. Distribution of underground pipelines

Place a single meandering tube or loop around the building or a network of parallel tubes installed between collectors to increase the flow of air circulating in the well (Tichelmann loop). Length between 30 and 50 m and buried between 1.5 and 3 m depth. Pipe spacing greater than 3 times their diameter (will ensure good heat exchange of each tube with the floor). Knowing that the air velocity within the well must be between 1 and 3 m / s. Limiting the number of elbows will minimize the pressure drop within the duct and facilitate its maintenance.

V.III. BALANCING THE DISTRIBUTION SLEEVE NETWORK

The balancing of the distribution network is the final stage of the aeraulic design and, more importantly, balancing is carried out by means of a device called the "diaphragm" which creates an additional pressure drop in The section a balanced, the test of the balancing of the network is carried out by the following condition at each branch point:

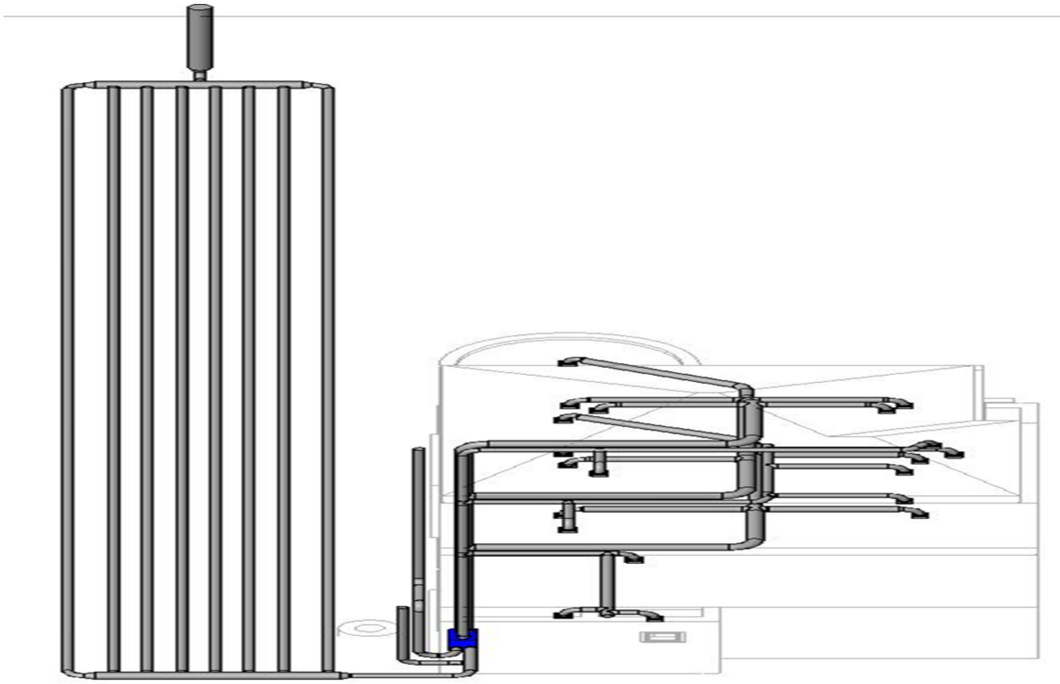


Figure 4: Canadian Well Scheme and Air Distribution System

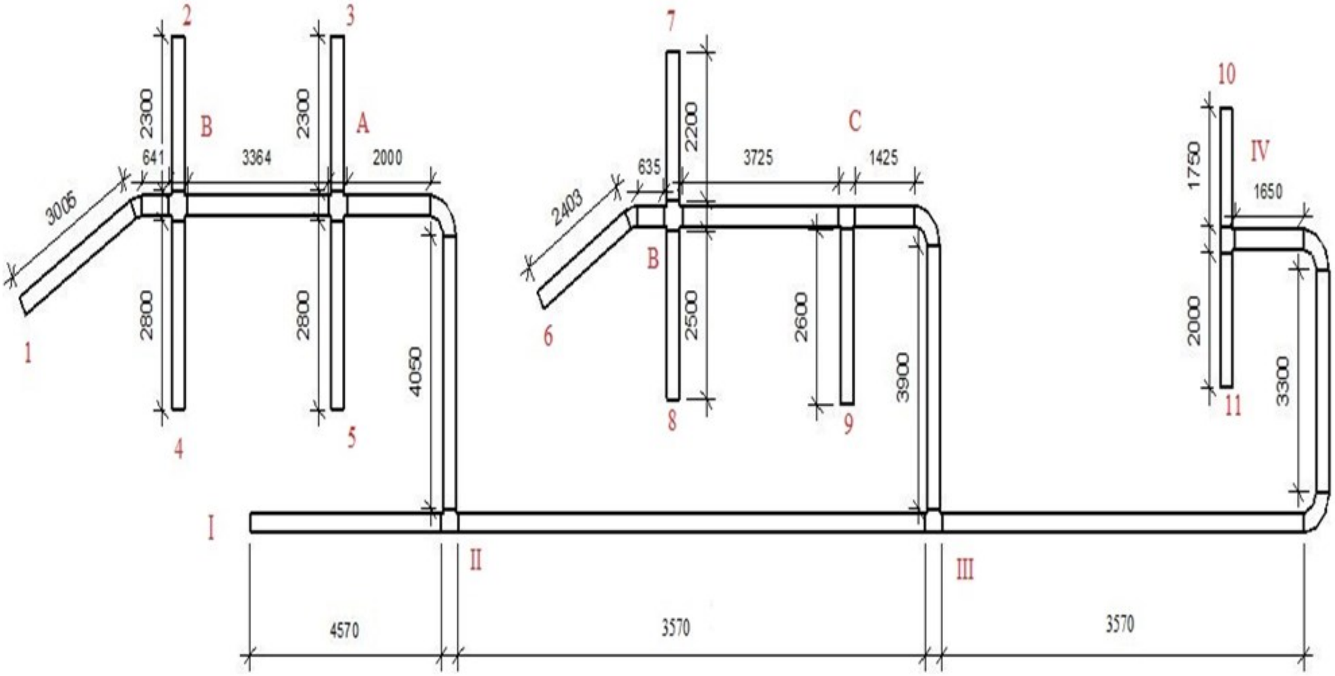


Figure 5: Villa distribution network

Tronçons	Vs [m^3/s]	W_{est} [m/s]	S_{est} [m²]	d [m]	S_{eff} [m²]	W_{eff} [m/s]	L [m]	Æ [m]	R [Pa/m]	ΔP_L [Pa]	$\sum\xi$	ΔP_S [Pa]	ΔP_T (bouche) [Pa]	ΔP_T [Pa]
