Mastère CréaCity

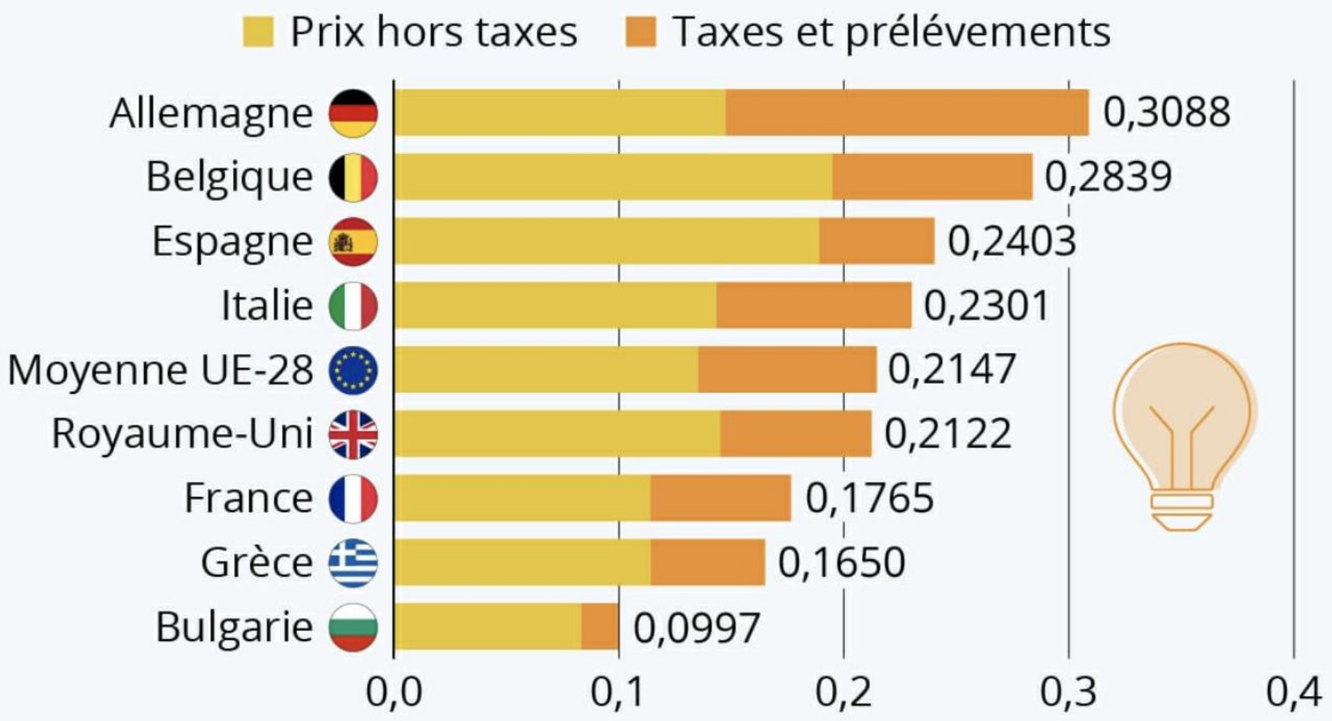
Cours « Smart City»

Chapitre 6 : Réseau électrique intelligent (Smart Grid)

Professeur Isam Shahrour

Le prix de l'électricité en Europe

Prix de l'électricité dans une sélection de pays en 2019 (euro par kilowattheure) *



* Premier semestre 2019. Pour une consommation domestique comprise entre 2 500 et 5 000 kW/h.

Source : Eurostat

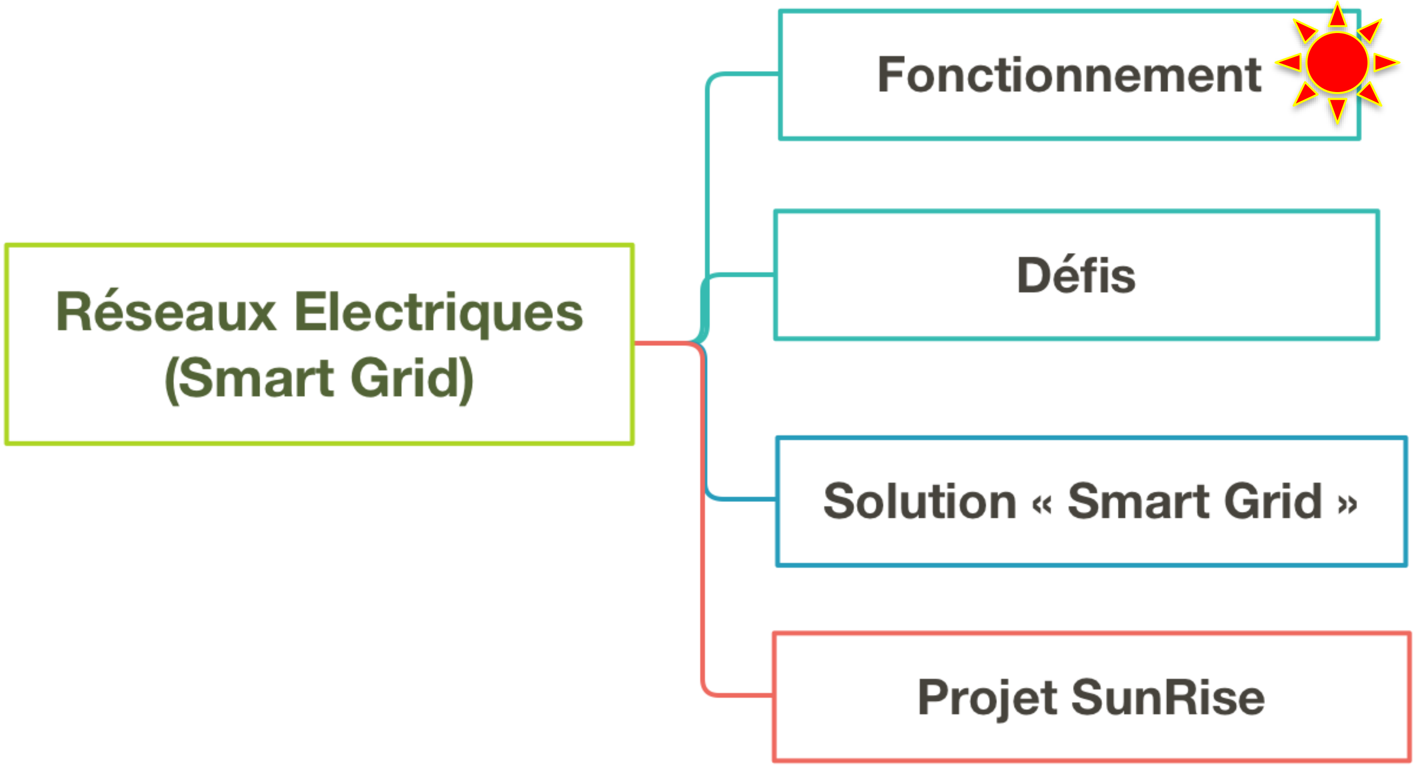
Smart Grid – NEMA Report (2011)

NEMA: Association of electrical and medical imaging equipment manufacturers (US)

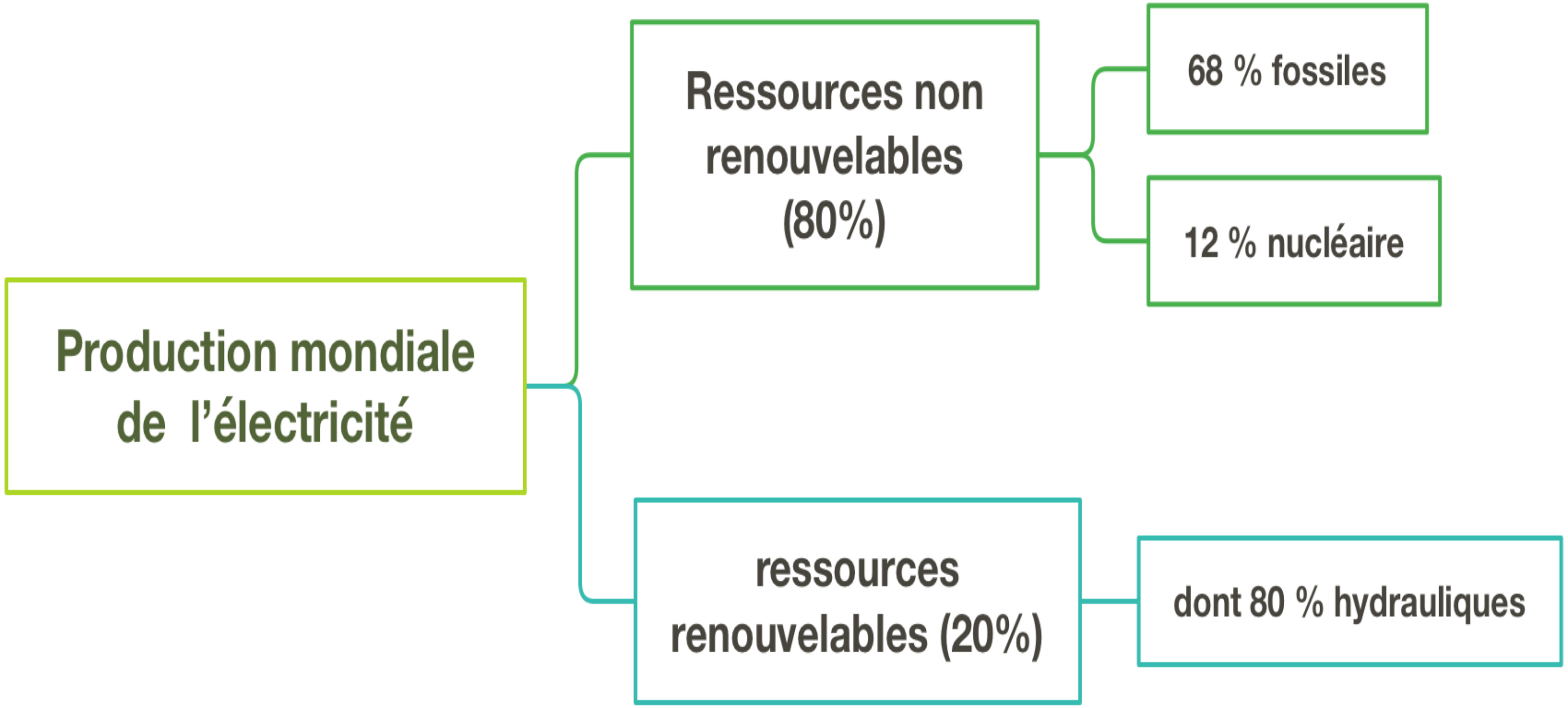
Smart Grid
Building on The Grid
volume 2

Smart Grid is the solution we desperately need to solve many global energy problems. Like the printing press, automobile, and light bulb before it, Smart Grid will change the course of human history. It is changing the way we think about and interact with our electrical system.

