Analysis of smart micro-grid for energy resource management

Thesis submitted to obtain the PhD degree in Power Engineering
Awarded by SELINUS UNIVERSITY

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PLAN

❶ Mastering energy: context, challenges, approaches;

❷ Strategies for smart management of energy resources;

❸ Micro-grid modeling;

❹ Dimensioning of production and storage systems and network impact;

❺ Assessment and prospects

Plan

❶ **Mastering energy:**

- Context and energy and environmental issues;
- Mutation of the electricity power grid;
- Building : Micro-grid

Context

- Global warming;
- Exhaustion of fossil energy reserves;
- Increase in demand;
- Establishment of sustainable development.

Issues

National and international guidelines:

- Reduction of energy consumption;

- Reduction of greenhouse gas emissions;

- Encourage the use of renewable energies

Plan

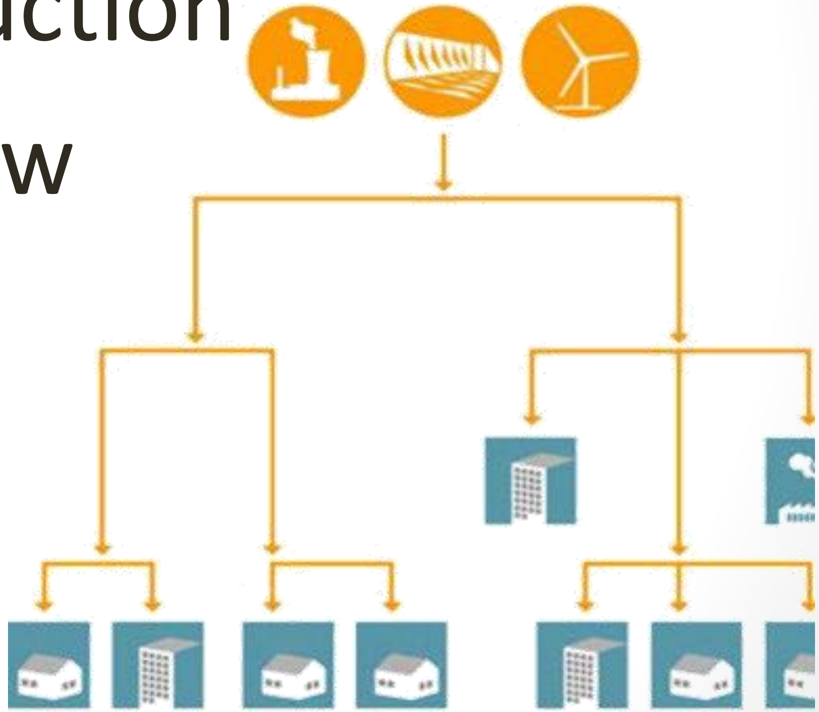
❶ Context of the mastering energy

- Context and energy and environmental issues
- Mutation of the power grid

- The building: a micro-grid

Mutation of the power grid

- **<u>Traditional power grid:</u>**
- Centralized production
- Unidirectional flow



Mutation of the Power grid

<u>Current and future power grid:</u>

- **Decentralized production**
- **Intermittence**
- **Bidirectional flow**

Mutation of the power grid

Problematic:

Impact on the operation of the power grid from the massive injection of decentralized generation

Goal :

Enable interaction between the various players in the network with great flexibility to ensure an efficient, sustainable, economical and secure electricity supply.

Solutions:

Develop intelligent systems capable of minimizing the impacts induced by the insertion of decentralized production

Search new network architectures

Plan

❶ Context of energy management

- Context and energy and environmental issues;
- Mutation of the power grid;
- The building: a micro-grid

The building: a micro-grid

- Building: multisource and multi-charge system
- Real time control and management system for energy flows

• Promote autonomy, so self-consumption

• Minimize the energy cost of managing / exploiting resources

Plan

➊ Context and stakes of the mastery of the energy;

➋ Strategies for intelligent management of energy resources;

- Evaluation criteria;
- Strategies for managing energy resources;

➌ Micro-network modeling;

➍ Dimensioning of production and storage systems and network impact;

➎ Assessment and prospects

Energy cost criteria

- Use of renewable energy :

$$J_{EnR} = \frac{\%_{EnR_c} \times \%_{ac}}{100}$$

- Self-consumption:

$$\%_{ac} = 100 \times \frac{EnR_c}{EnR_p}$$

- EnR coverage rate:

- $\%EnR_C = 100\ x\ \frac{EnR_C}{EnR_C + E_{SNEL}}$

J_{EnR}: *global criterion (%);*

$\%_{ac}$: *percentage of renewable energy consumed in relation to the total energy consumed (%);*

EnR_C: $percentage\ of\ renewable\ energy\ of\ renewable\ origin$ *(%);*

E_{SNEL}: $Energy\ withdrawn\ from\ the\ local\ electricity\ grid$ *(KWh)*

EnR_C: *Renewable energy consumed (KWh)*

EnR_P *: Renewable energy produced (KWh)*

Economic cost criterion

$$J_{Cost} = \sum_{t} E_{inj}(t).P_{En}(t) - E_{SNEL}.P_{En}(t)$$

J_{cost}: Economic cost criterion ($)

E_{inj}: Energy injected into the electricity grid (KWh)

E_{SNEL}: Energy withdrawn from the electricity grid (KWh)

$P_{En}: Price\ of\ electric\ energy(\$.KWh^{-1})$

Interaction with the power grid

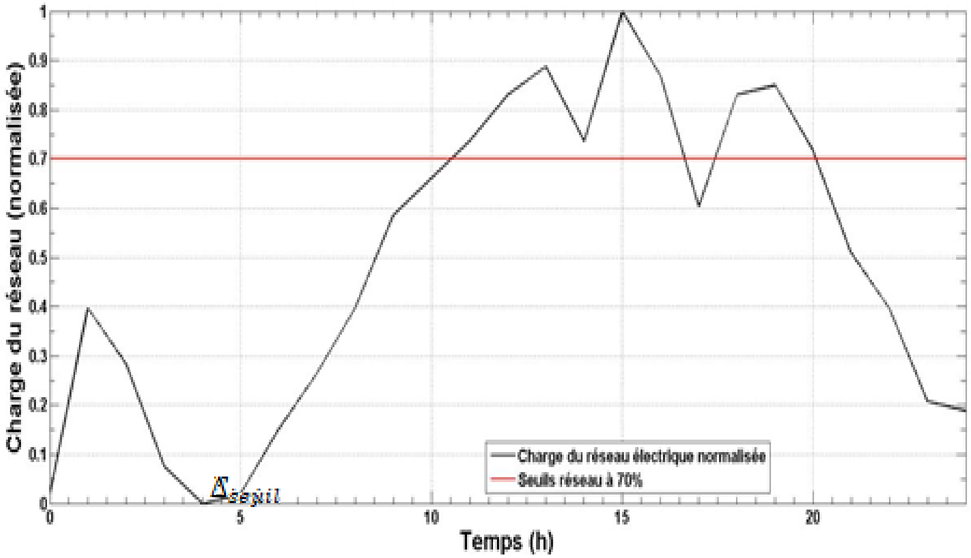
Time ranges of the different charging periods of the power grid

Season	Dry season	Rainy Season
Peak period	7h-13h 14h-16 18h-20	11h-17h
Intermediate period	0h-2h 6h-7h 13h – 14h	0h-2h 7h-10h 17h-23h
Off peak period	2h-6h 23h-24h	2h-7h 23h-24h

Grid Thresholds:

- **70 %**
- **30 %**

Power Grid impact



- Injection impact:

$$I_{inj} = \frac{1}{1000} x \sum_t E_{inj}(t) x \Delta E_{state}(t)$$

- Impact in withdraw:

$$I_{with} = \frac{1}{1000} x \sum_t E_{SNEL}(t) x \Delta E_{state}(t)$$

- Global impact :

$$I_o = I_{with} + I_{Inj}$$

E_{inj} Energy injected into the electricity grid [kWh]

E_{SNEL} Energy withdrawn from the electricity grid [kWh]

$\Delta_{State\ or\ seuil}$ Standardized gap between the threshold and the state of the power grid