I-II	0.8592	7	0.122	0.395	0.125	6.83	4.57	0.4	1.78	8.1346	0	0	0	8.13
II-A	0.40382	5	0.080	0.32	0.0779	5.18	6.5	0.315	0.9	5.85	1.7	2.73	0	8.58
A-3	0.03610	4	0.009	0.1	0.0122	2.94	2.3	0.125	1.05	2.41	2.2	1.14	10	13.55
A-5	0.1019	4	0.02548	0.18	0.0314	3.24	2.8	0.2	0.7	1.96	2.2	1.38	10	13.34
A-B	0.2657	5	0.053	0.26	0.049	5.41	3.4	0.250	1.36	4.65	0.20	0.348	0	4.98
B-2	0.075	4	0.0142	0.143	0.0120	2.83	2.3	0.16	0.7	1.61	2.2	1.05	10	12.66
B-4	0.1043	4	0.026	0.1822	0.0314	3.31	2.8	0.2	0.71	1.98	2.4	1.57	10	13.55
B-1	0.1043	4	0.026	0.1822	0.0314	3.31	3.6	0.2	0.71	2.56	1.4	0.912	10	13.47
II-III	0.4529	7	0.064	0.287	0.0779	5.81	3.57	0.315	1.4	4.998	0.2	0.4	0	5.73
III-C	0.2946	5	0.0589	0.273	0.049	6	6	0.25	1.78	10.68	2.2	4.75	0	15.43
C-9	0.12537	4	0.0313	0.1997	0.0314	3.990	2.6	0.2	1	2.6	2.2	2.11	10	14.71
C-D	0.1692	4	0.0423	0.232	0.0314	5.38	3.7	0.2	1.52	5.624	0.2	0.346	0	5.97
D-7	0.0452	4	0.0113	0.12	0.0122	3.68	2.2	0.125	1.63	3.586	2.2	1.78	10	15.36
D-8	0.062	4	0.0155	0.1405	0.02	3.08	2.5	0.16	0.85	2.125	2.4	1.368	10	13.5
D-6	0.062	4	0.0155	0.1405	0.02	3.08	3	0.16	0.85	2.55	1.4	0.792	10	13.34
III-IV	0.15823	5	0.0316	0.2	0.0314	5.03	8.5	0.2	1.57	13.34	2	3.03	0	16.37
IV-10	0.06115	4	0.0152	0.1395	0.02	4.03	1.7	0.16	0.85	1.44	2.3	1.27	10	12.71
IV-11	0.097	4	0.0242	0.175	0.0314	3.08	2	0.2	0.68	1.36	2.3	1.3	10	12.66