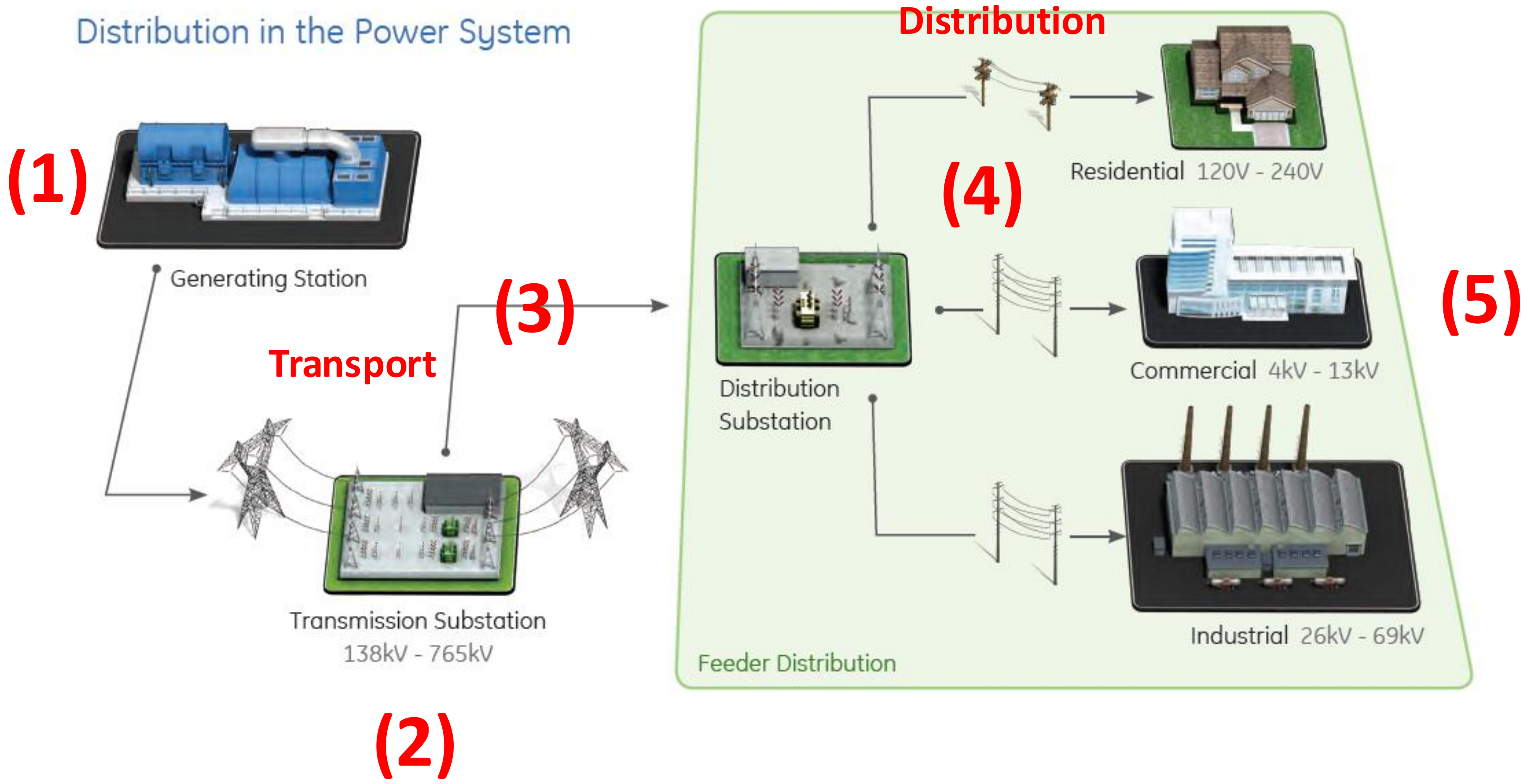
Plan du cours



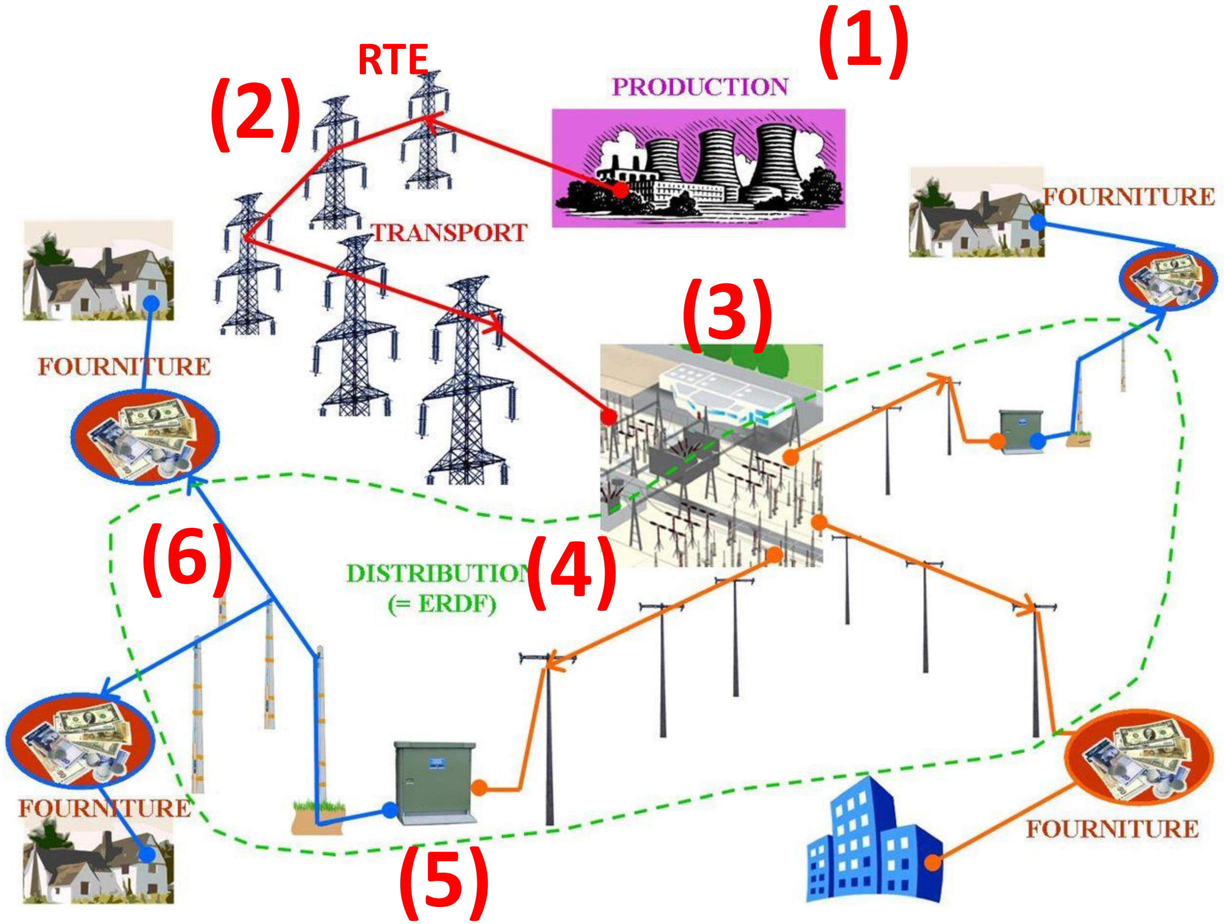
Sources d’électricité



Système Electrique

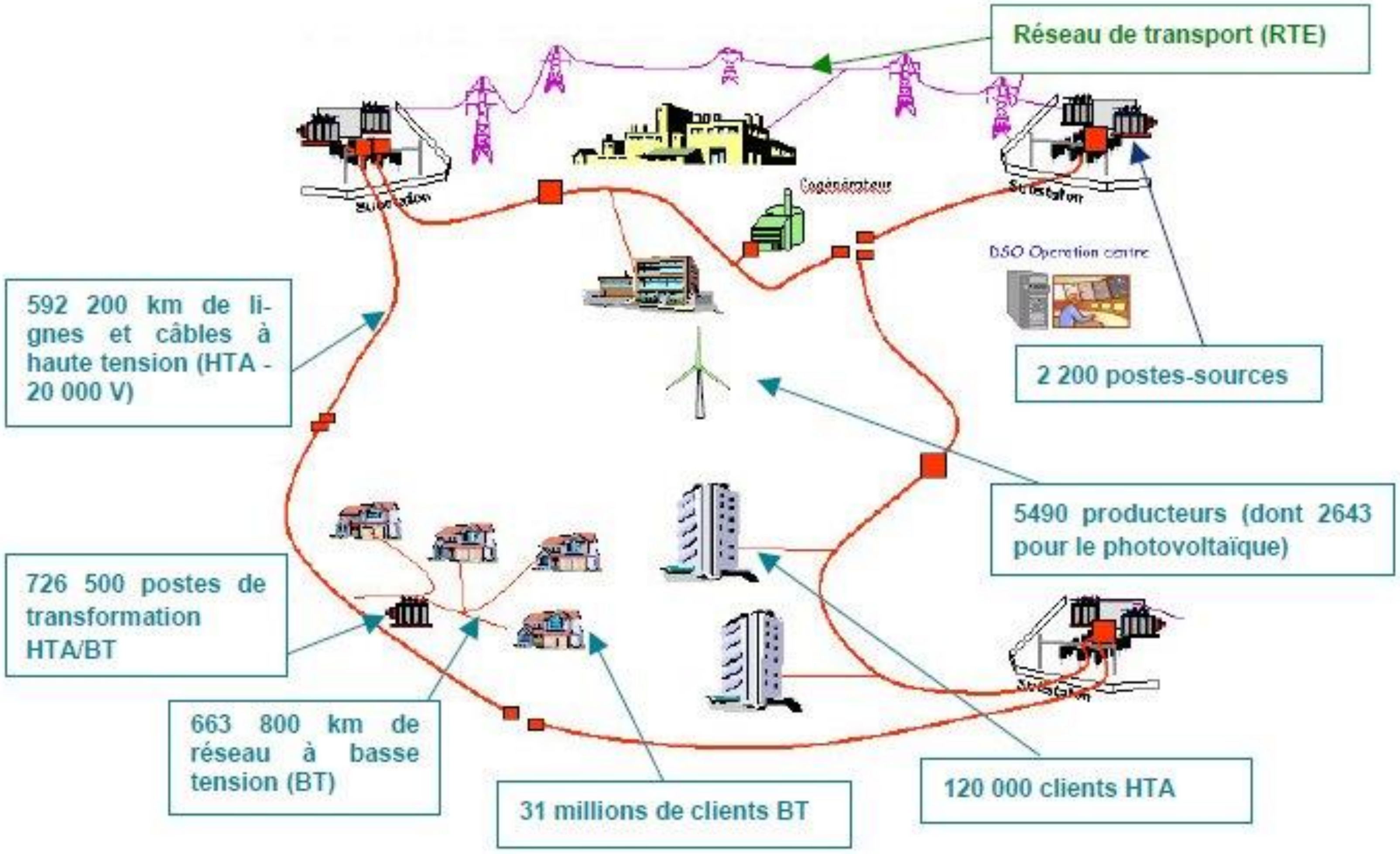


Système électrique en France

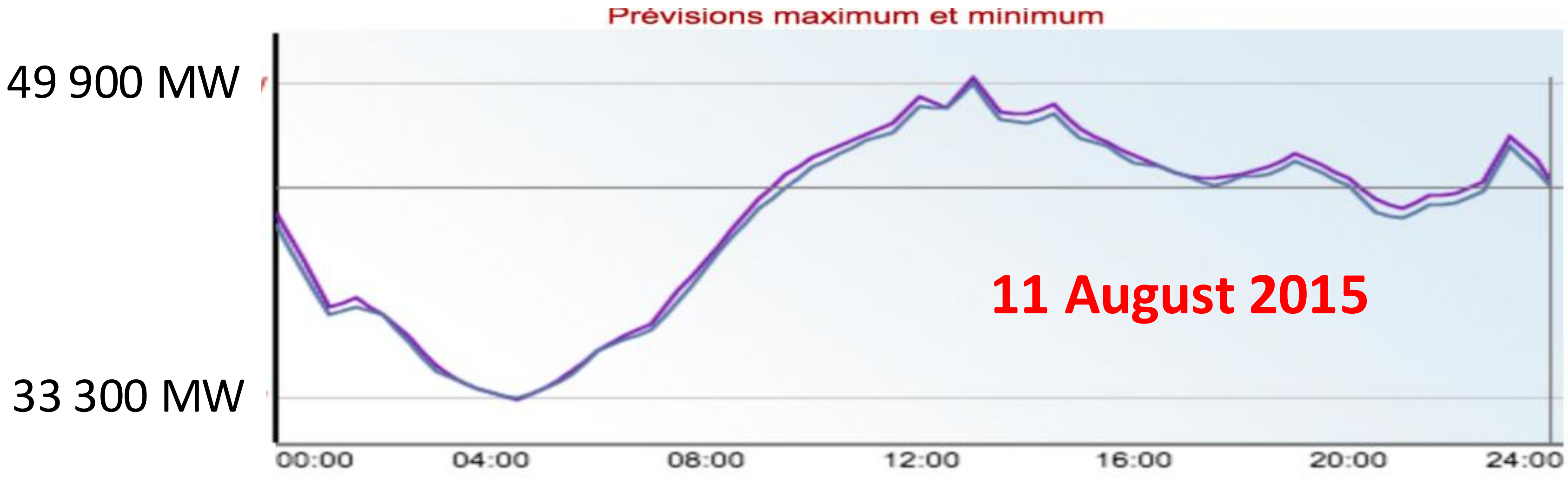