Plan

➀ Context and stakes of the mastering the energy

➋ **Strategies for intelligent management of energy resources**

- Evaluation criteria

Strategies for managing energy resources: o Without storage

o With storage

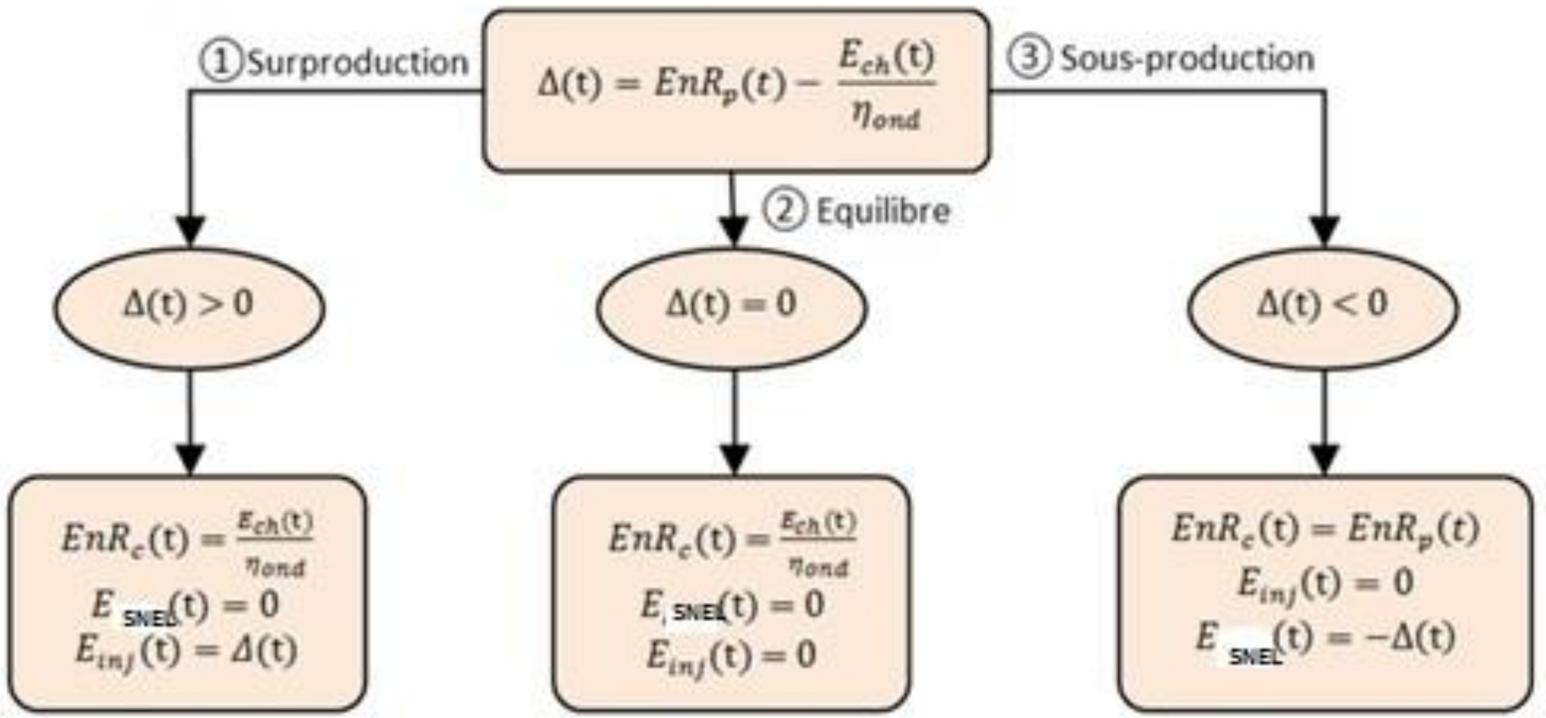
o Predictive

➂ Micro-network modeling

➃ Dimensioning of production and storage systems and network impact

➄ Assessment and prospects

Management strategy without storage



Plan

➊ Context and stakes of the mastering energy

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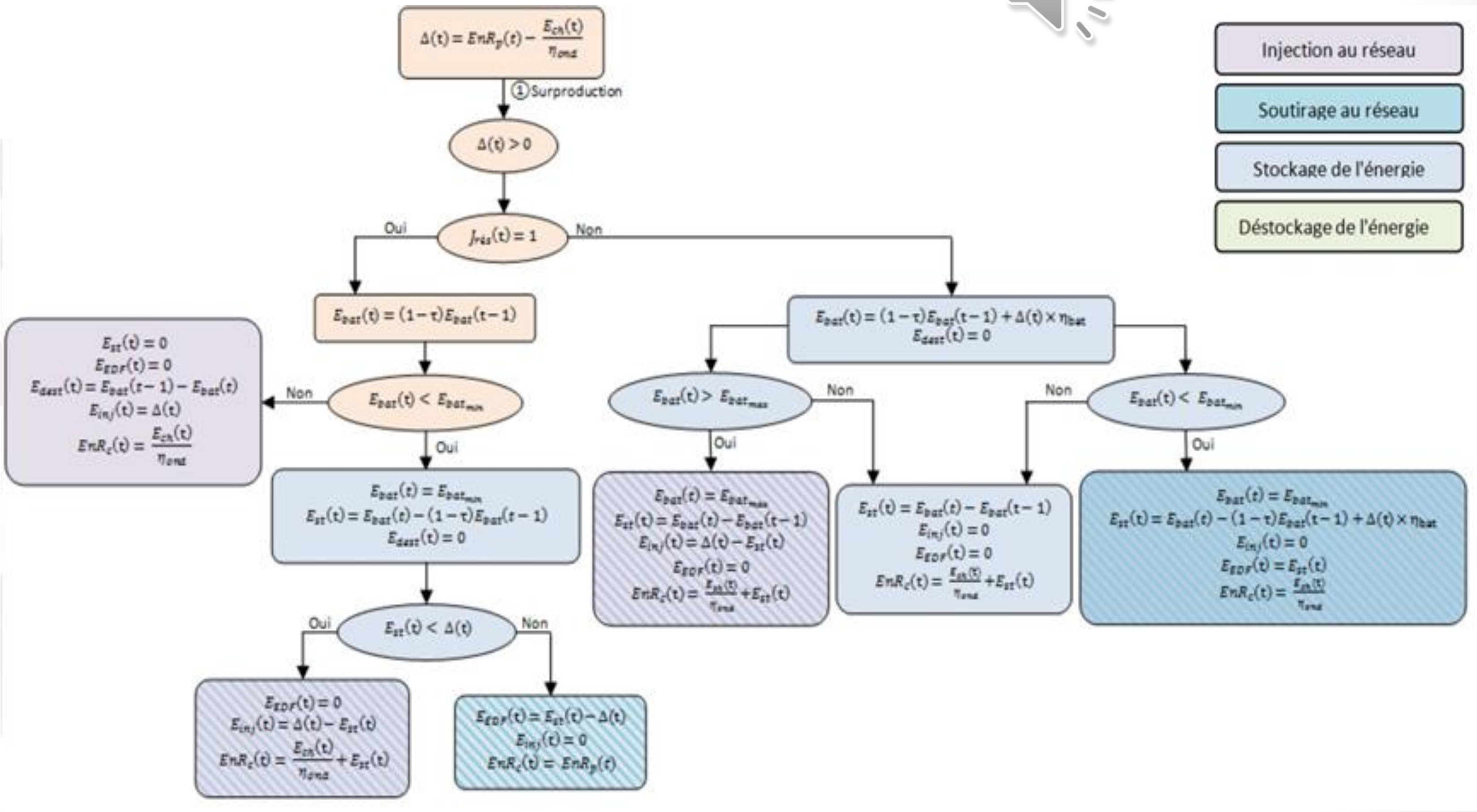
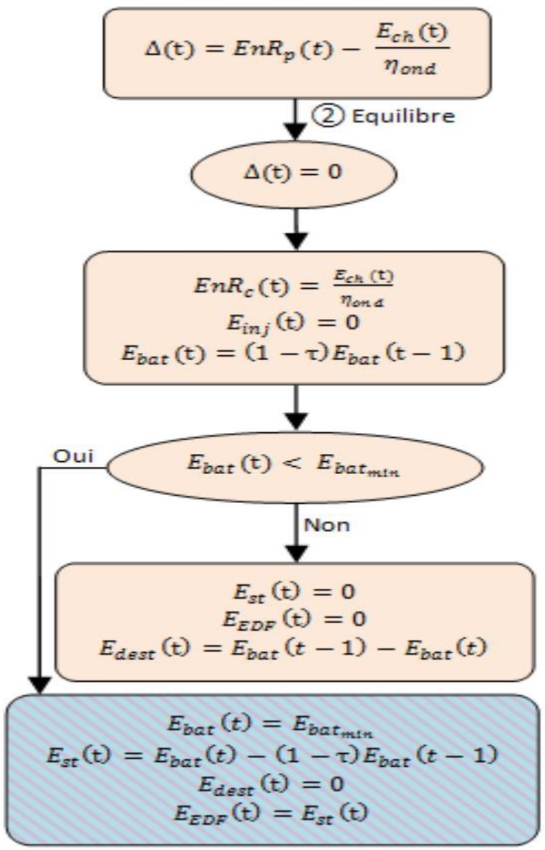
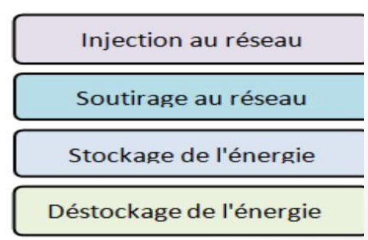
Management strategy with storage