Tableau 15: Canadian Well Sizing and Air Distribution and Total load losses of each section of the network

VIII. CONCLUSION

Our study of the air conditioning of a room by a Canadian well has allowed us to deepen our knowledge of the use of renewable energies in the design of the various elements of an installation and to draw some conclusions.

Geothermal ventilation has many advantages but does not benefit from advertising as important as solar. All renewable energies have their specificities, advantages and disadvantages. The Canadian well has the disadvantage of not being very well suited for renovation.

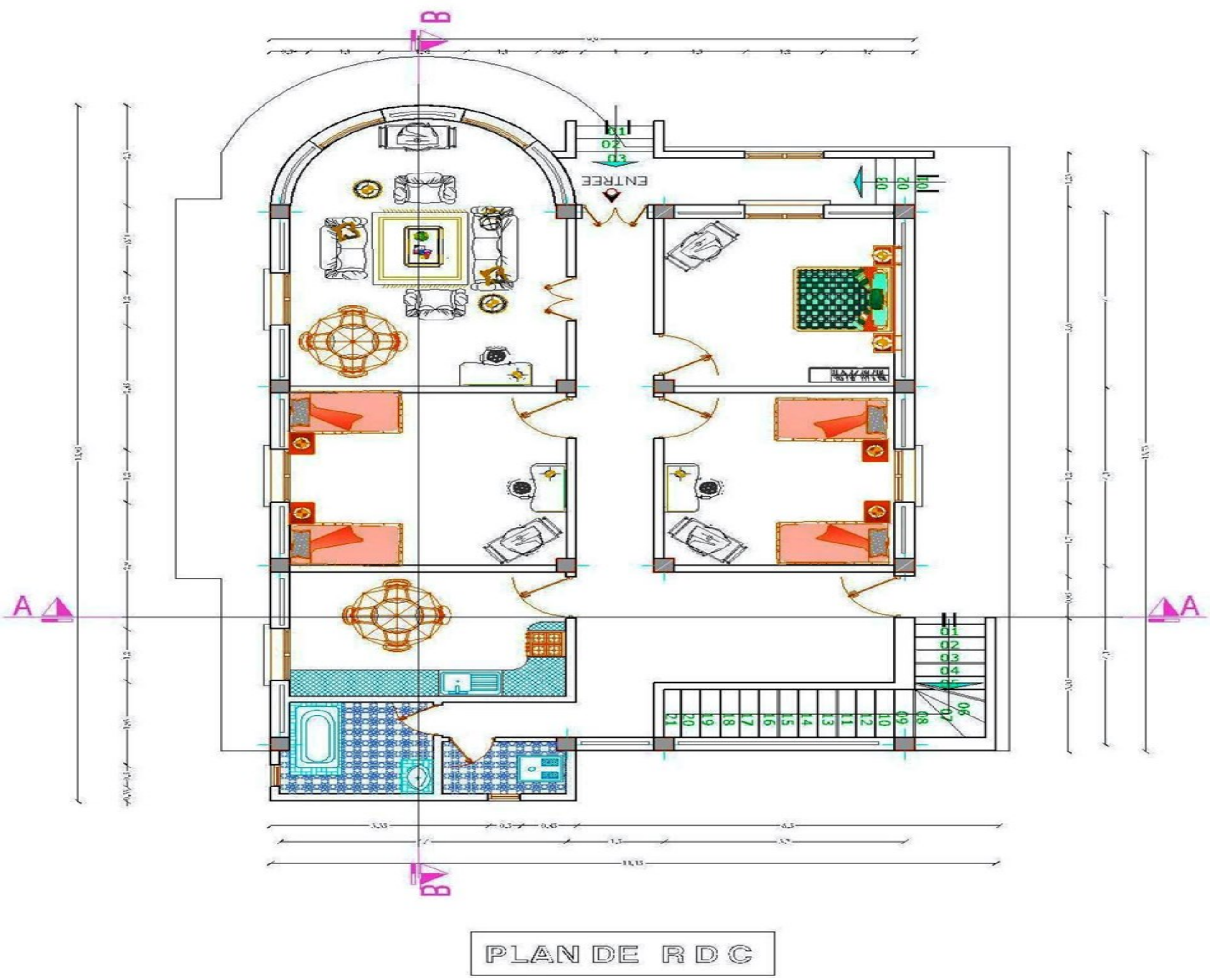
However, progress is steadily increasing in this area. The Canadian well uses clean, inexhaustible energy, since every day our planet is warmed by the rays of the sun, which it stores in the form of calories. This does not necessitate any delivery Nor energy storage, the cost of the installation is quickly amortized with respect to operating cost.