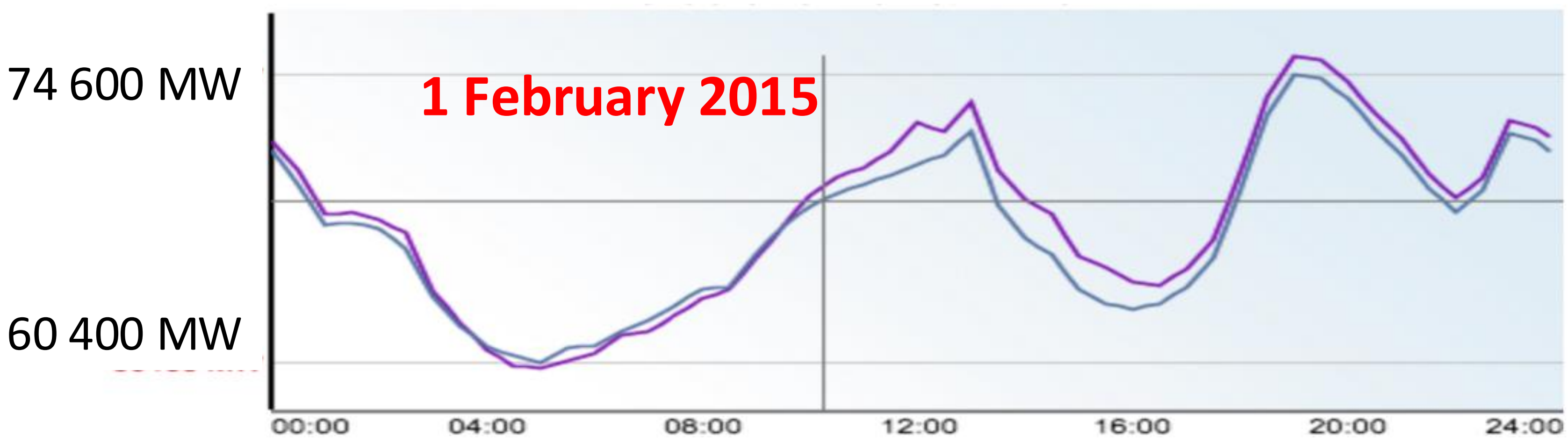
Lignes HTB (Haute Tension) (400 kV)
Lignes HTA (Moyenne Tension) (63 à 225 kV)
Ligne Basse Tension (230 et 400 V)

Système électrique en France

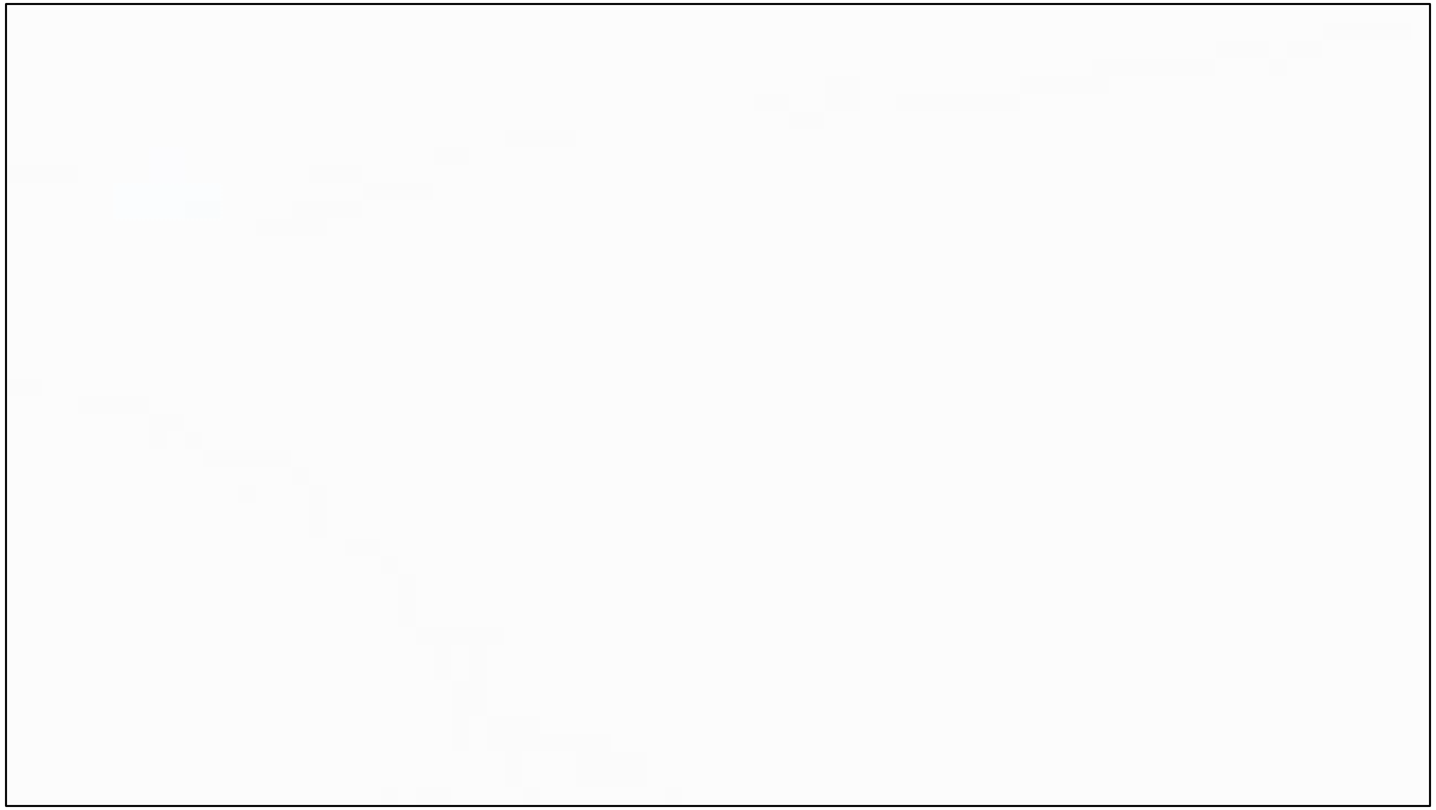


Profil de consommation d’électricité (France)