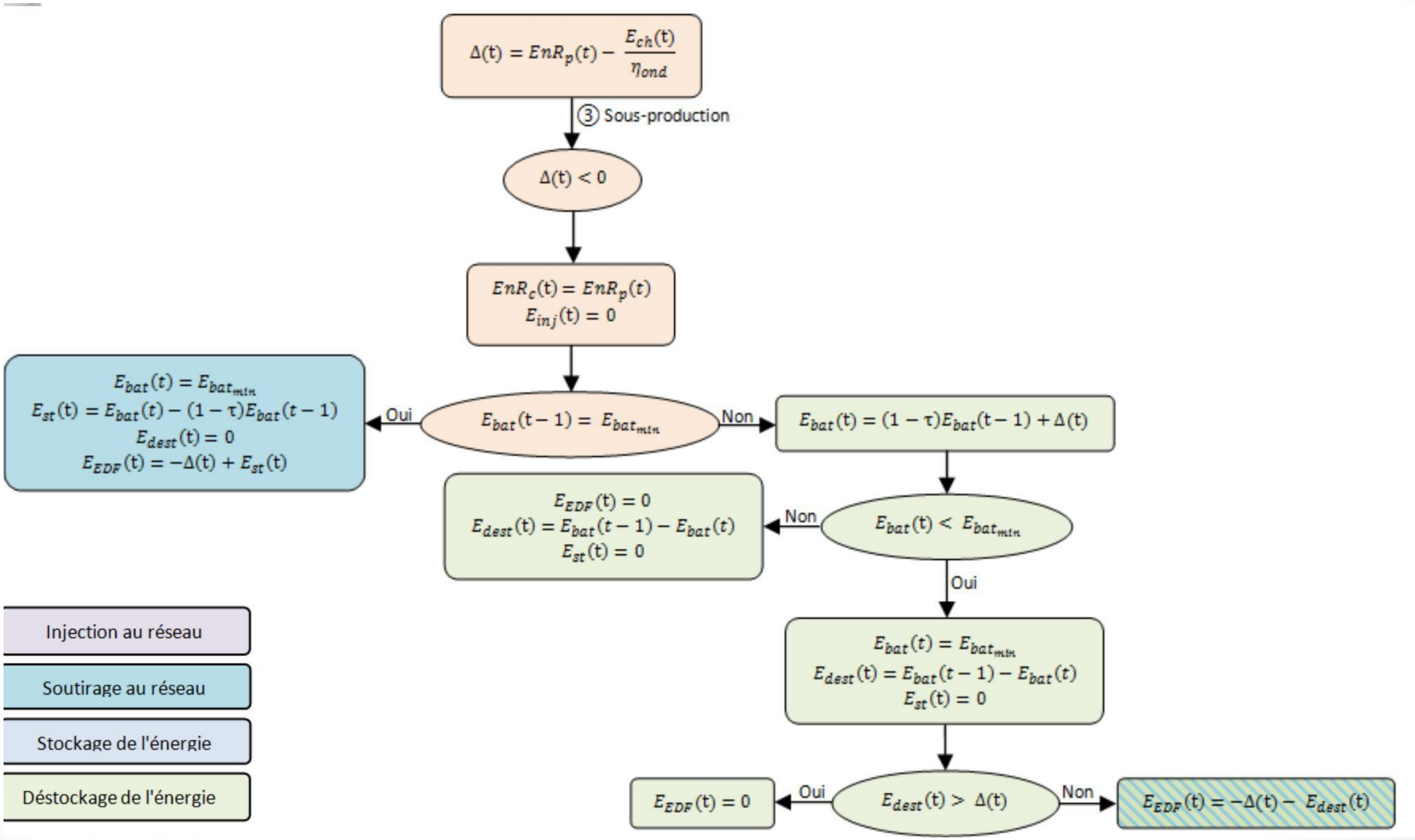


Management strategy with storage





Management strategy with storage



Plan

❶ Context and stakes of the mastery of the energy

❷ Strategies for intelligent management of energy resources

● Evaluation criteria

Strategies for managing energy resources:

o Without storage

o With storage

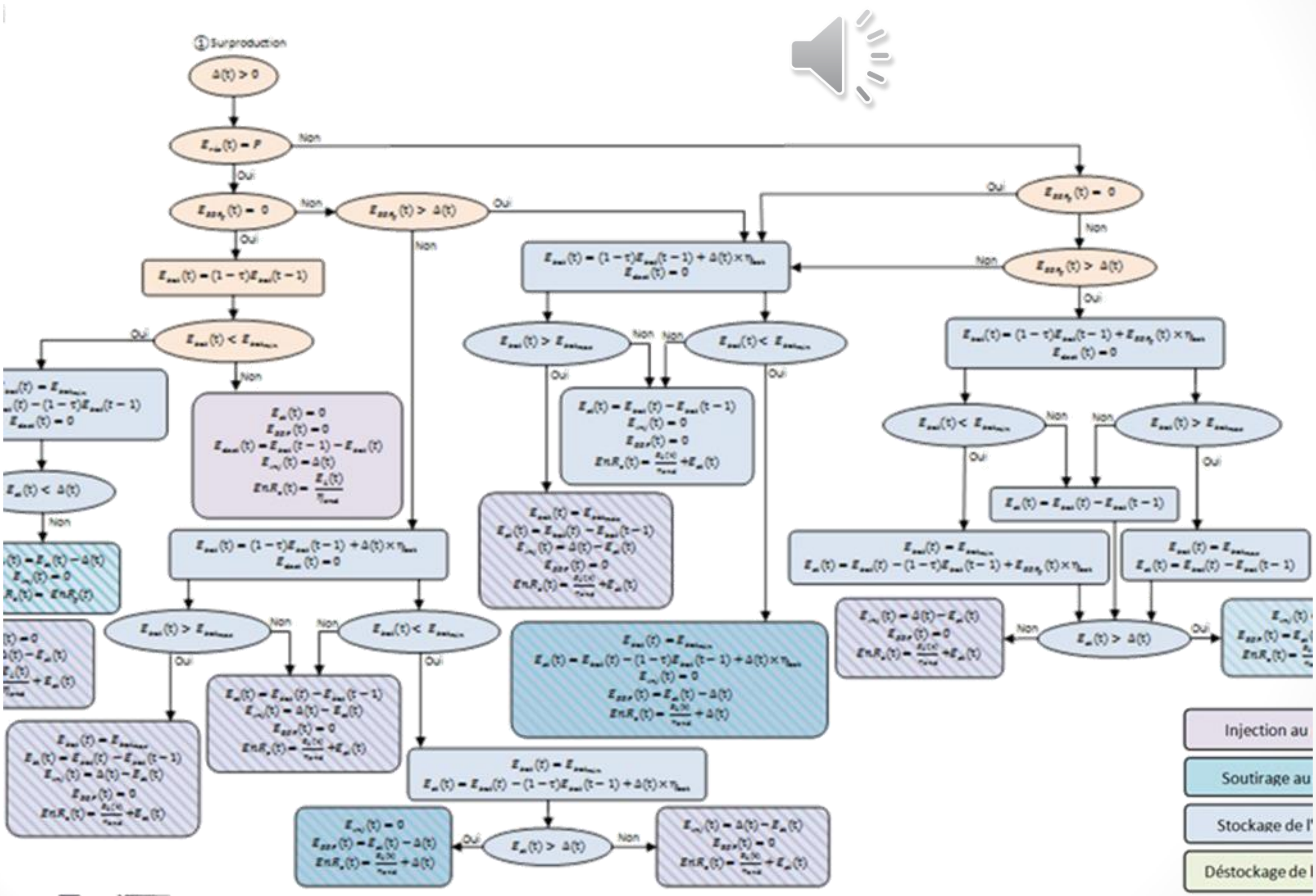
o Predictive

❸ Micro-network modeling

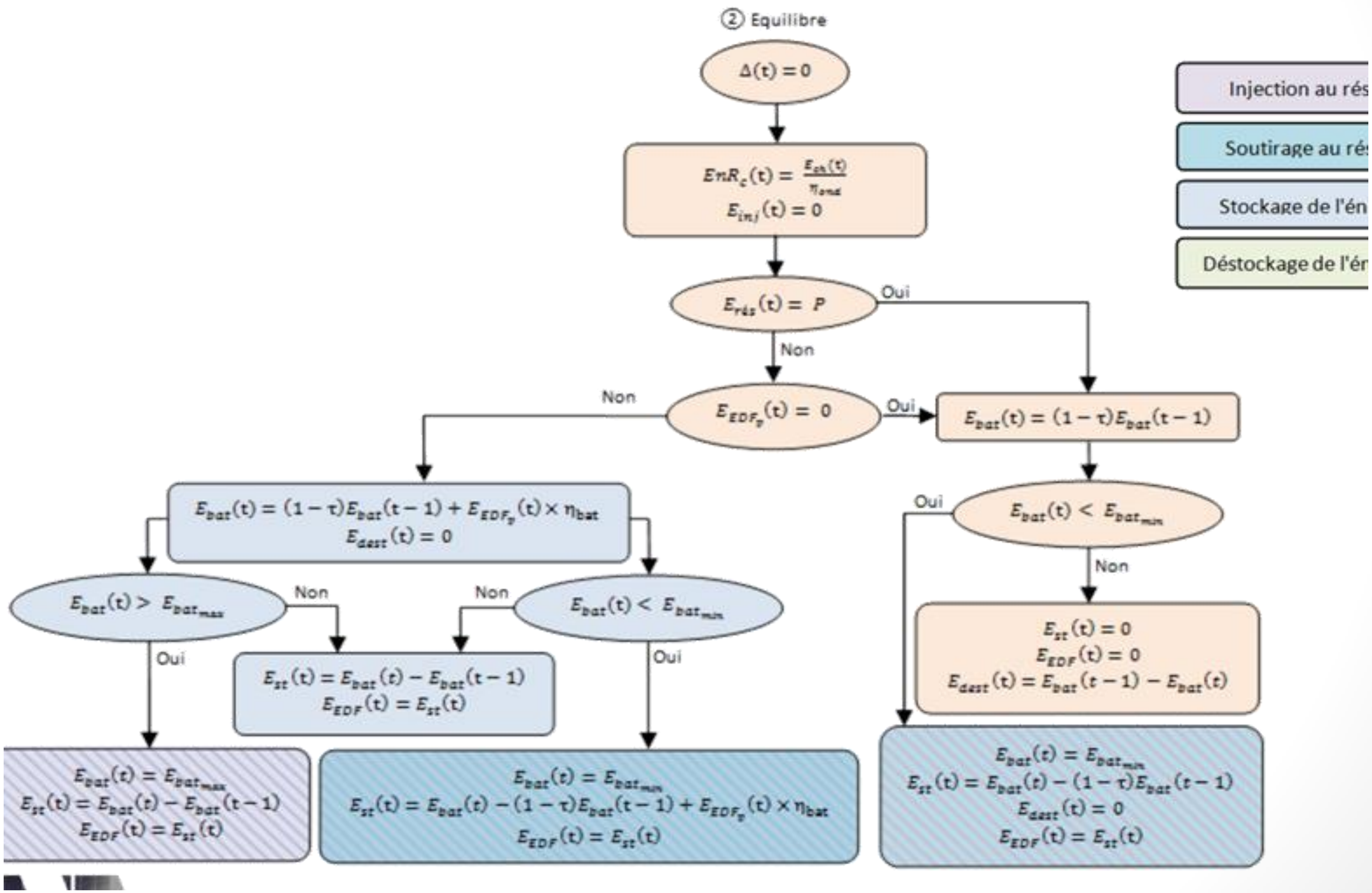
❹ Dimensioning of production and storage systems and network impact