Geo-ventilation is also very flexible to use, it is independent of climatic aliases, unlike solar energy.

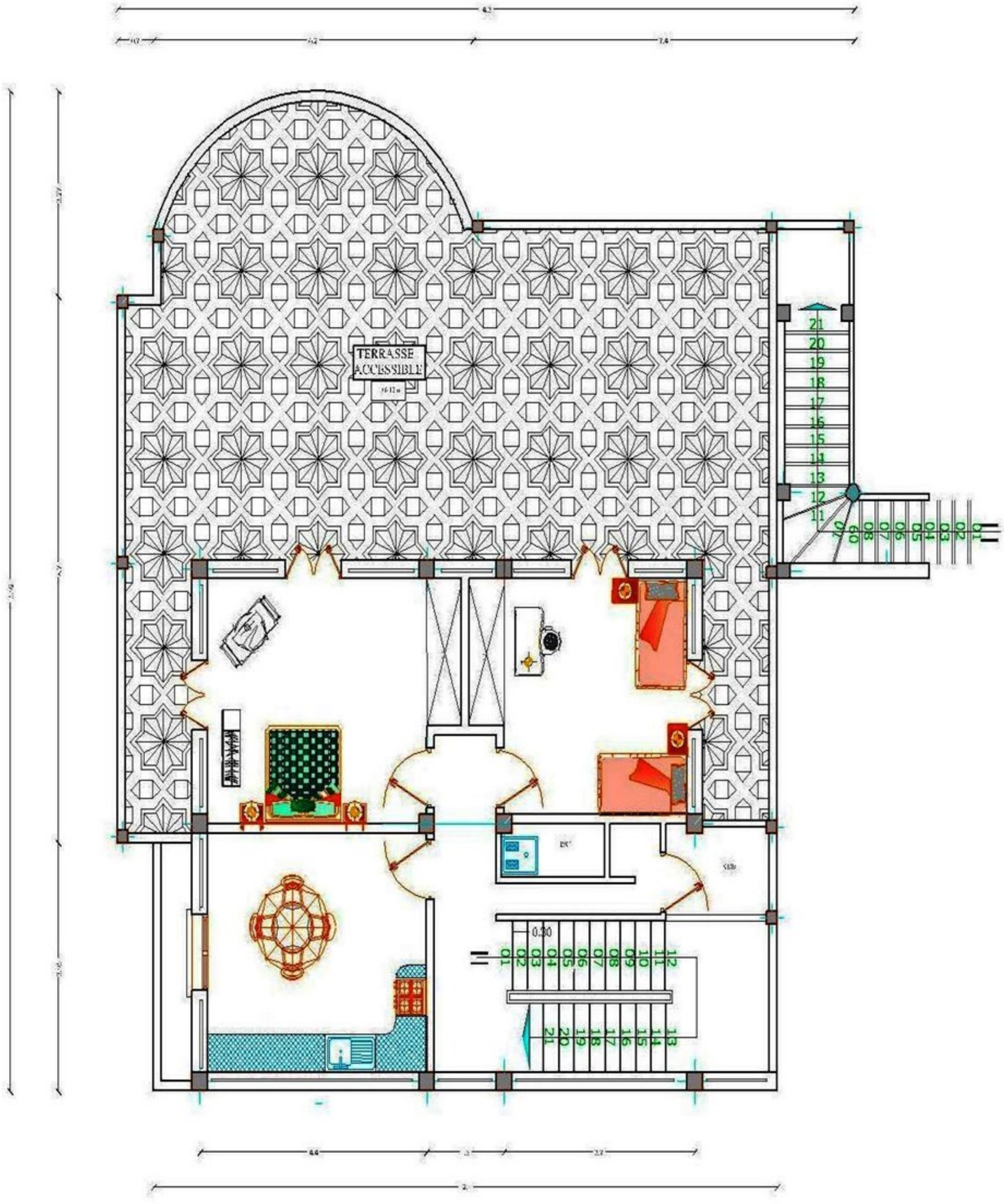
The Canadian well should benefit from a larger promotion because it is suitable for all situations in case of new construction. In addition, it does not generate greenhouse gases or pollution of any kind.