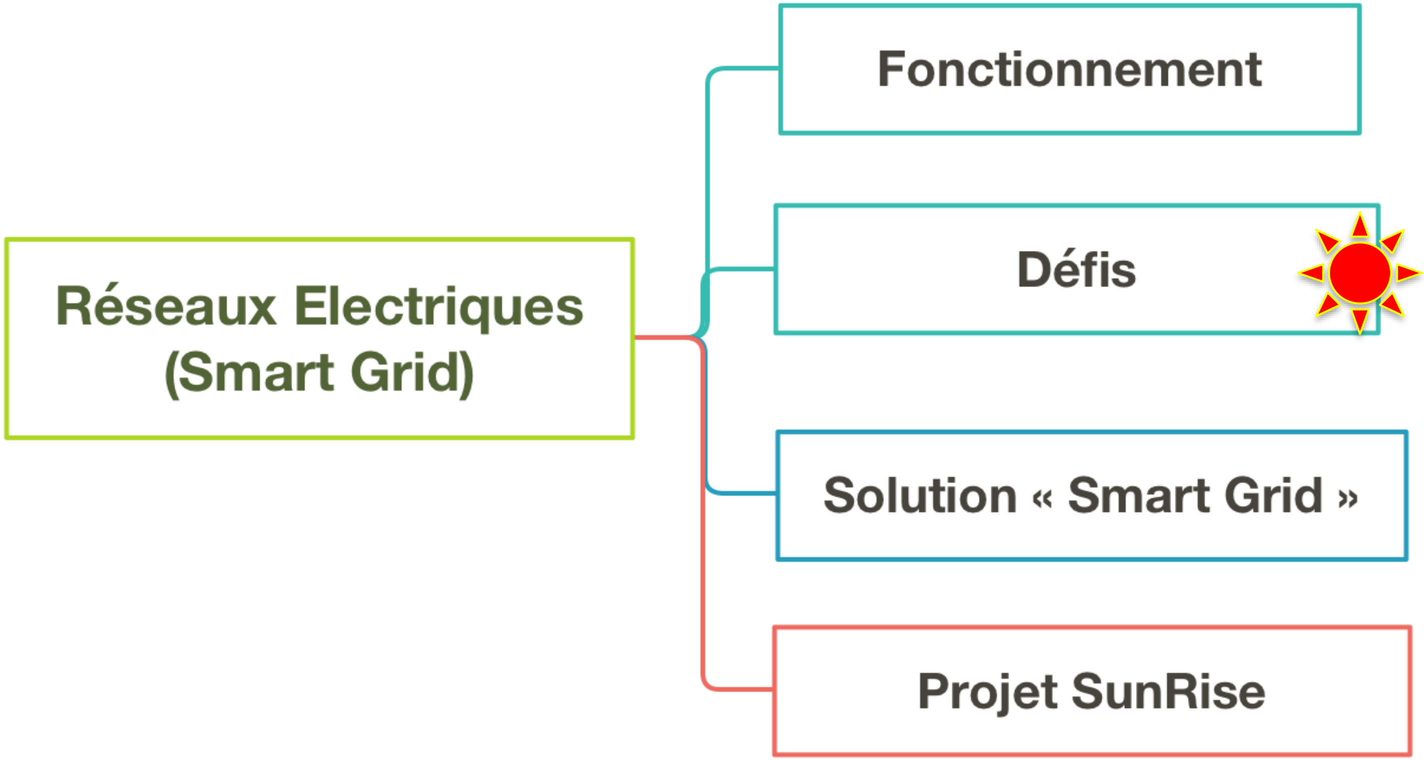


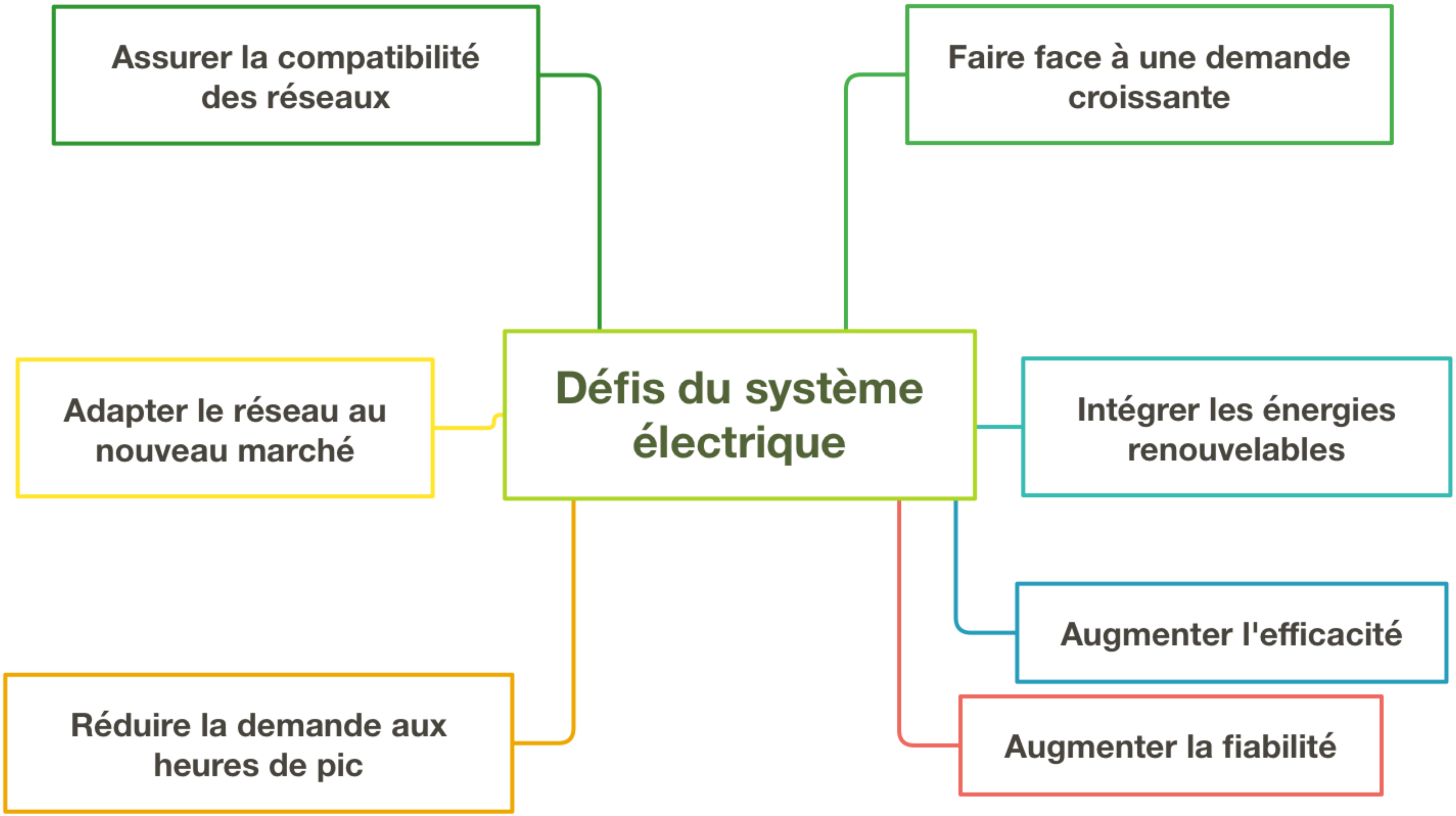


Fonctionnement



Plan du cours




Assurer la compatibilité des réseaux
Faire face à une demande croissante
Adapter le réseau au nouveau marché
Défis du système électrique
Intégrer les énergies renouvelables
Augmenter l'efficacité
Augmenter la fiabilité
Réduire la demande aux heures de pic

Défis du système électrique

1. Demande croissante

La demande croissante est liée au développement urbain

A l'horizon 2030, L'agence internationale de l'énergie estime un besoin en investissement de 6 trillions $ pour l'infrastructure de transmission et de distribution et autant pour la génération.

Défis du système électrique

2. Intégration des énergies renouvelables

Le développement des énergies renouvelables nécessite des solutions innovantes (technologie, stockage, logiciels, compétences de gestion) pour leur intégration dans le réseau électrique et plus généralement dans la stratégie de demande-réponse.

Défis du système électrique

3. Augmenter l'efficacité du système électrique

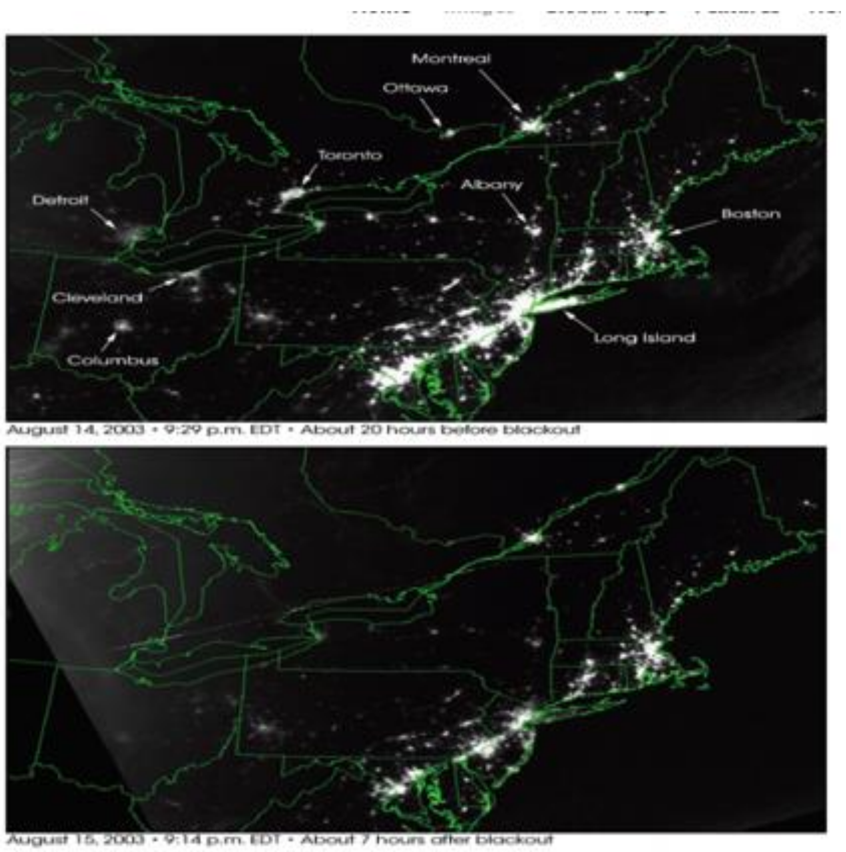
- Environ 66% de l'énergie primaire est perdue dans la conversion d'énergie (génération).
- Jusqu'à 16% de l'électricité est perdue dans le réseau *(L'administration de l'énergie des États-Unis a estimé les pertes à 20 milliards de dollars en 2005).*

Défis du système électrique

4. Augmenter la fiabilité du réseau
Assurer la continuité du service électrique, qui est vitale pour l'industrie, les services et la qualité de vie.

L’arrêt du service peut causer d'énormes perturbations et pertes économiques.

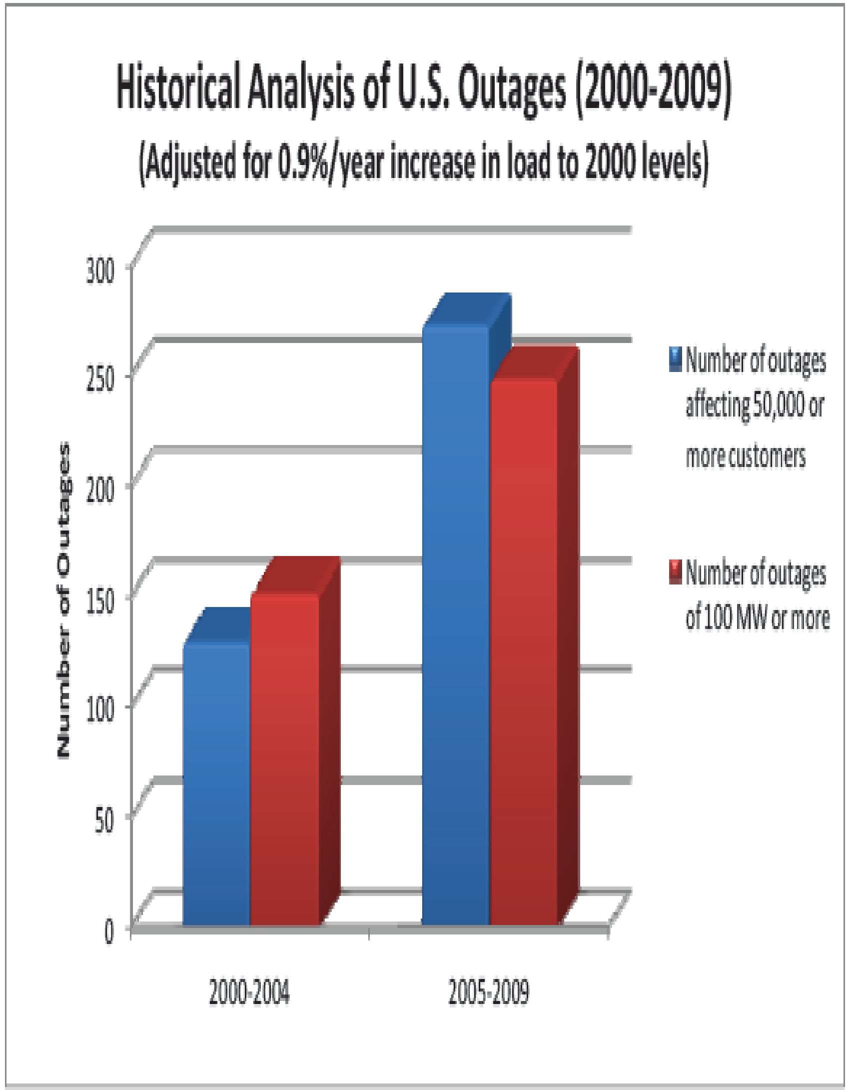
Energy Security



US Blackout (2003)

- **50 Million people**
- **24 hours for full recovery**
- **Cost: $6 to $10 billion**

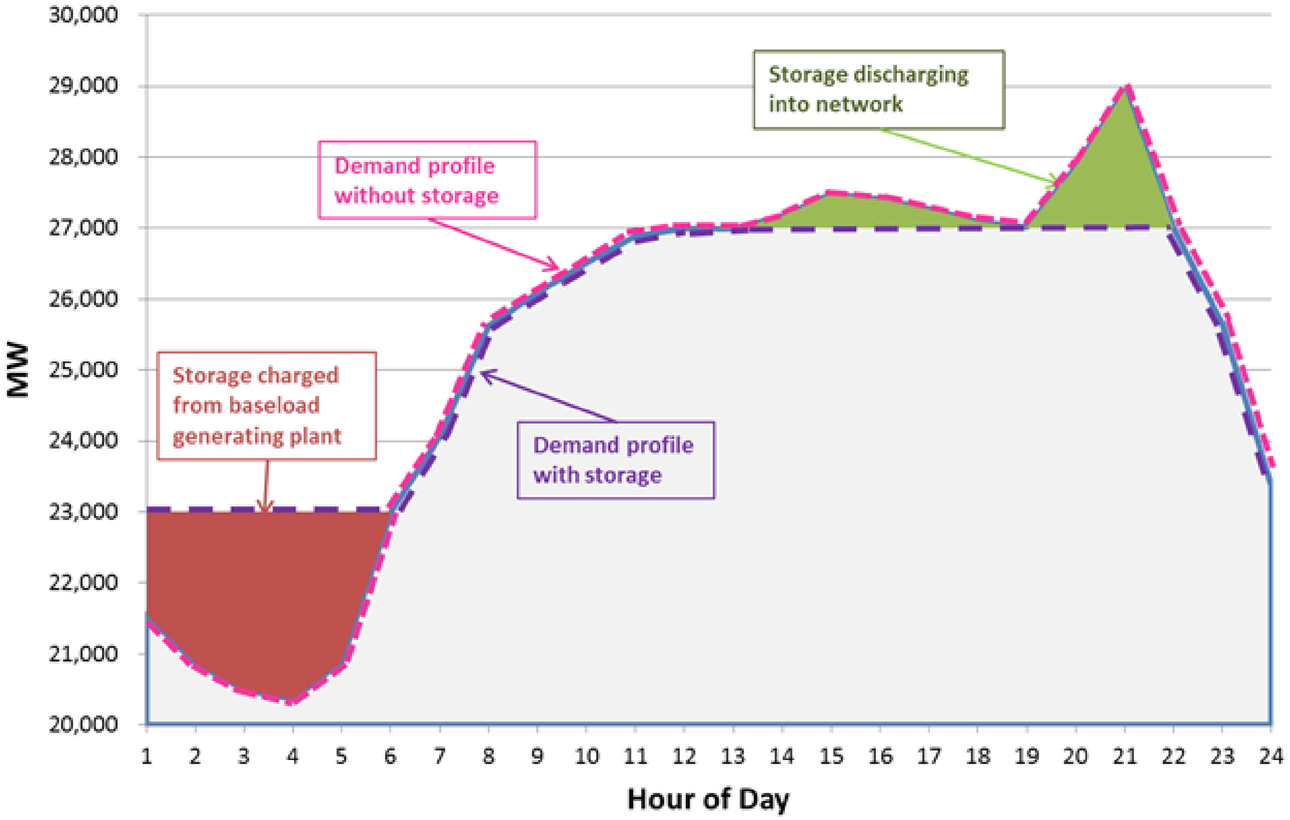
Pannes électriques aux Etats-Unis: entre 80 et 190 milliards $/an



Défis du système électrique

5. Réduire la demande aux heurs de pic

(Réduit considérablement les infrastructures,..)