❺ Assessment and prospects

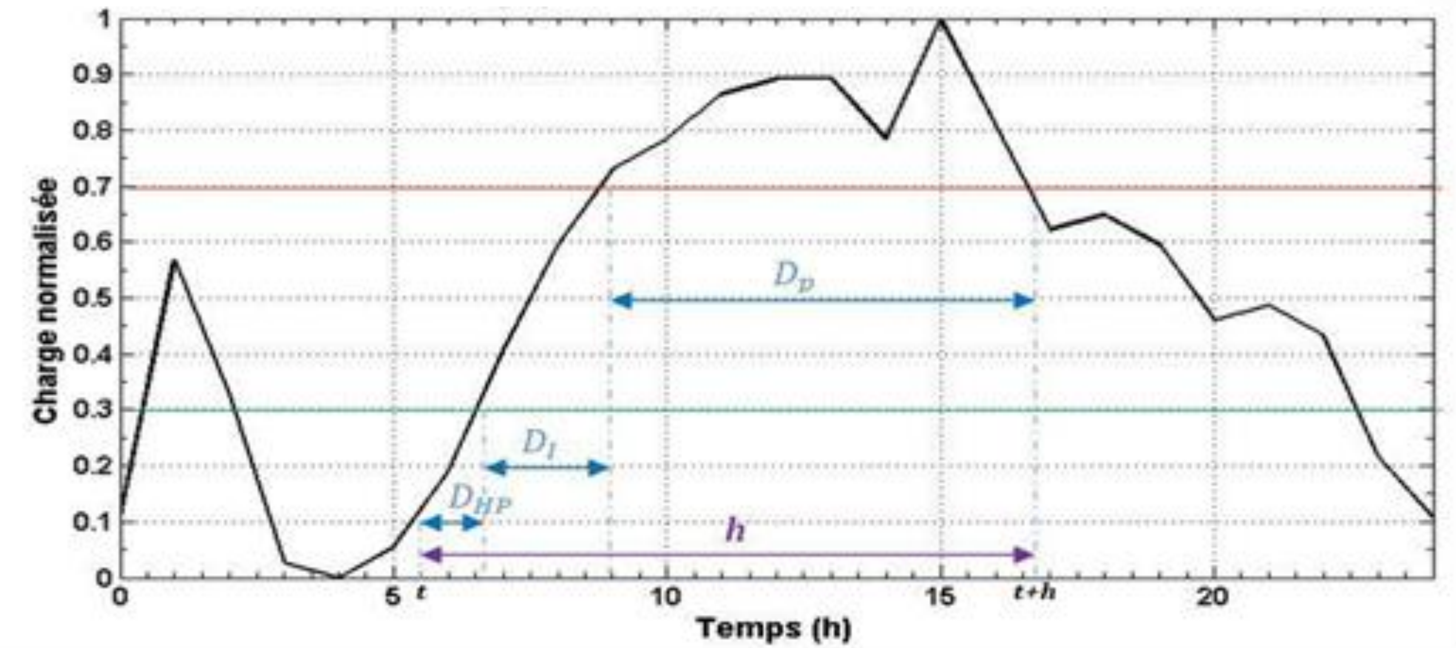
Predictive management strategy



Predictive management strategy



Horizon of prediction



1.Power grid off-peak period:

- Threshold
- 30%

$$h = D_{HP} + D_I + D_P$$

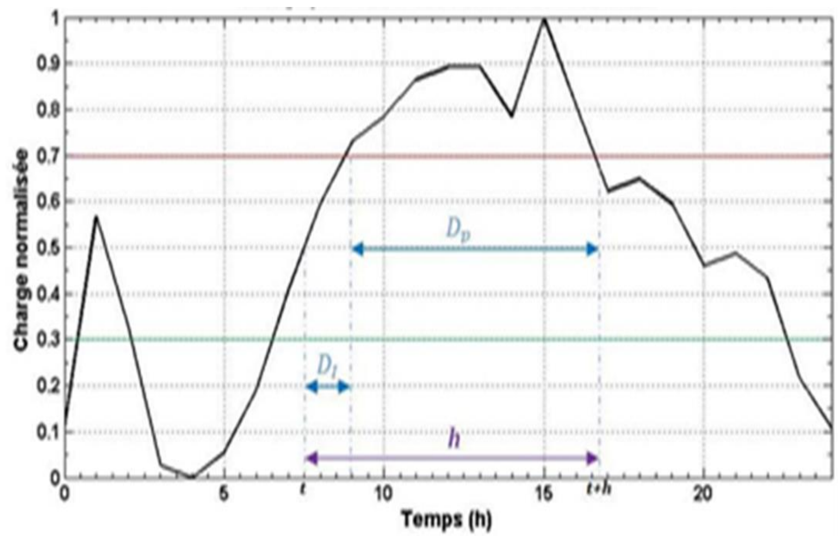
Horizon of prediction

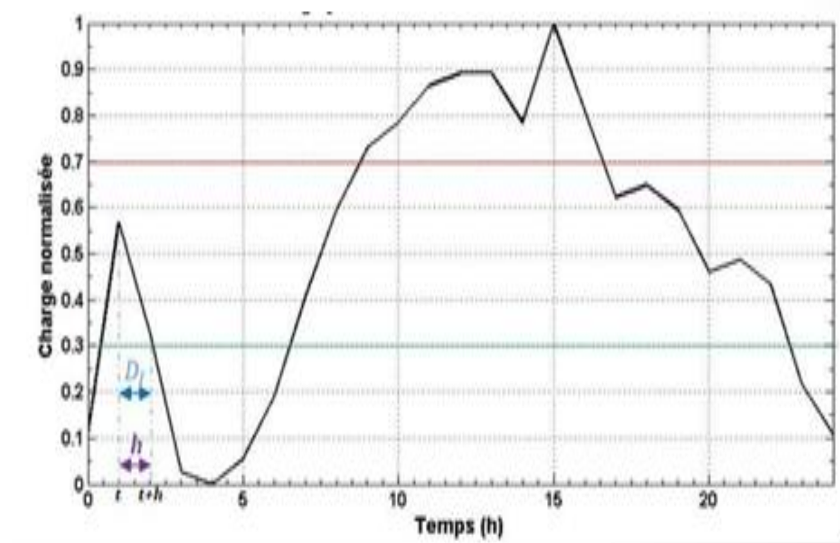
2. Power grid in interim period: Followed by a peak period , Threshold 70% $h = D_I + D_P$

Followed by a lean period:

$$h = D_I$$

- Threshold 30%





Prediction of data

- Load of the habitat:

$$ch_{hab}^{j+1}(t+i) = ch_{hab}^{j}(t+i) + 0.1x\left(T_{ext}^{j+1}(t) - T_{ext}^{j}(x)\right)$$

- Load of the power grid:

$$ch_{res}^{j+1}(t+1) = ch_{res}^{j}(t+i) + 0{,}001x\left(T_{ext}^{j+1} - T_{ext}^{j}(x)\right)$$

Prediction of data

- Photo Voltaic production:

$$EnR_{pv}(t+i) = EnR_{pv}{}^{j}(t+i) + 0{,}001x\left(I_r^{j+1} - I_r^{j}(t)\right) \quad (16)$$

Plan

- Context and stakes of the mastery of the energy;
- Strategies for intelligent management of energy resources;
- Modeling the micro-network Load modeling under TRNSYS;
- Modeling of decentralized production
- Modeling of the storage system;
- Dimensioning of production and storage systems and network impact;
- Review and Prospects.

Load modeling under TRNSYS

<u>* Thermal models of individual habitats:</u>

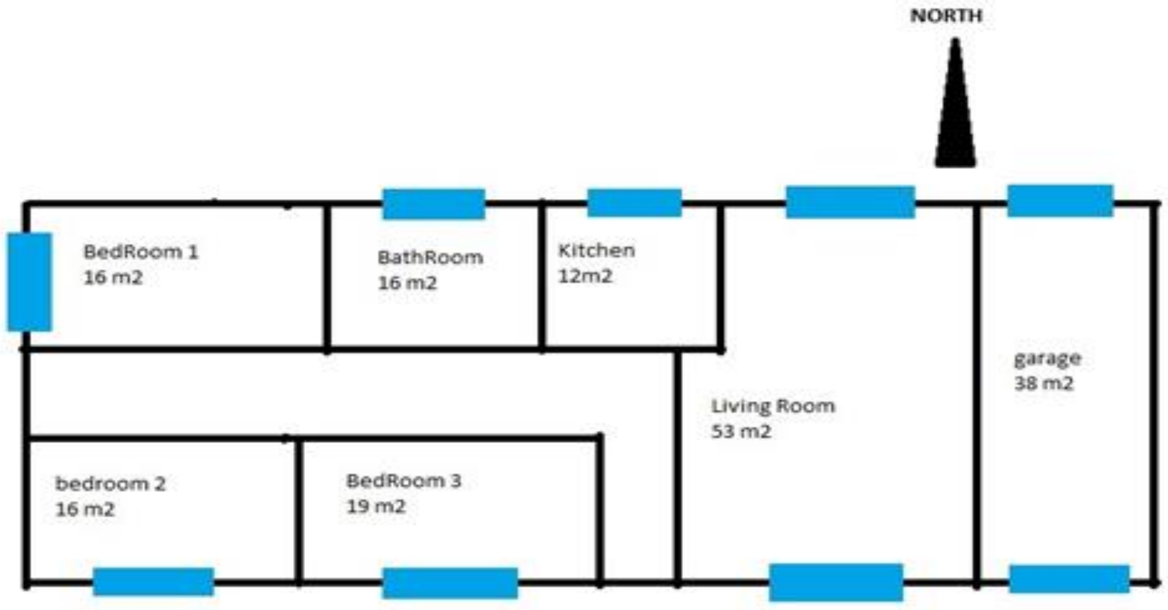
- Condominium apartments;
- Private house;
- Different levels of insulation: tropical ordinary house or RT 2005 (New style proposed in this thesis);

<u>* Modeling lifestyles of inhabitants:</u>

- Single person;
- Couple without children;
- Couple and four children.