Finally, this project allowed us to introduce ourselves to computer tools, such as the Revit MEP, widely used in design offices.

X. APPENDICES

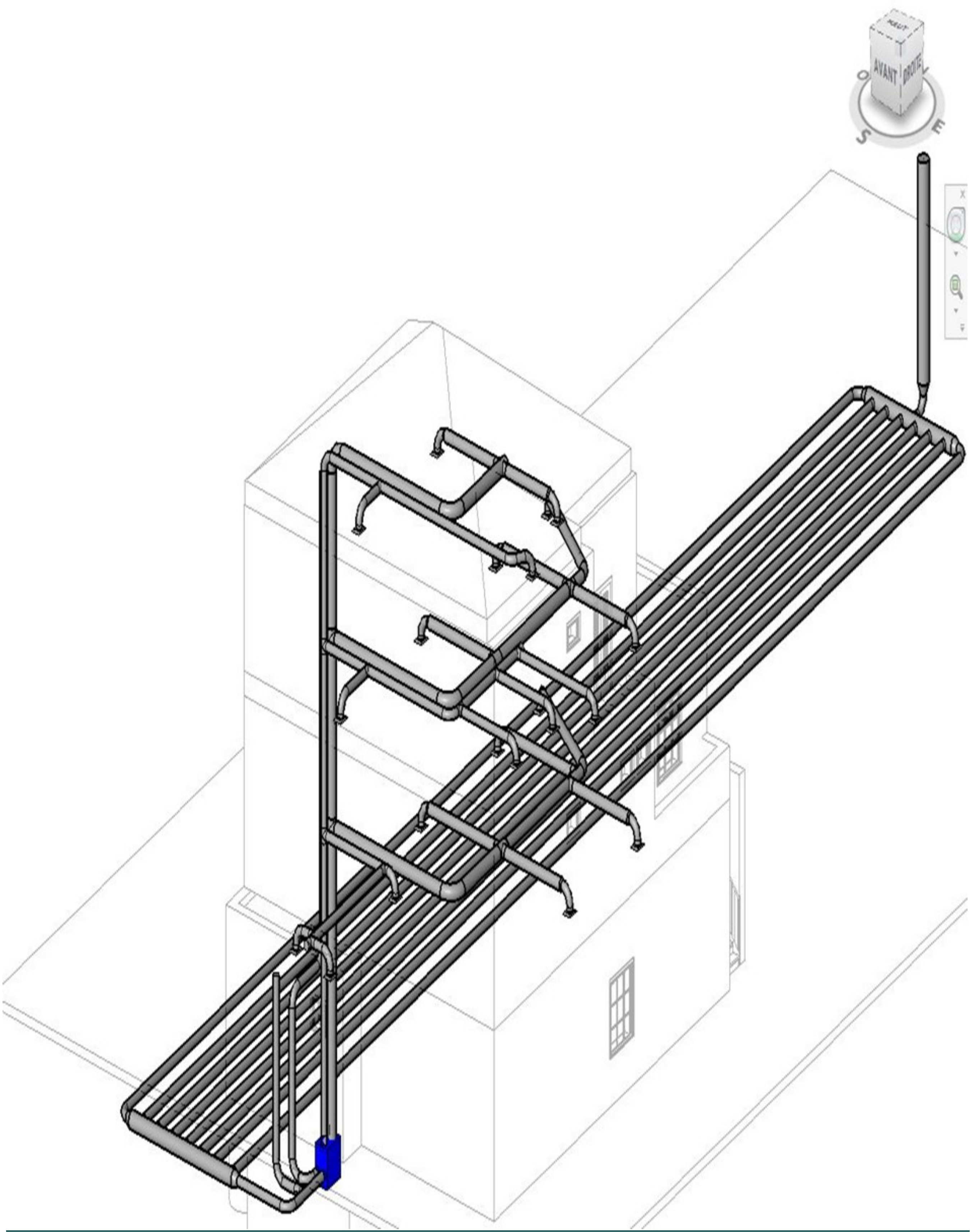


DRC Architecture Plan