Deploying battery storage in commercial buildings: opportunities and challenges, 5 June 2013 | [Issue 3]
By Amir Kavousian, Justin Ho, Larry Win, and Heming Yip

Défis du système électrique

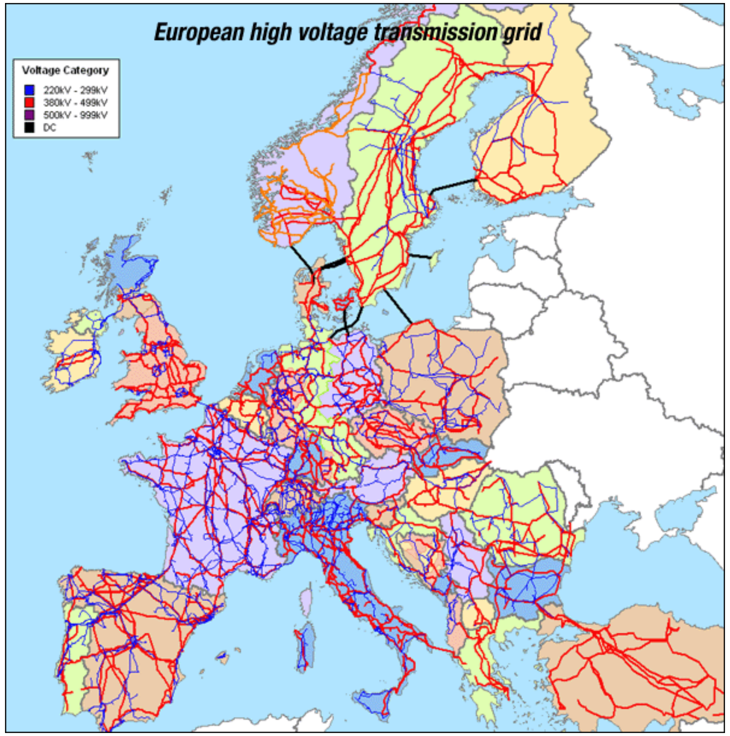
6. Adapter le réseau au nouveau marché

- Dans un marché ouvert, le prix de l'électricité pourrait fluctuer considérablement dans une journée.
- L'innovation est nécessaire pour aider les utilisateurs à bénéficier de ces opportunités ou (et) à réduire leur impact.

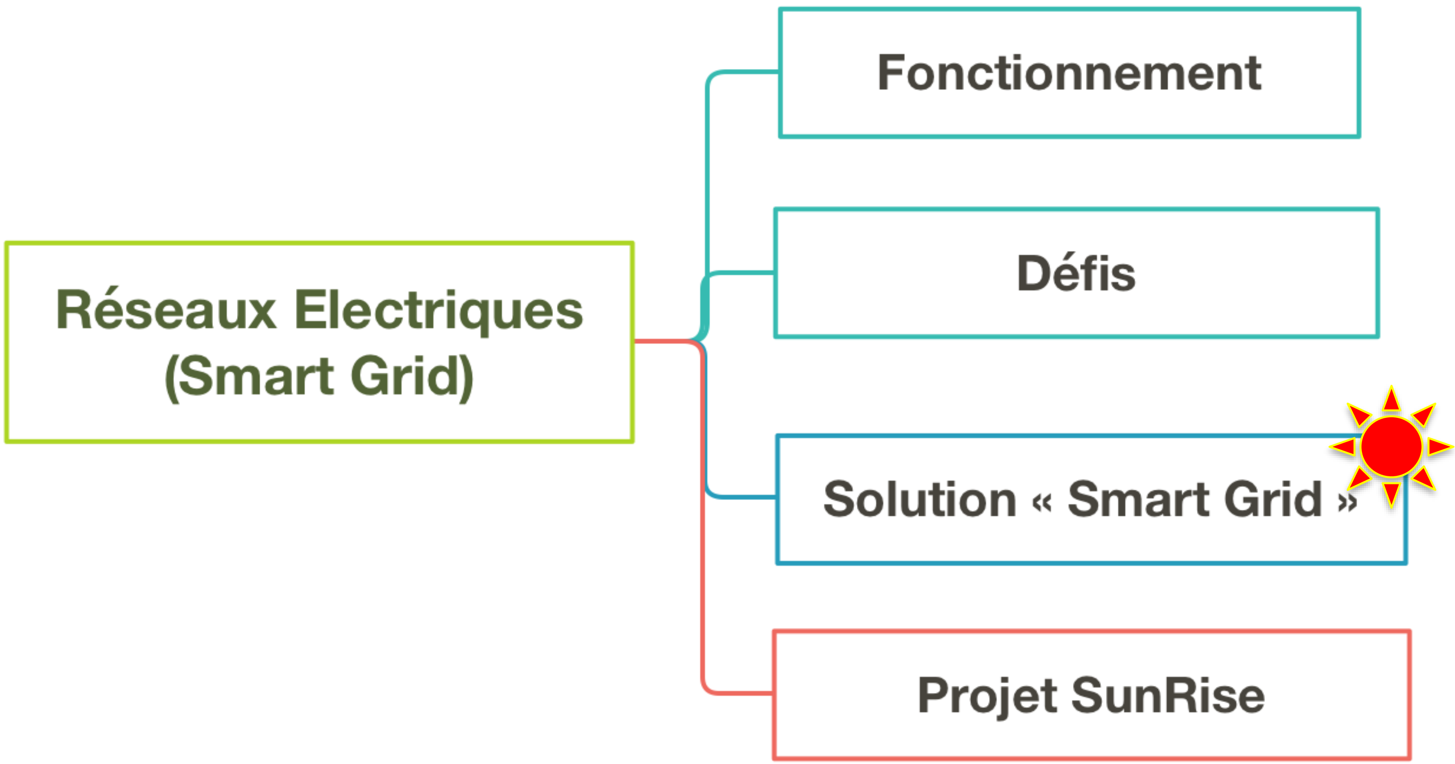
Défis du système électrique

7. Compatibilité des réseaux

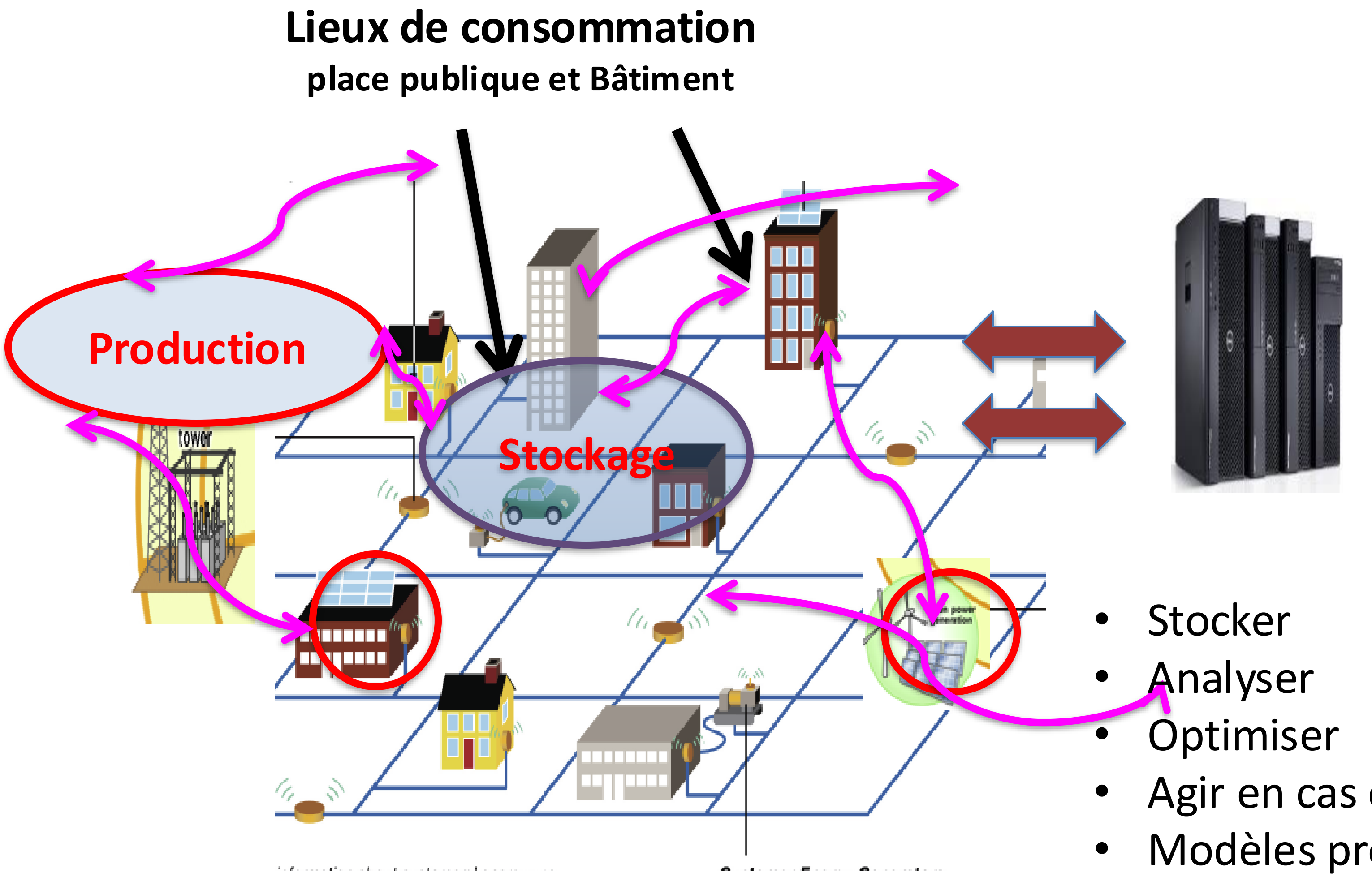
La compatibilité est vitale pour l'interconnexion des réseaux entre les pays.