Thermal models of individual habitats under TRNSYS

Case study: house of 150 m² according to the ordinary tropical sub-saharan house located in Lubumbashi in DR Congo, inhabited by four people (a couple and four children)



Thermal models of individual habitats under TRNSYS

Composition of the elements for an insulation level

Element	**Material**	**Thickness [M]**	**[W.m-2.K-1] [W.m-2.K-1]**
Exterior wall	Cooked brick Exterior plaster	0,013 0,02	0,602 0.45
Interior wall	Cooked brick Exterior plaster	0.013 0.02	0.845 -
Ground	Floor tile Mortar Heavy concrete	0,022 0,05 0,16	0.415 0,4
Ceiling	Wood ceiling	0,03	0,196
garage ceiling	Wood ceiling	0,03	0,196
Window	single glazing	0,00025	0,87

Modeling the lifestyle of the inhabitants

Occupancy scenarios and temperature setpoints Tc RT 2005
Scenario

	Week presence	Week-end presence
bedroom	0h-7h ; 21h-24h	0h-7h ; 21h-24h
kitchen	7h-8h30 ; 12h-13h30; 19h-20h30	7h-8h30 ; 12h-13h30 ; 19h-20h30
Living room	6h-7h30 ; 12h30-13h30; 19h30-21h30	9h-14h ; 19h-22h
Corridor	6h-8h30 ; 12h-14h; 18h-21h	9h-21h

Plan

➊ Context and stakes of the mastery of the energy

➋ Strategies for intelligent management of energy resources

➌ Micro-network modeling

- Modeling of load under TRNSYS Modeling of decentralized production
- Modeling of the storage system

➍ Dimensioning of production and storage systems and network impact

➎ Assessment and prospects

Modeling of decentralized production systems Mix-energy

- Solar panel
- Model 194 under TRNSYS

- Based on the calculus method presented by DeSoto1 and defined by different semi-empirical equations

- Determines the current and the

- power of the photovoltaic panel at a specific voltage

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- Load modeling under TRNSYS;
- Modeling of decentralized production Modeling of the storage system;

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Modeling of the storage system: Mix-energy battery

Description of the battery operation:

- Charge mode:

$$E_{bat}(t) = (1-\tau).E_{Bat}(t-1) + \left(EnR_p(t) - \frac{E_{ch}(t)}{\eta_{ond}}\right).\eta_{bat} \quad (38)$$

- Discharge mode:

$$E_{bat}(t) = (1-\tau).E_{bat}(t-1) + \left(EnR_p(t) - \frac{E_{ch}(t)}{\eta_{ond}}\right) \quad (39)$$

- Constraints:

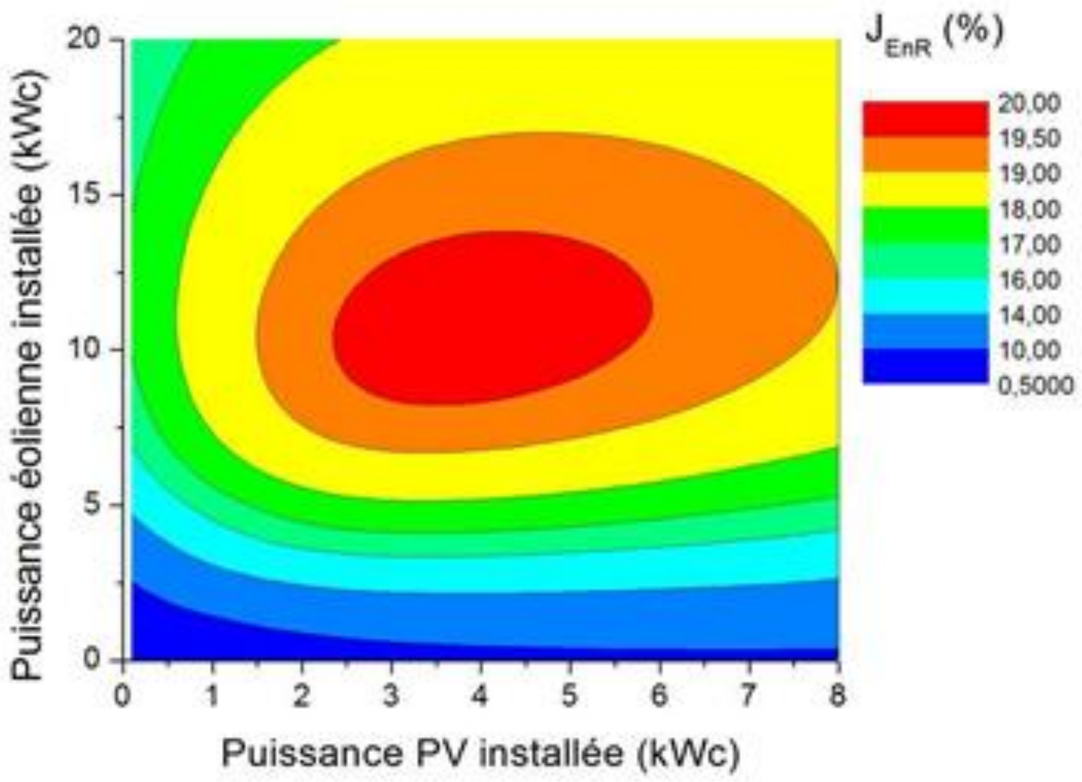
$$E_{bat_{min}} = (1-DOD)xE_{bat_{min}} \quad (41)$$

Plan

- Context and stakes of the mastery of the energy
- Strategies for intelligent management of energy resources
- Modeling of the micro-network
- **Dimensioning of production and storage systems and network impact:**
- **o Without storage**
- o With storage
- o Predictive
- Review and Prospects