PLAN DU 2eme ETAGE

FAÇADE PRINCIPALE



3D of the project Model (villa + Canadian well + aeraulic network) with Map

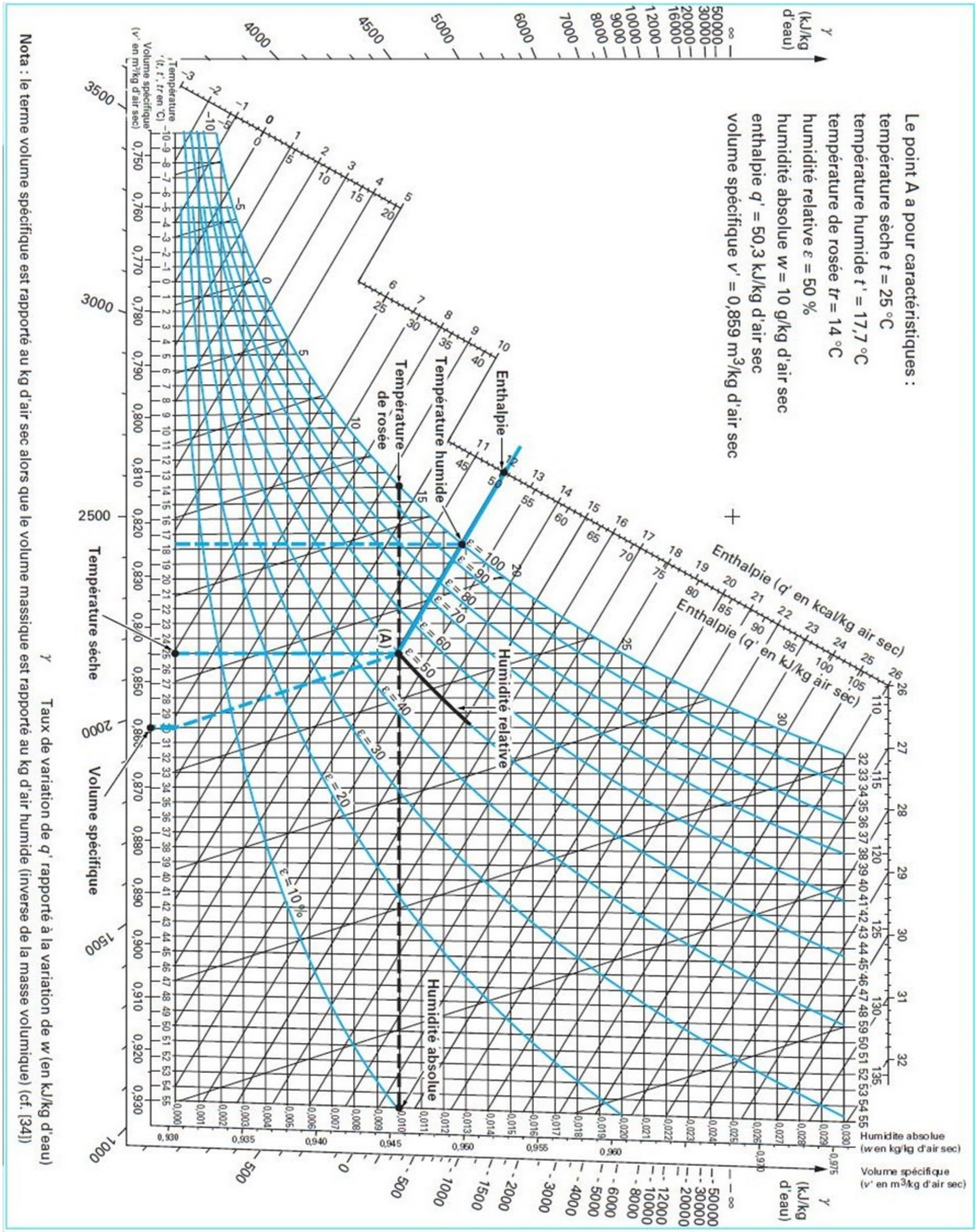
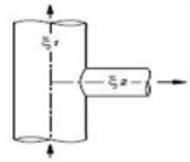