Plan du cours

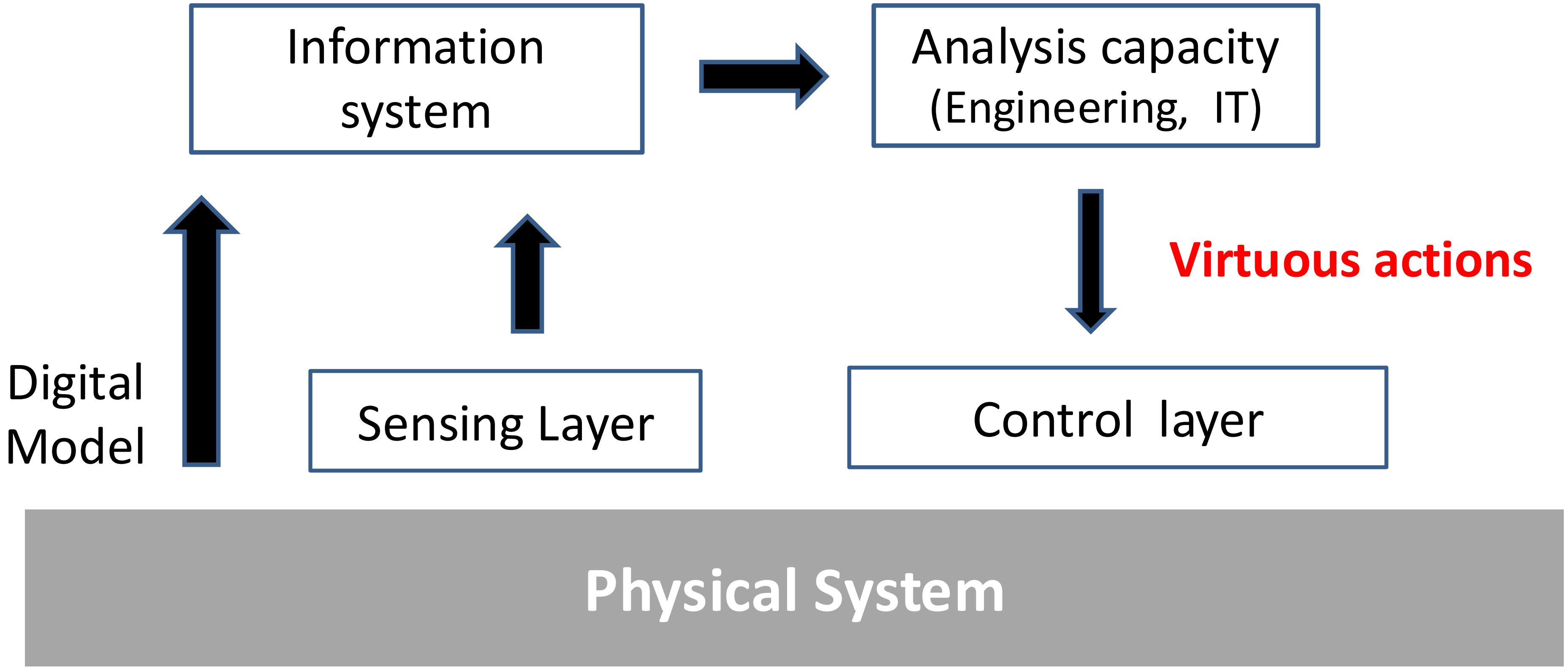


Concept Smart Grid



- Stocker
- Analyser
- Optimiser
- Agir en cas d’anomalie
- Modèles prévisionnels

Intelligent system



Substation monitoring

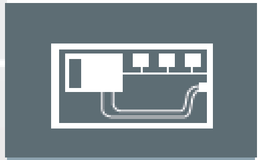
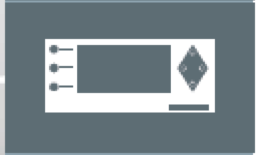
Intelligent Transformer Substations for Future-Proof Power Distribution

The Modular Concept Based on 8DJH Medium-Voltage Switchgear

www.siemens.com/transformersubstations

The integration of components into the medium-voltage switchgear

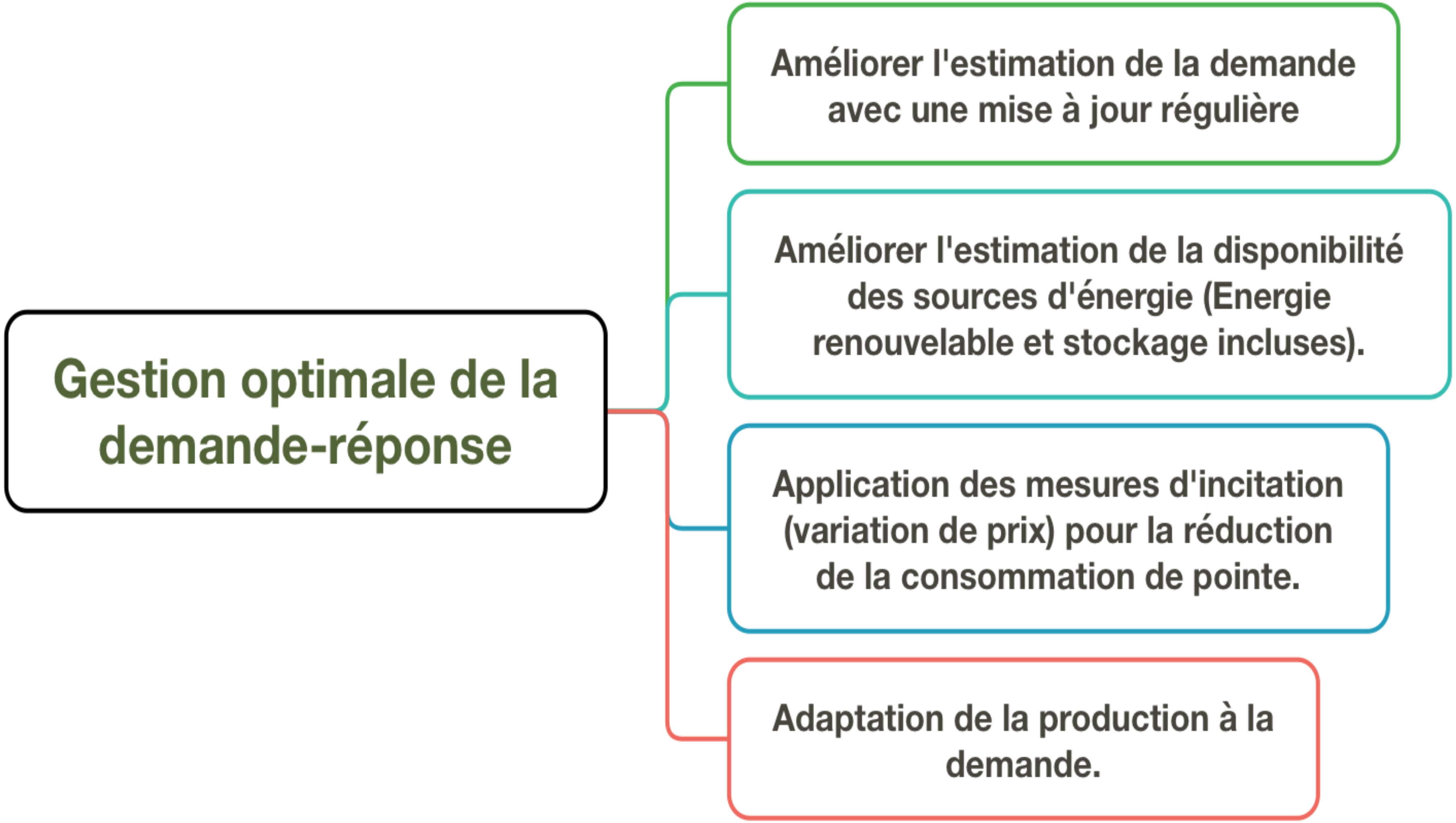
Overview and explanation of the components:

	Component	Function
Battery 	Uninterruptible power supply (UPS) Depending on the requested bridging time in case of power failures, an uninterruptible power supply based on battery or capacitor modules is used.	The task of the UPS is to continue to ensure the communication and/or the possibility to telecontrol the transformer substation in case of power failure.
Central Unit 	Remote terminal unit The remote terminal unit (RTU) is equipped with binary inputs and outputs, various communication interfaces, and freely programmable user programs.	Inside the intelligent transformer substation, the RTU serves as a connecting element to the network control center. It collects all relevant signals and receives control commands, or works autonomously according to predetermined control or regulation algorithms.
Communication system 	Communication modem The selection of the communication modem to be used is determined by the selected or available telecommunication technology.	Communication modems are employed for safe data transmission from the remote terminal unit to the network control center using the selected telecommunication technology.
Smart short Circuit 	Intelligent SC indicators Intelligent short-circuit and ground fault indicators with or without direction indication can be used in all grid types. For communication with the RTU, a Modbus RTU interface is available.	Intelligent short-circuit / ground fault direction indicators report short-circuits or ground faults in the medium-voltage distribution grid. Relevant measured values are acquired, allowing for an active load management in the distribution grid.
Motor 	Remotely controllable operating mechanisms Motor operating mechanisms inside the ring-main unit are available in original equipment manufacturer quality. If required, retrofitting is easily possible.	In order to reduce the reclosing times in case of fault, the switch-disconnectors or circuit-breakers are equipped with motor operating mechanisms for remote control.
Current Sensor 	Current sensors Current sensors with low-power transformer technology are available as closed or divisible ring cores.	The current signal serves to detect short-circuits and ground faults, and can be used as a measured value for load flow control or for optimal utilization of the grid capacity.
Voltage Sensor 	Voltage sensors Voltage sensors as resistor dividers are available as cast-resin plugs for insertion into the cable T-plug.	The voltage signal serves to detect the direction of the short-circuit or ground fault, and can be used as a measured value for load flow control or voltage regulation.