Dimensioning of production systems without storage

RT2005 insulation, refined temperature control, with load control



Dimensioning of production systems

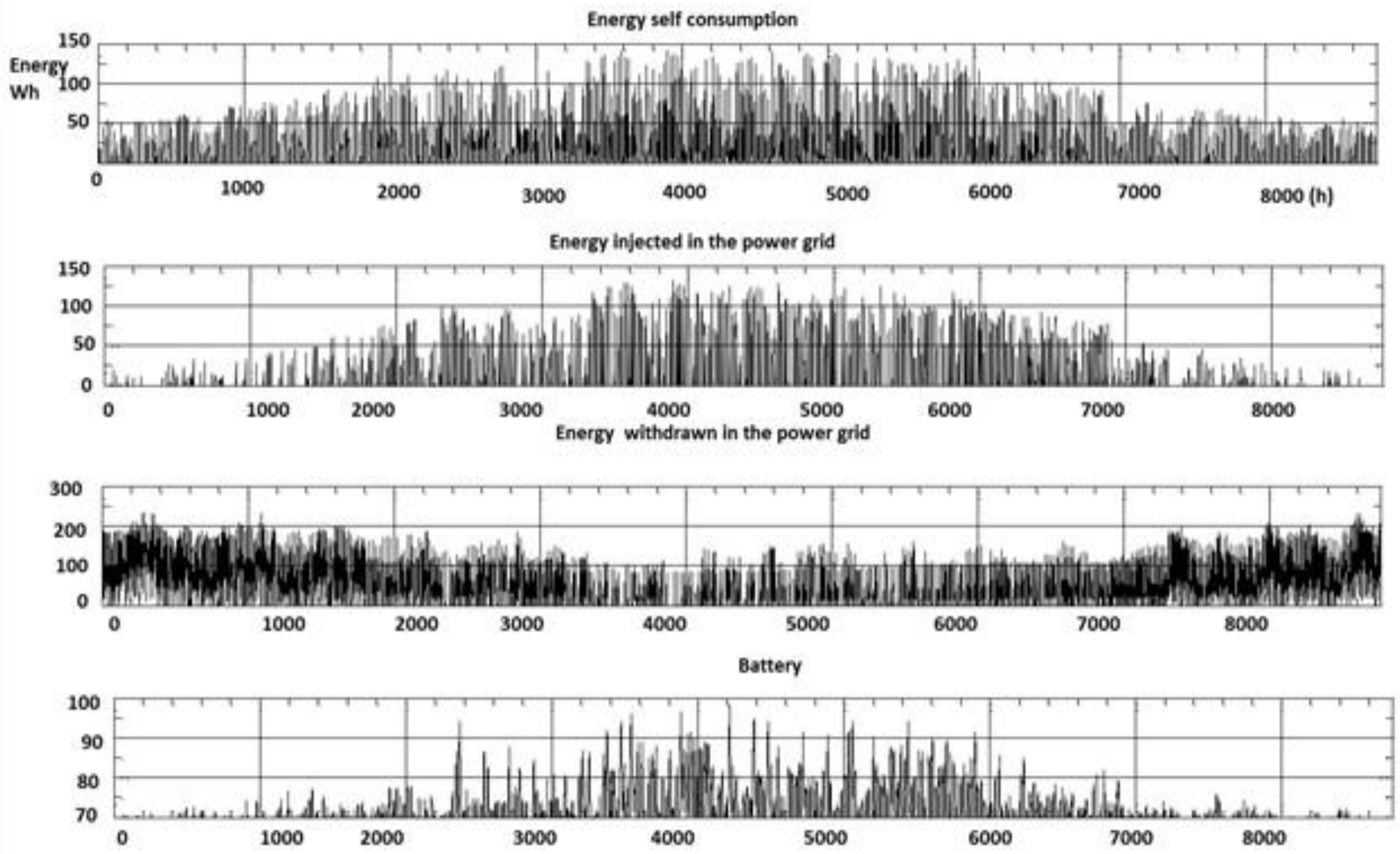
- Without storage

Scenarios		Power KW	EnR_C (KWh)	EnR_{inj} (KWh)	E_{SNEL} (KWh)	E_{kWh}	$\%_{ac}$ %	$\%EnR_C$ %	J_{EnR} %	J_{cost} ($)
T_c RT 2005 Piloting	*Without*	8	6803	5029	38958	-	14,87	62,88	8,55	-1995,55
		8	8584	2934	37174	1746	18,76	72,54	13,61	-1973,47
		8	18114	17442	27174	-	39,58	50,44	20,17	- 524,12
		8	22605	12156	27648	4497	49,40	63,58	31,40	-634,29
	With	8	6587	5246	23161	-	19,40	55,66	8,01	-1954,66
		8	8443	8549	39159	1862	18,46	71,35	13,17	-1973,35
		8	18591	3061	37158	-	40,64	48,68	31,03	-435,39
		8	23283	19600	27154	4697	50,90	60,96	9,55	-463,39
T_c Refined Piloting	*Without*	8	6900	14079	22468	-	16,38	58,61	15,02	-463,48
		8	8653	4933	35236	1758	20,54	73,12	20,80	-1746,59
		8	16496	2870	33480	-	39,49	52,65	32,72	-607,14
		8	20873	14514	25640	4240	49,54	66,05	8,97	-651,37
	With	8	6688	9980	21218	-	15,88	56,52	14,55	-1745,05
		8	8515	5145	35432	1833	20,22	71,96	20,32	-1764,05
		8	16447	2994	33600	-	39,05	52,65	32,36	-606,18
		8	20754	15155	25672	4314	49,28	65,57	9,15	-650,43
T_c RT 2005 Piloting	*Without*	8	5632	10085	21370	-	19,17	47,60	18,36	-1011,08
		8	7988	6201	23743	2361	27,19	67,51	19,30	-1034,75
		7,4	12009	6428	21381	-	40,88	47,60	35,51	-226,64
		7,4	16290	13434	17366	4287	55,46	67,51	8,37	-270,62
	With	8	5391	8394	13089	-	18,38	47,10	17,68	-1008,46
		8	7834	6442	23939	2448	26,71	64,03	18,48	-1033,04
		7,9	11923	3567	21490	-	40,65	45,56	35,04	-182,38
		7,9	16404	14259	17406	4486	55,93	66,20	10,03	-227,37
	Without	8	5673	8985	12928		20,91	45,24	20,07	881,74

Dimensioning of production systems without storage

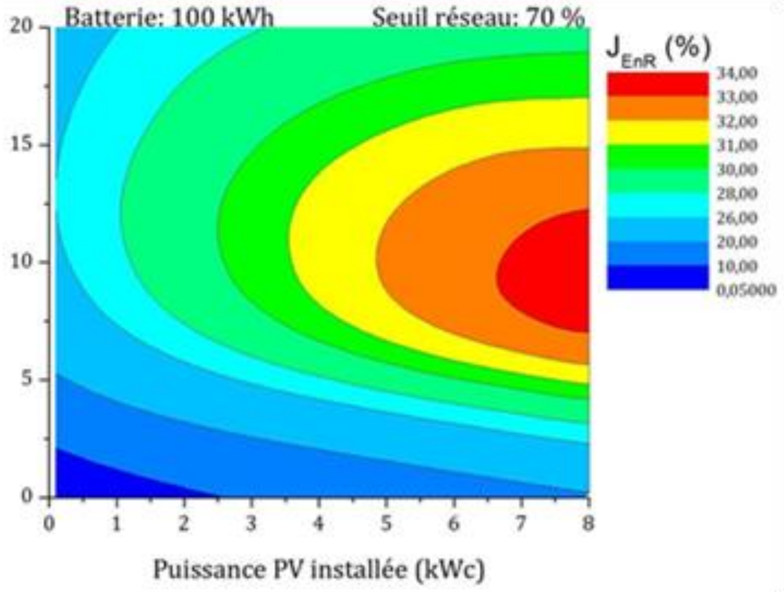
Scenarios			EnR_c (%)	EnR_{inj} (%)	EnR_{SNEL} (%)	$\%_{ac}$ (%)	$\%_{EnRc}$ %	J_{EnR} %	J_{cost} ($)
nsulatio n type ordinary tropical house	T_c RT 2005 Piloting	Without Optimized PV vs Optimized PV Optimized PV	↗ 26,18	↘ 41,66	↘ 4,58	↗ 26,16	↗ 26,16	↗ 59,18	↗ 0,92
		With Optimized PV vs Optimized PV Optimized PV	↗ 28,18	↗ 41,65	↘ 4,75	↗ 28,19	↗ 28,19	↗ 64,42	↗ 0,96
	T_c Refined Piloting	Without Optimized PV vs Optimized PV Optimized PV	↗ 25,41	↘ 41,82	↘ 4,98	↗ 24,76	↗ 25,40	↗ 57,28	↗ 1,13
		With Optimized PV vs Optimized PV Optimized PV	↗ 27,32	↘ 41,81	↘ 5,17	↗ 27,32	↗ 27,33	↗ 62,21	↘ 1,06
nsulatio	T_c RT 2005 Piloting	Withou Optimized PV vs Optimized PV Optimized	↗ 41,83	↘ 44,72	↘ 9,95	↗ 41,83	↗ 41,84	↗ 101,10	↗ 2,34

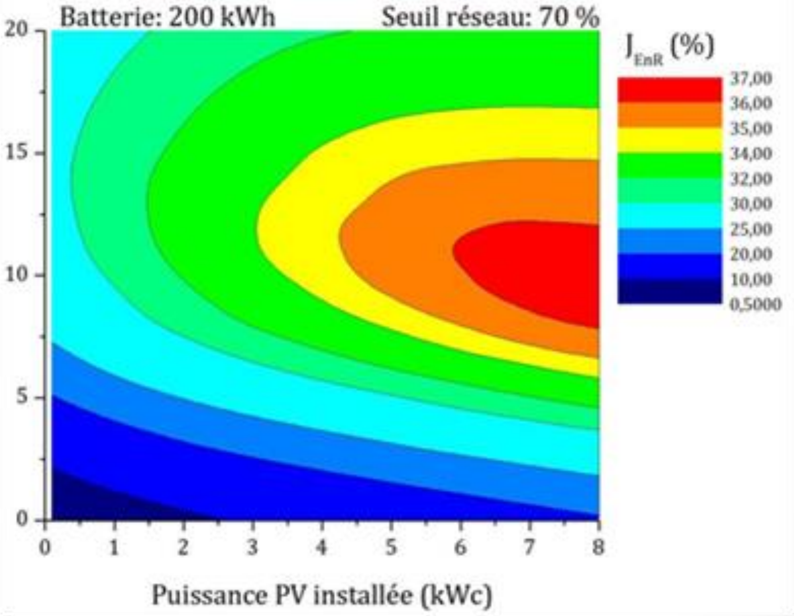
Standard PV 3kWc and optimized 7.9 kWc



Dimensioning of production and storage systems for a 70% network threshold

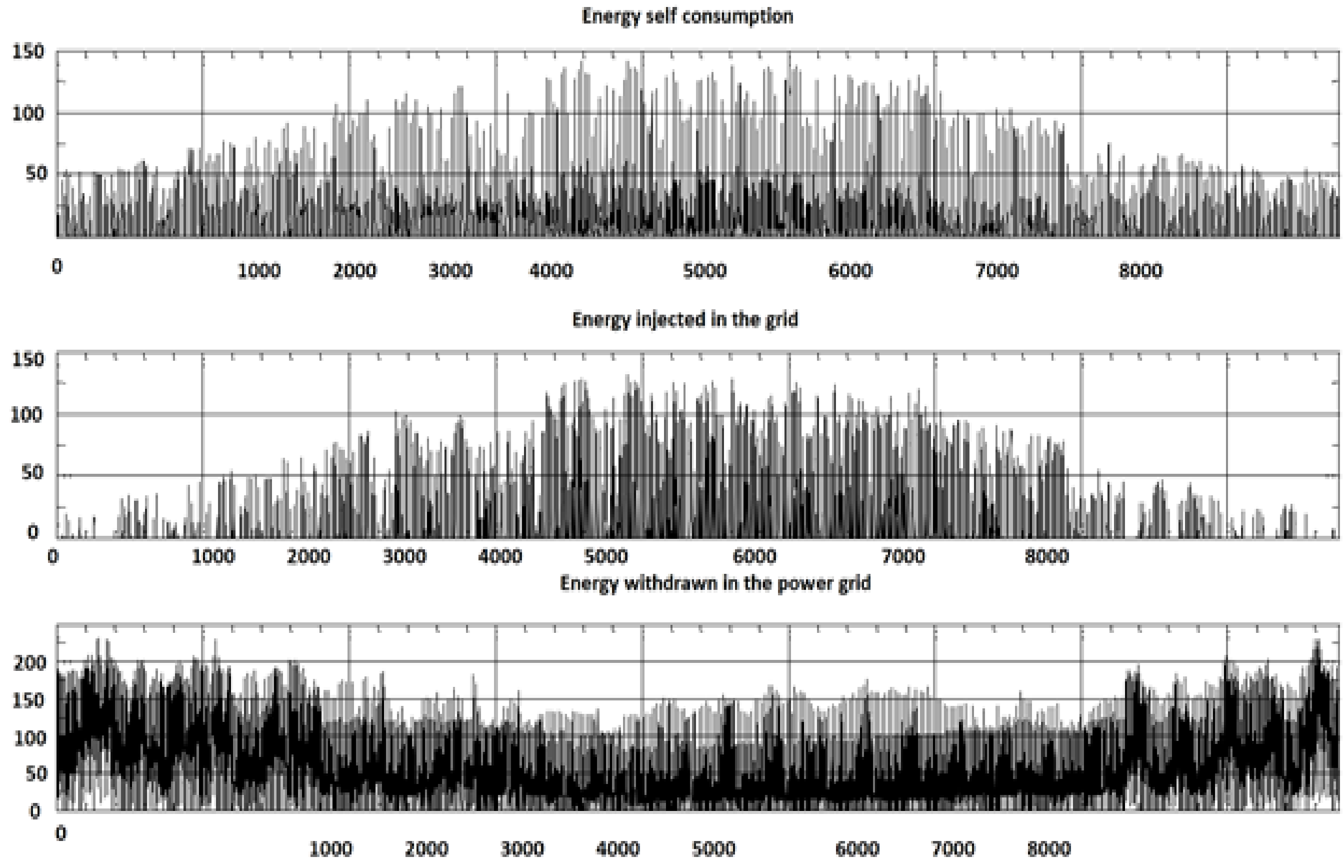
RT2005 insulation, refined temperature control, with load control