Diagram of air humid (H-X)

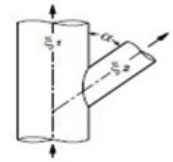
Conduites cylindriques – valeurs indicatives des coefficients ξ - dérivations et jonctions

Dérivation à 90°



$\xi_1 = 0{,}2$ $\xi_2 = 1{,}3$

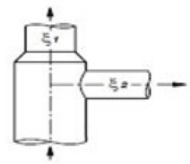
Dérivation à 30°, 45° et 60°



$\xi_1 = 0{,}2$

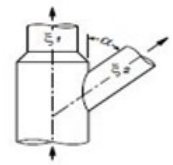
ξ2		
α = 30°	α = 45°	α = 60°
0,4	0,7	0,9

Dérivation à 90° avec réduction



$\xi_1 = 0{,}4$ $\xi_2 = 1{,}3$

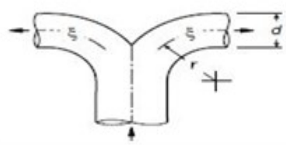
Dérivation 30°, 45° et 60° avec réduction



$\xi_1 = 0{,}4$

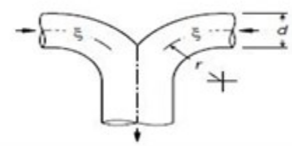
ξ2		
α = 30°	α = 45°	α = 60°
0,4	0,7	0,9

Dérivation à double coude



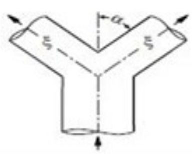
r/d	ξ
0,50	1,2
0,75	0,6
1,00	0,4
1,50	0,3
2,00	0,2

Jonction à double coude



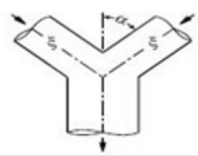
r/d	ξ
0,50	1,1
0,75	0,5
1,00	0,3
1,50	0,2
2,00	0,2

Dérivation en Y



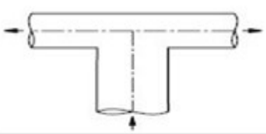
α	ξ
30°	0,3
45°	0,7
60°	1,0

Jonction en Y



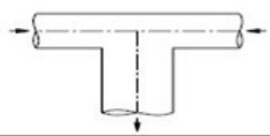
α	ξ
30°	0,3
45°	0,6
60°	0,9

Dérivation en T



$\xi_1 = 1{,}4$

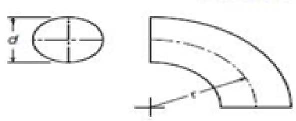
Jonction en T



$\xi_1 = 1{,}3$

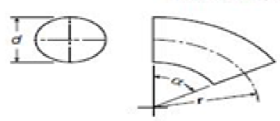
Conduites cylindriques – valeurs indicatives des coefficients ξ - coudes