différents types de compteurs électriques

Linky pourquoi les nouveaux compteurs électriques posent question

Le réseau intelligent permet

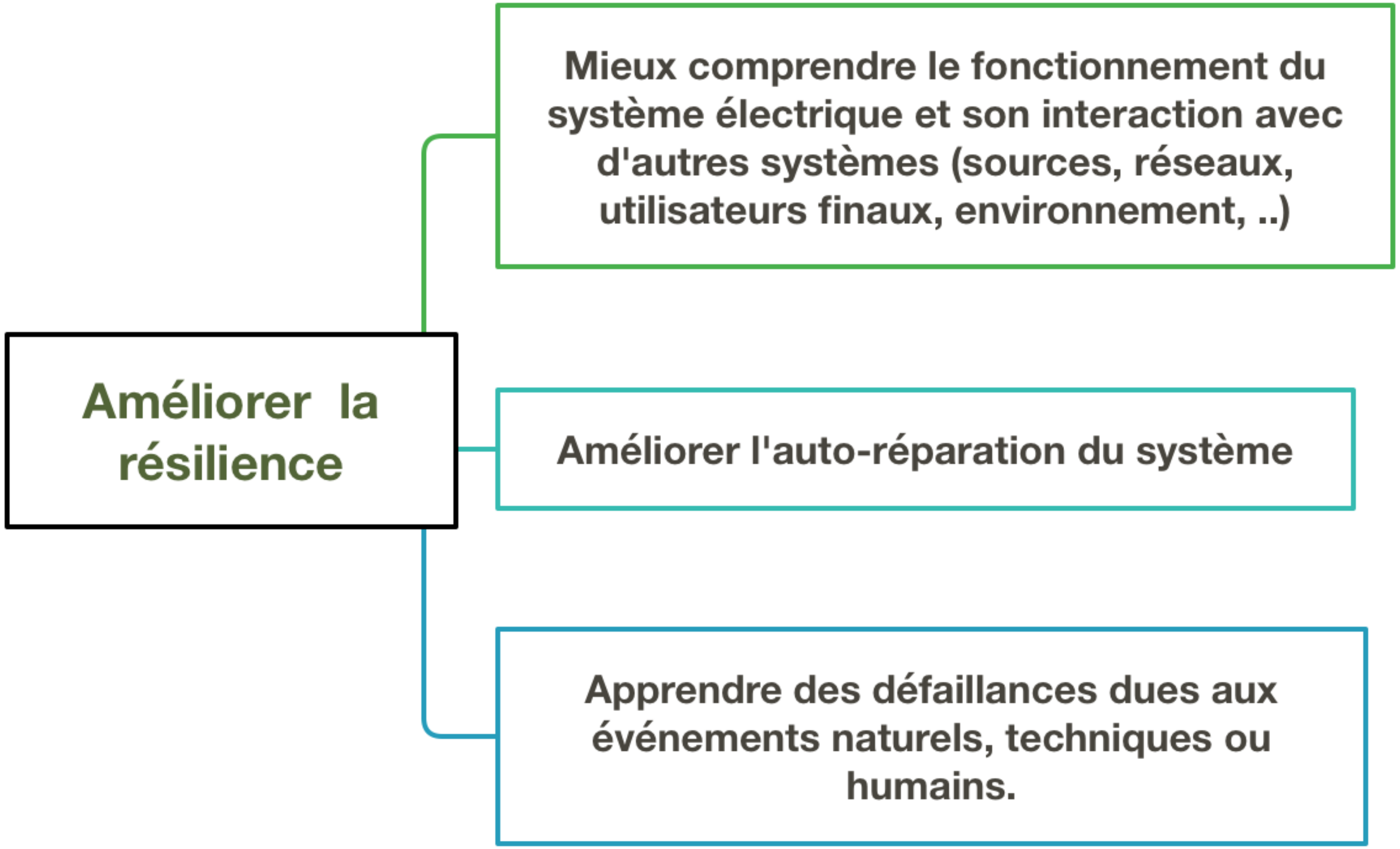


Le réseau intelligent permet

2. Réduire les défaillances

- Localisation rapide des défaillances.
- Intervention rapide et automatique pour confiner les défaillances et de limiter leur extension.
- Réparation rapide
- Assurer une bonne remise en marche

Le réseau intelligent permet



Le réseau intelligent permet

4. Accroître l’interaction avec les usagers

A travers un système d'information et de communication via des plateformes, on peut mieux interagir avec les usagers, mieux cerner les usages et les attentes et développer de nouveaux services,…

Fonctionnement du réseau intelligent

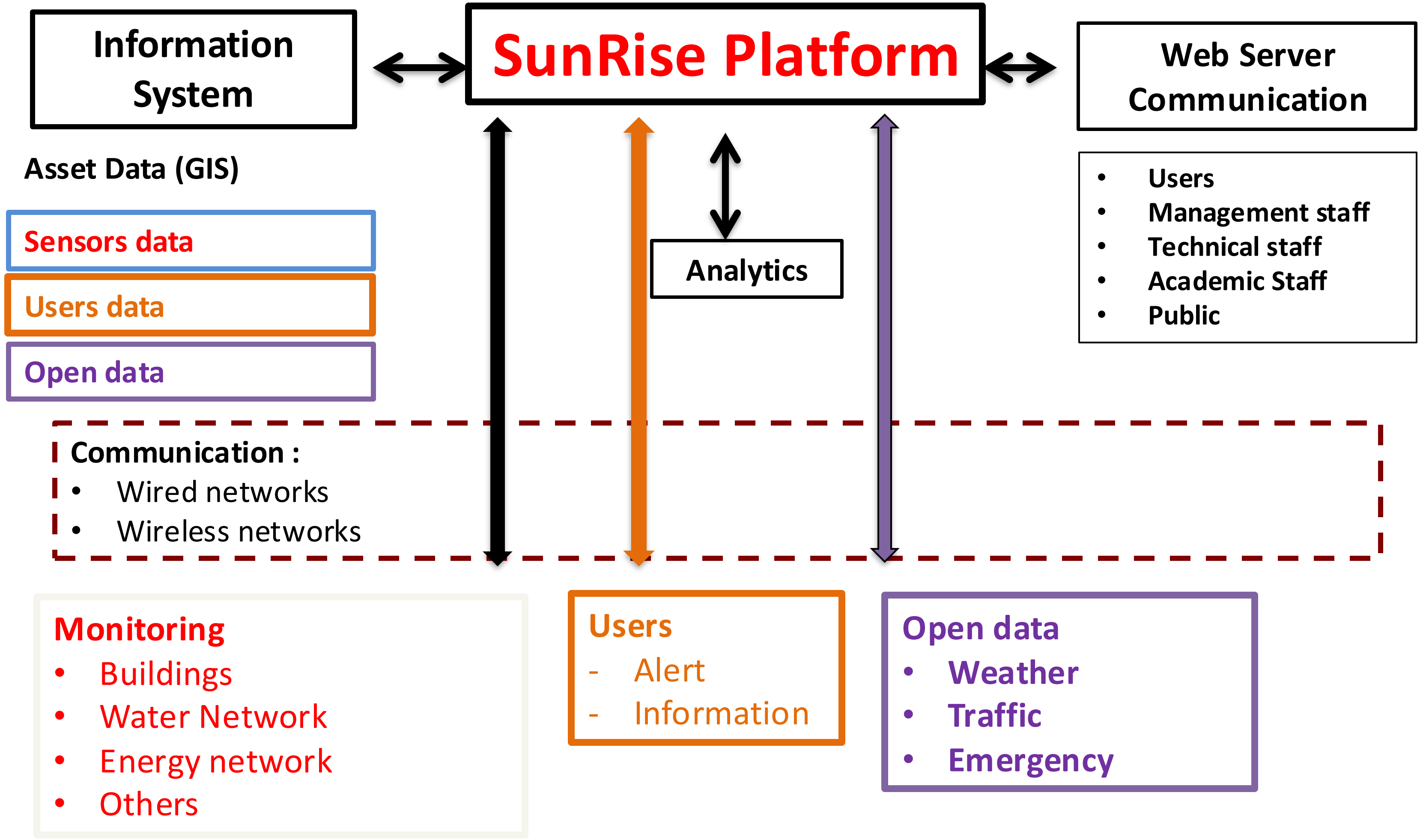
Fonctionnement du réseau intelligent

Les réseaux électriques intelligents

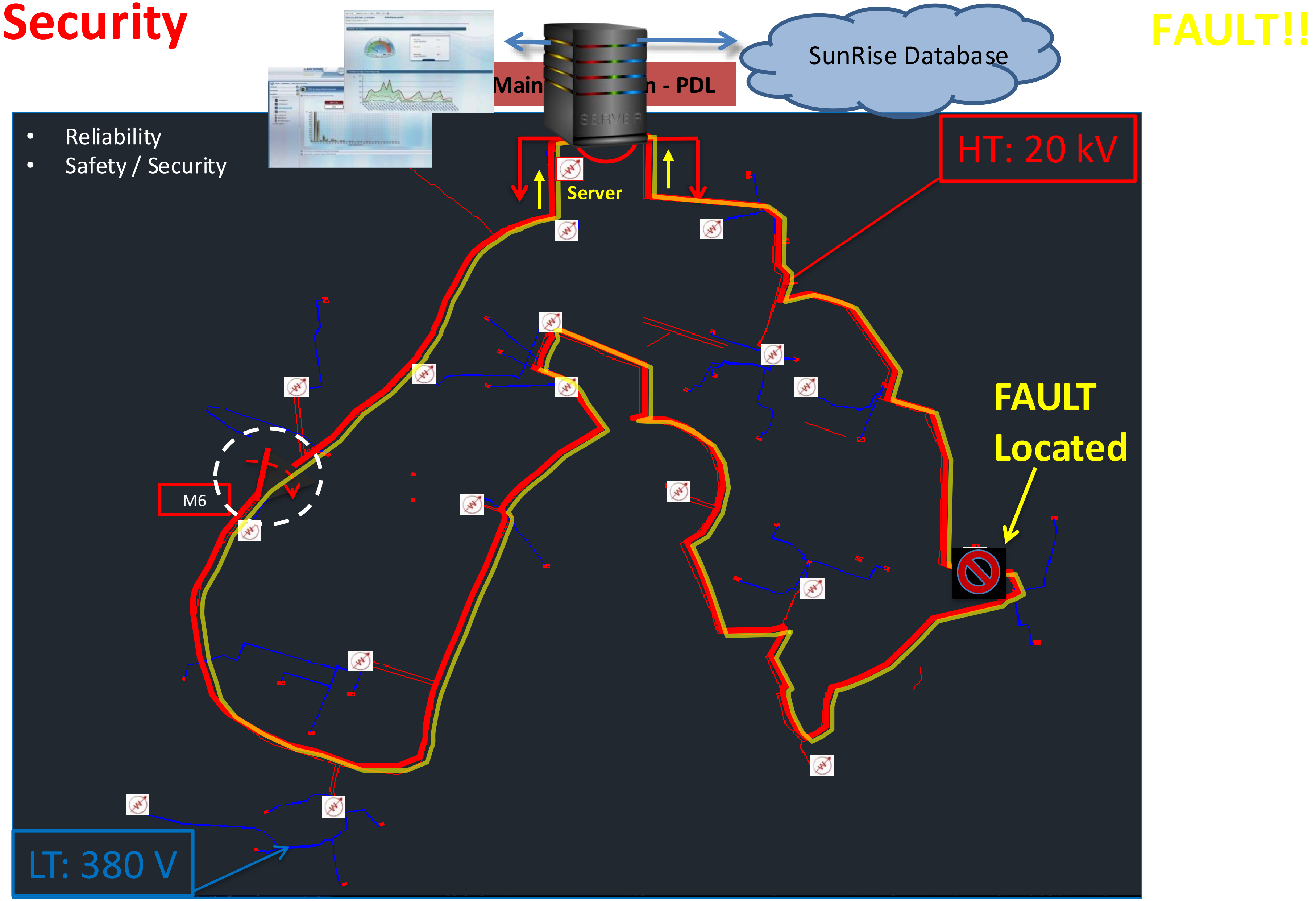
Plan du cours

Réseaux Electriques (Smart Grid)

- Fonctionnement
- Défis
- Solution « Smart Grid »
- Projet SunRise


Information System
SunRise Platform
Web Server Communication
Asset Data (GIS)
Sensors data
Users data
Open data
Analytics
Users
Management staff
Technical staff
Academic Staff
Public
Communication :
Wired networks
Wireless networks
Monitoring
Buildings
Water Network
Energy network
Others
Users
- Alert
- Information
Open data
Weather
Traffic
Emergency

Operational Security



Substation function (N)

Transformers

Distribution Panel (TGHT)