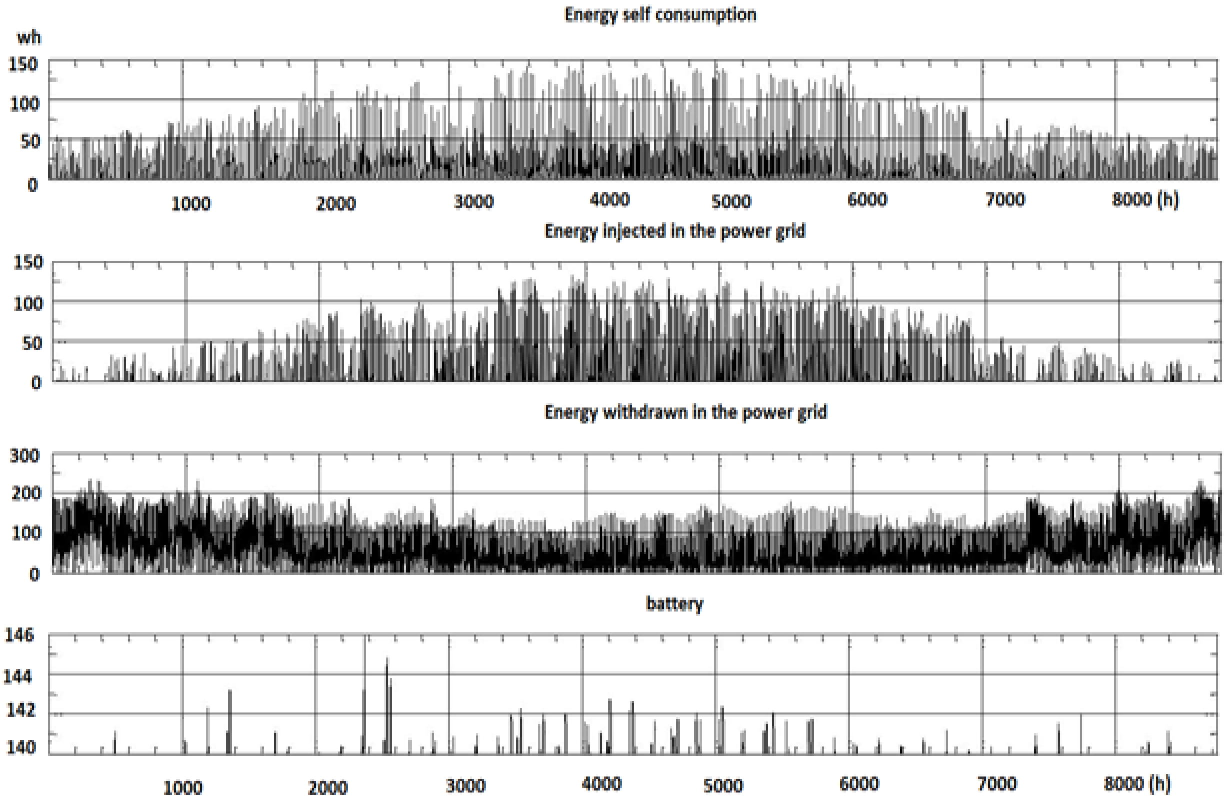
Dimensioning of production and storage systems for a 70% power grid threshold

Scenarios			EnR_c (%)	EnR_{inj} (%)	EnR_{SNEL} (%)	$\%_{ac}$ (%)	$\%_{EnRc}$ %	J_{EnR} %	J_{cost} ($)
nsulatio n type rdinary tropical house	**T_c RT 2005 Piloting**	*Without Optimized PV vs Optimized PV Optimized PV*	↗ 26,18	↘ 41,66	↘ 4,58	↗ 26,16	↗ 26,16	↗ 59,18	↗ 0,92
		With Optimized PV vs Optimized PV Optimized PV	↗ 28,18	↗ 41,65	↘ 4,75	↗ 28,19	↗ 28,19	↗ 64,42	↗ 0,96
	T_c Refined Piloting	*Without Optimized PV vs Optimized PV Optimized PV*	↗ 25,41	↘ 41,82	↘ 4,98	↗ 24,76	↗ 25,40	↗ 57,28	↗ 1,13
		With Optimized PV vs Optimized PV Optimized PV	↗ 27,32	↘ 41,81	↘ 5,17	↗ 27,32	↗ 27,33	↗ 62,21	↘ 1,06
nsulatio	**T_c RT 2005 Piloting**	*Withou Optimized PV vs Optimized PV Optimized*	↗ 41,83	↘ 44,72	↘ 9,95	↗ 41,83	↗ 41,84	↗ 101,10	↗ 2,34


Energy self consumption
150
100
50
0
1000
2000
3000
4000
5000
6000
7000
8000
Energy injected in the grid
150
100
50
0
0
1000
2000
3000
4000
5000
6000
7000
8000
Energy withdrawn in the power grid
200
150
100
50
0
0
1000
2000
3000
4000
5000
6000
7000
8000

Dimensioning of production and storage systems for a 30% network threshold

Scenarios			EnR_c (%)	EnR_{inj} (%)	EnR_{SNEL} (%)	$\%_{ac}$ (%)	$\%_{EnRc}$ %	J_{EnR} %	J_{cost} ($)
nsulatio n type rdinary tropical house	**T_c RT 2005 Piloting**	*Without Optimized PV vs Optimized PV Optimized PV*	↗ 0,85	↗ 1,33	↘ 0,12	↗ 0,85	↗ 0,81	↗ 1,64	↗ 0,07
		With Optimized PV vs Optimized PV Optimized PV	↗ 0,88	↗ 1,30	↘ 0,11	↗ 0,88	↗ 0,90	↗ 1,87	↗ 0,18
	T_c Refined Piloting	*Without Optimized PV vs Optimized PV Optimized PV*	↗ 0,80	↗ 1,30	↘ 0,12	↗ 0,88	↗ 0,79	↗ 1,57	↗ 0,08
		With Optimized PV vs Optimized PV Optimized PV	↗ 0,82	↗ 1,24	↘ 0,12	↗ 0,81	↗ 0,82	↗ 1,67	↗ 0,08
nsulatio	**T_c RT 2005 Piloting**	*Withou Optimized PV vs Optimized PV Optimized*	↗ 1,68	↗ 1,94	↘ 0,33	↗ 1,67	↗ 1,68	↗ 3,38	↗ 0,15