Coude à 90°



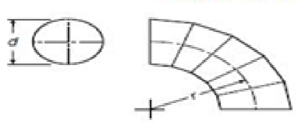
r/d	ξ
0,50	0,9
0,75	0,5
1,00	0,4
1,50	0,3
2,00	0,2

Coude à 30°, 45° et 60°



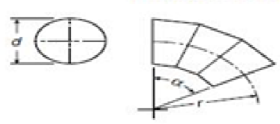
r/d	ξ		
	α = 30°	α = 45°	α = 60°
0,50	0,3	0,5	0,7
0,75	0,2	0,3	0,3
1,00	0,1	0,2	0,3
1,50	0,1	0,2	0,2
2,00	0,1	0,1	0,1

Coude 90° à secteurs



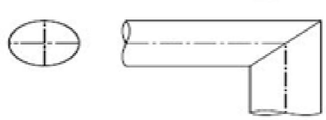
r/d	ξ
0,50	1,1
0,75	0,6
1,00	0,4
1,50	0,3
2,00	0,2

Coude 30°, 45° et 60° à secteurs



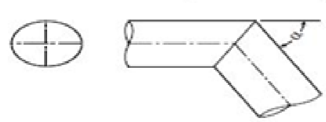
r/d	ξ		
	α = 30°	α = 45°	α = 60°
0,50	0,4	0,6	0,7
0,75	0,2	0,3	0,4
1,00	0,1	0,2	0,3
1,50	0,1	0,2	0,2
2,00	0,1	0,1	0,1

Coude 90° à angle vif



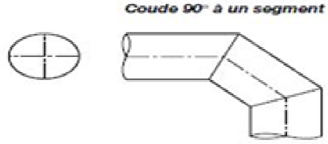
$\xi = 1{,}4$

Coude 30°, 45° et 60° à angle vif



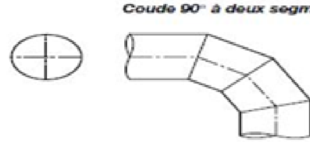
ξ		
α = 30°	α = 45°	α = 60°
0,4	0,7	1,0

Coude 90° à un segment



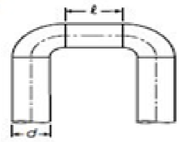
$\xi = 1{,}3$

Coude 90° à deux segments



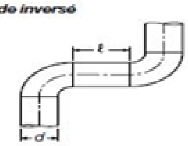
$\xi = 1{,}2$

Double coude



ℓ/d	ξ
< 1	4,0
1 ÷ 2	3,0
> 2	2,0

Double coude inversé



ℓ/d	ξ
< 1	3,5
1 ÷ 2	2,7
> 2	2,0

IX. REFERENCES

[1] B. HERZOG « Le puits canadien » édition EYROLLES, 2010.

[2] A. THIEBAUT « Le puits canadien et le puits provençal » édition S.A.E.P.

[3] F. LOYAU « Puits canadien et ventilation basse énergie » L'Inédite, 2009.

[4] S.T.M. de MEDEA, «Données climatiques : Ville de Médéa de 2006 à 2010»2011.

[5] J. FOURIER «Théorie analytique de la chaleur » édition J. GABAY, 1988.

[6] H. RIETSCHEL « Traité de chauffage et de climatisation tome 2» édition DUNOD 1974.

[7] D. AMITRANO « Eléments de dimensionnement d'un échangeur air/sol »,2006.

[8] J.HEINTZ « Les puits canadiens/provençaux » CETIAT 2008.

[9] RECKNAGEL, «Manuel pratique du génie climatique »3éme édition PYC
LIVRES, 1981.

[10] L. SCHRIVER-MAZZUOLI «La pollution de l'air intérieur » édition Dunod,
Paris, 2009.

[11] F. BLASINGER- FULDA « Initiation à la régulation » 2004.

[12] R. MEIERHANS, U STEINEMANN « Installations de ventilation énergétiquement performantes » Office fédéral des questions conjoncturelles
1994.

[13] T. SALOMON, R. MIKOLASEK, B. PEUPORTIER, S. THIERS, Y. JAUTARD ET A. TROMBE « Dimensionnement du puits climatique » Ademe 2003.

[14] P.DE HAUT « Chauffage, isolation et ventilation écologiques » édition EYROLLES 2007. Confidential