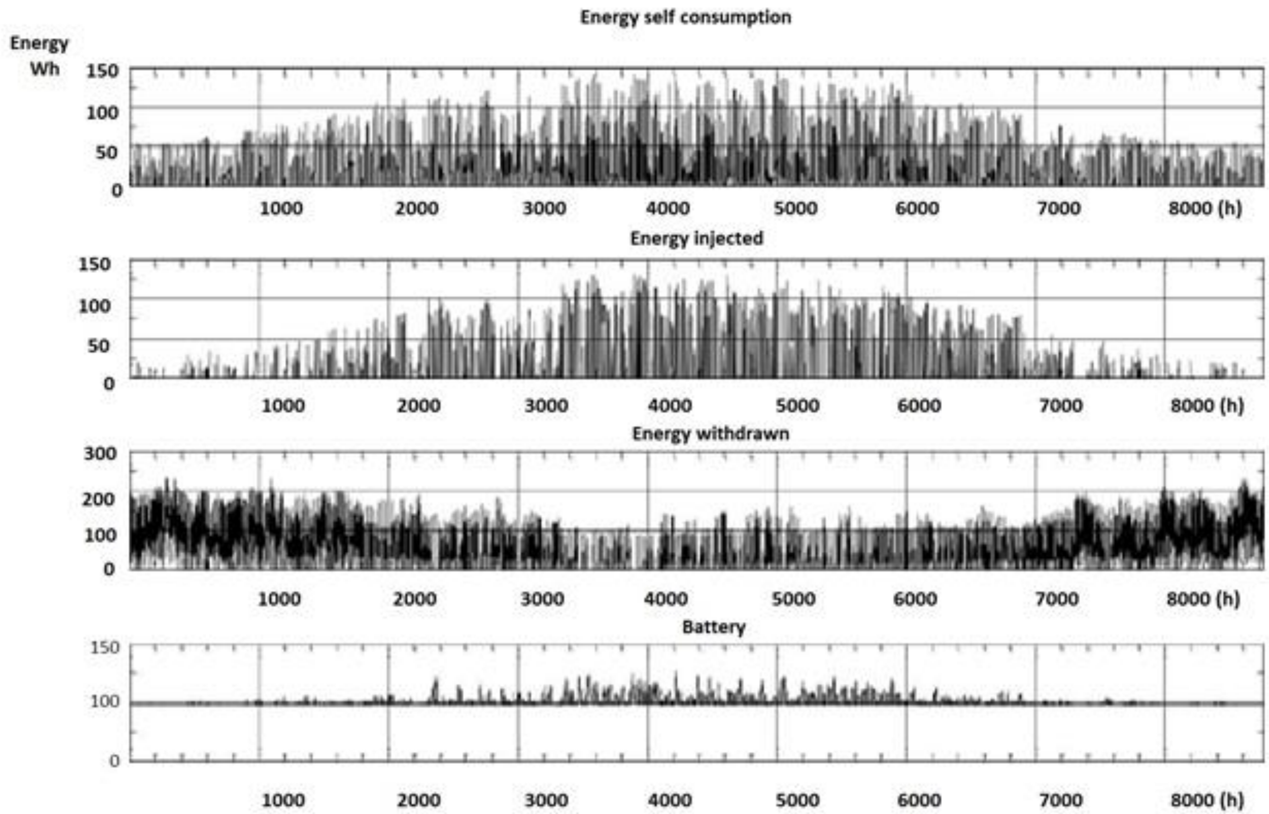
Energy self consumption
wh
150
100
50
0
1000
2000
3000
4000
5000
6000
7000
8000 (h)
Energy injected in the power grid
150
100
50
0
Energy withdrawn in the power grid
300
200
100
0
battery
146
144
142
140
1000
2000
3000
4000
5000
6000
7000
8000 (h)

Dimensioning of production and storage systems with predictive management

Scenarios			Powe KW	EnR_C (KWh)	EnR_{inj} (KWh)	E_{SNEL} (KWh)	E_{stock} kWh	Battery kWh	$\%_{ac}$ %	$\%EnR_C$ %	J_{EnR} %	J_{cost} ($)
	T_c RT 2005 Piloting	*Without*	8	11359	11359	23602	20797	200	64,58	48,32	31,20	-709,11
			8	17754	16484	28107	-	-	51,86	38,80	20,12	-591,86
			8	22175	11281	23591	4121	200	64,77	48,46	31,58	- 709,52
			8	19204	14777	26567	1458	200	56,09	41,97	23,54	-679,54
		With	8	22410	12354	23349	20593	200	63,03	48,39	30,88	-1954.66
			8	17917	17639	27829	-	-	50,39	39,17	17,74	-1958,24
atio			8	22486	12262	23265	4575	200	63,24	49,15	31,08	-665,87
			8	19422	15868	26334	1513	200	54,62	42,46	23,09	-683,92
e	T_c Refined Piloting	*Without*	8	20811	10055	21332	19091	200	65,85	38,53	9,55	-651,37
ary			8	16496	14514	25640	-	-	52,65	42,11	9,70	-406.35
cal			8	20873	9980	21268	4240	200	66,05	16,51	20,75	-425.76
se			8	18048	13304	24098	1417	200	57,11	42,56	24,25	-1745,63
		With	8	21134	5145	23939	18936	200	63,67	49,39	8,01	-1746,85
			8	16490	5081	16697	-	-	46,85	39,49	8,16	-413,93
			8	21183	17636	14908	4330	200	63,85	49,54	19,86	-432,93
			8	18288	15509	21457	1195	200	51,46	42,83	23,72	-1062,23
	T_c RT 2005 Piloting	*Without*	7,4	16413	5145	21366	14423	200	45,65	55,79	9,55	-1063,86
			7,4	11924	5081	15196	-	-	51,95	41,05	9,70	-103,39
			3,5	16404	17636	13378	4330	200	45,65	55,75	20,75	-121,68
			3,5	13084	15509	21645	1168	200	51,95	45,09	25,36	-1008,46
atio		*With*	7,9	16388	5517	21533	11430	200	45,46	55,79	8,97	-1010,20
			7,9	16388	5410	15391	15688	-	46,44	41,85	9,12	-33,27
RT			7,9	12057	14991	13626	1424	200	43,93	55,85	20,34	-52,25
5			7,9	16382	12946	35432	14490	200	56,20	45,09	24,82	-915,84
	T_c Refined Piloting	*Without*	7,7	13084	6442	36390	13272	200	47,14	63,05	9,17	-191,68
			7,7	15711	6319	24817	-	-	48,82	46,57	9,48	-147,68
			7,7	11443	16120	23020	4427	200	44,69	63,95	19,57	-191,52
			7,7	15711	14001	23446	1178	200	50,73	50,49	25,34	-160,58
		With	8	15728	8504	11367	13272	200	45,97	51,49	8,37	-165,02
			8	11305	13707	15779	-	-	20,08	58,07	9,59	-119,43
			8	15727	8501	11361	4427	200	45,97	41,74	19,11	-165,02
			8	12476	12329	14618	1178	200	47,13	49,08	25,36	-131,93

Predictive vs. Non-predictive approach with storage and 70% threshold

Scenarios			EnR_c (%)	E_{stock}	EnR_{inj} (%)	EnR_{SNEL} (%)	$\%_{ac}$ (%)	$\%_{EnRc}$ %	J_{EnR} %	J_{cost} ($)
ulatio n ype linary opical ouse	T_c RT 2005 Piloting	*Without Optimized PV vs Optimized PV Optimized PV*	↗ 0,17	↗ 93,38	↘ 0.51	↘ 0,04	↗ 0,17	↗ 0,16	↗ 0,29	↗ 0,003
		With Optimized PV vs Optimized PV Optimized PV	↗ 0,19	↗ 93,26	↗ 0,049	↘ 0,04	↗ 0,18	↗ 0,16	↗ 0,30	↗ 0,01
	T_c Refined Piloting	*Without Optimized PV vs Optimized PV Optimized PV*	↗ 0,25	↗ 92,25	↘ 0,45	↘ 0,05	↗ 0,15	↗ 0,15	↗ 0,27	↗ 0,02
		With Optimized PV vs Optimized PV Optimized PV	↗ 0,29	↗ 86,45	↘ 0,67	↘ 0,07	↗ 0,30	↗ 0,30	↗ 0,62	↘ 0,87
ulatio n	T_c RT 2005 Piloting	*Withou Optimized PV vs Optimized PV Optimized PVt*	↗ 0,28	↗ 85,63	↘ 0,65	↘ 0,08	↗ 0,27	↗ 41,84	↗ 0,55	↗ 0,03


Energy self consumption
Energy
Wh
150
100
50
0
1000
2000
3000
4000
5000
6000
7000
8000 (h)
Energy injected
150
100
50
0
1000
2000
3000
4000
5000
6000
7000
8000 (h)
Energy withdrawn
300
200
100
0
1000
2000
3000
4000
5000
6000
7000
8000 (h)
Battery
150
100
0
1000
2000
3000
4000
5000
6000
7000
8000 (h)

Predictive vs. vs. non-predictive approach to storage and threshold to 30%

Scenarios			70%			30%		
			I_{with} %	I_g %	I_{inj} %	I_{with} %	I_g %	I_{inj} %
Insulation type ordinary tropical house	**T_c RT 2005 Piloting**	*Without Optimized PV vs Optimized PV Optimized PV*	↗ 28,74	↗ 52,50	↗ 51,28	↘ 38,56	↗ 167,30	↗ 118,08
		With Optimized PV vs Optimized PV Optimized PV	↗ 27,70	↗ 51,10	↗ 49,85	↘ 38,62	↗ 157,45	↗ 111,33
	T_c Refined Piloting	*Without Optimized PV vs Optimized PV Optimized PV*	↗ 26,68	↗ 53,20	↗ 51,60	↘ 38,65	↗ 193,91	↗ 127,69
		With Optimized PV vs Optimized PV Optimized PV	↗ 27,60	↗ 51,70	↗ 59,29	↘ 38,71	↗ 178,09	↗ 118,13
	T_c RT 2005 Piloting	*Withou Optimized PV vs Optimized PV*	↘ 34,73	↗ 46,95	↗ 45,81	↘ 42,69	↗ 146,85	↗ 80,31

Plan

➊ Context and stakes of the mastery of the energy

➋ Strategies for intelligent management of energy resources

➌ Micro-network modeling

➍ Dimensioning of production and storage systems and network impact

➎ Assessment and prospects

Results

- Highlighting configurations favoring the use of renewable energy generation;
- Minimizing the impact of local production on the electricity grid;

→ Better match between decentralized generation, energy needs and network injection

Results

Most interesting strategy:

For the consumer:

- Without storage system, from an economic point of view;
- Non-predictive with storage, from an environmental point of view;

For the network manager:

- Predictive

Prospect

Refinement of modeling

• Thermal model of individual or collective habitats, tertiary buildings

• Occupant lifestyle scenarios: single person, couple without children

• Refinement of charge control

• Geographic location

Development of dynamic incentive pricing models for production and consumption management

- Energy management of a group of buildings (neighborhoods, agglomeration)

- Study of possible new architectures for the grid