Monitoring system

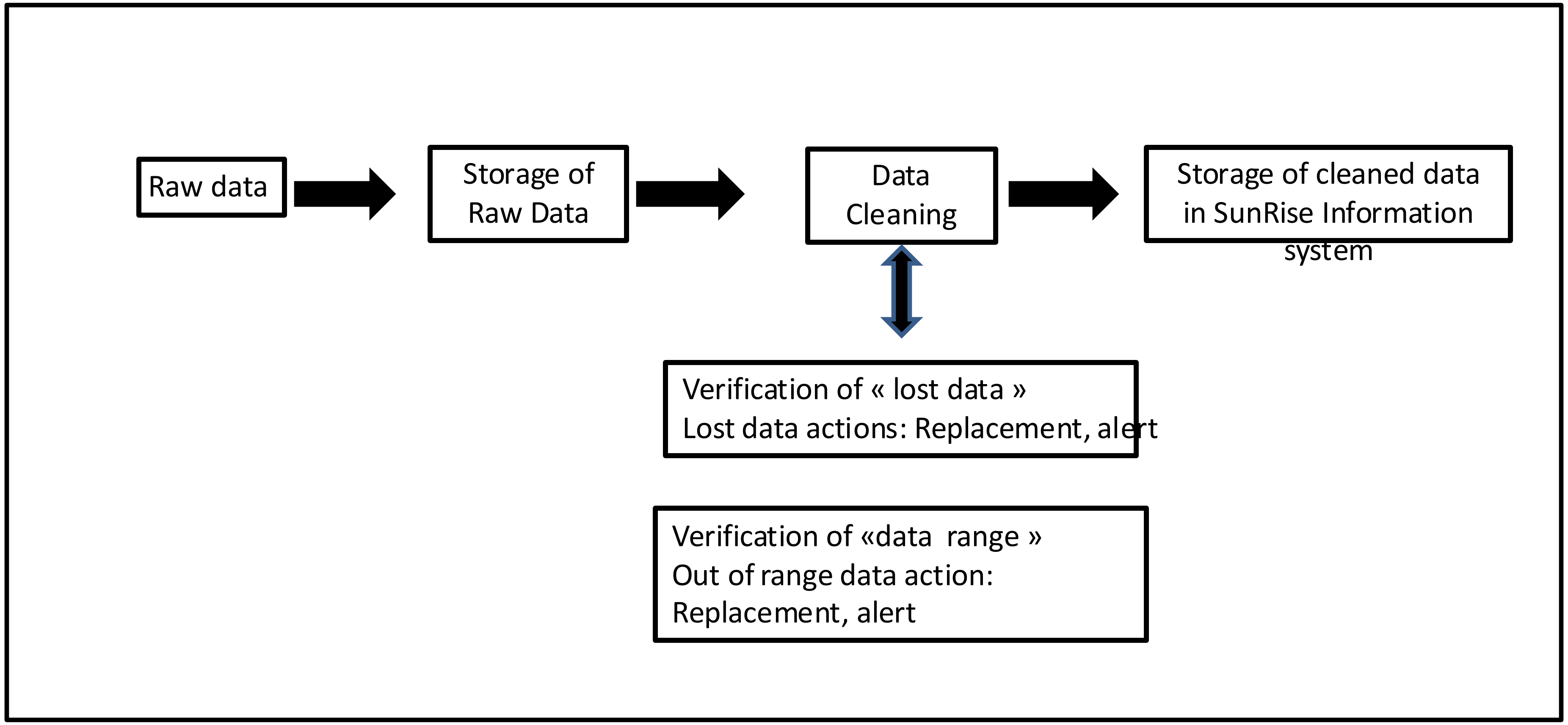
The system provides :

- Parameters (Current, Voltage, Frequency, Consumption,…)
- Events related to the service quality
- reports,…..

Figure 7: Vertelis Software

Methodology

Data Processing & Storage



Consumption Profile

1. Identification of days "categories":

- week end,
- working day,
- summer day,
- winter day,
- vacation day,
- specific event day

2. For each category and for each hour:

- Determination of the mean value (Vm) and standard deviation (Vsd).
- Construction of two expected intervals:
  - Interval 1: [Vm-2Vsd, Vm+2Vsd]
  - Interval 2: [Vm-3Vsd, Vm+3Vsd]

3. Conduct steps 1 and 2 to other time-scales (weekly, and monthly)

Global consumption of the scientific campus

Raw-data

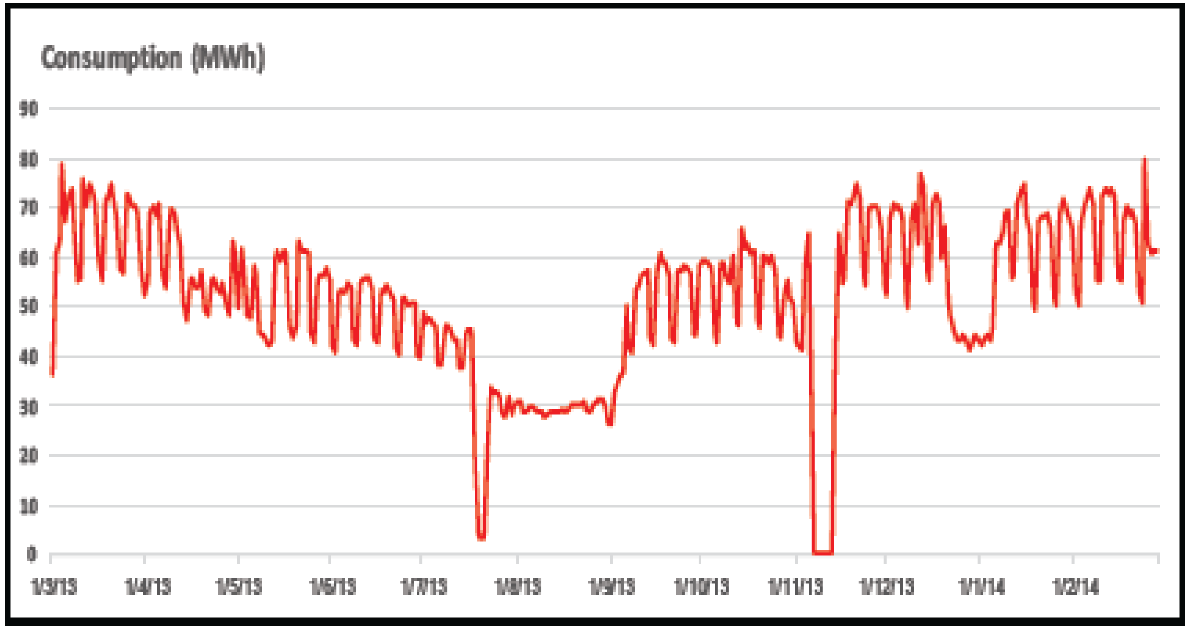


Figure 3.6. Daily consumption of the campus – Raw Data (Period 1/3/2013 – 28/2/2014)

Table 1 Statistical analysis of the daily consumption (Raw data)

Average (MWh)	51,80
Max ((MWh))	79,77
Min (MWh)	0,00
Standard deviatin (MW	15,70
Sdev/mean	0,30

Global consumption of the scientific campus

Consumption Classes

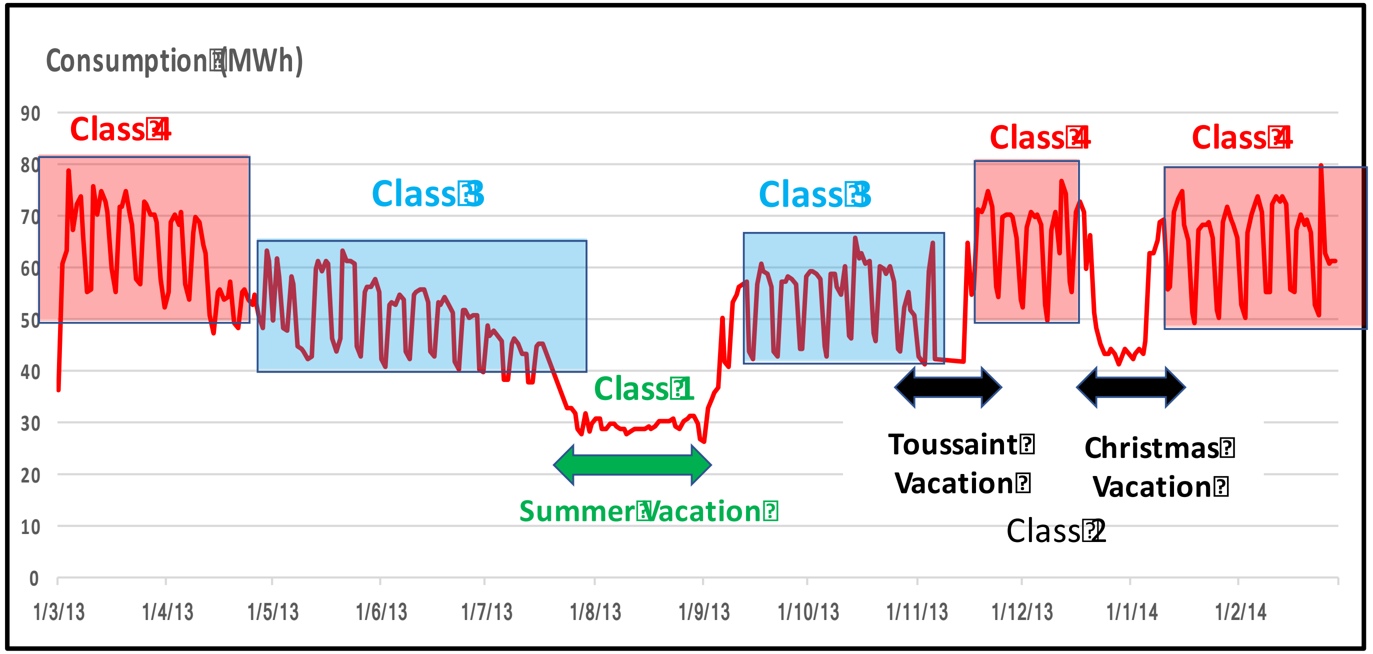


Figure 3.8. Level of the campus consumption

Table 3 Levels of the daily consumption of the campus

Level	Consumption	Period
1	30 (MWh/day)	Summer vacation
2	40 (MWh/day)	Class 2 and Week-end of class 3
3	50 (MWh/day)	Week-end of class 4
4	65 (MWh/day)	Working days of Class 3
5	80(MWh/day)	Working days of Class 4

Winter (Dec): Working Day vs. Weekend

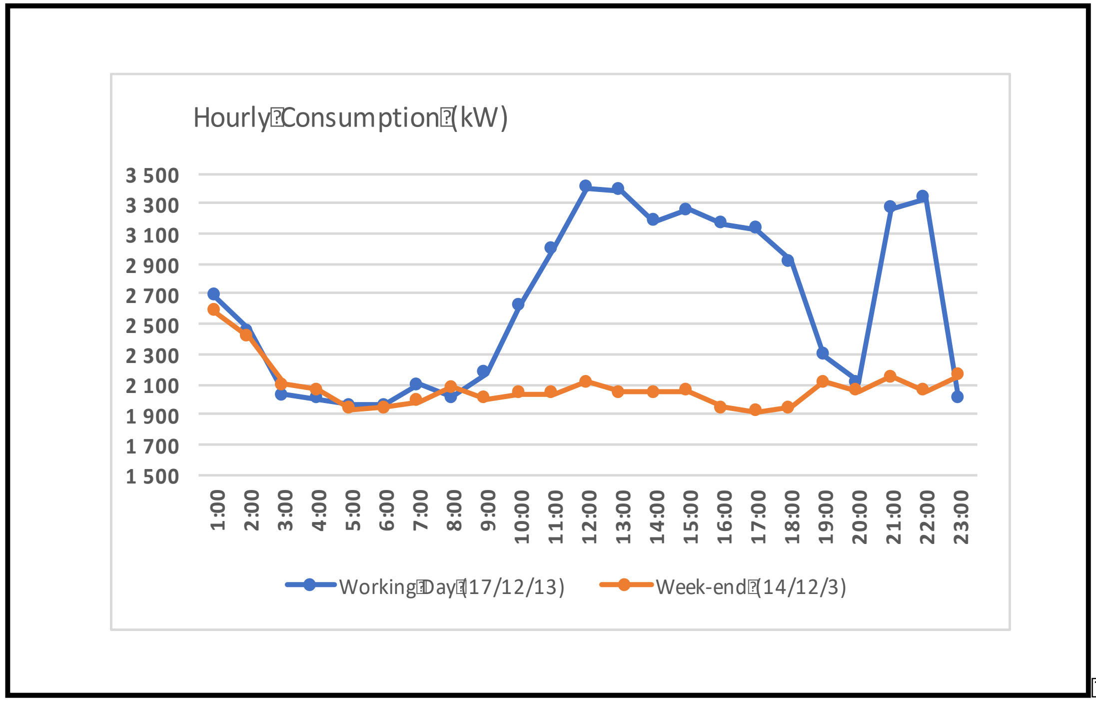
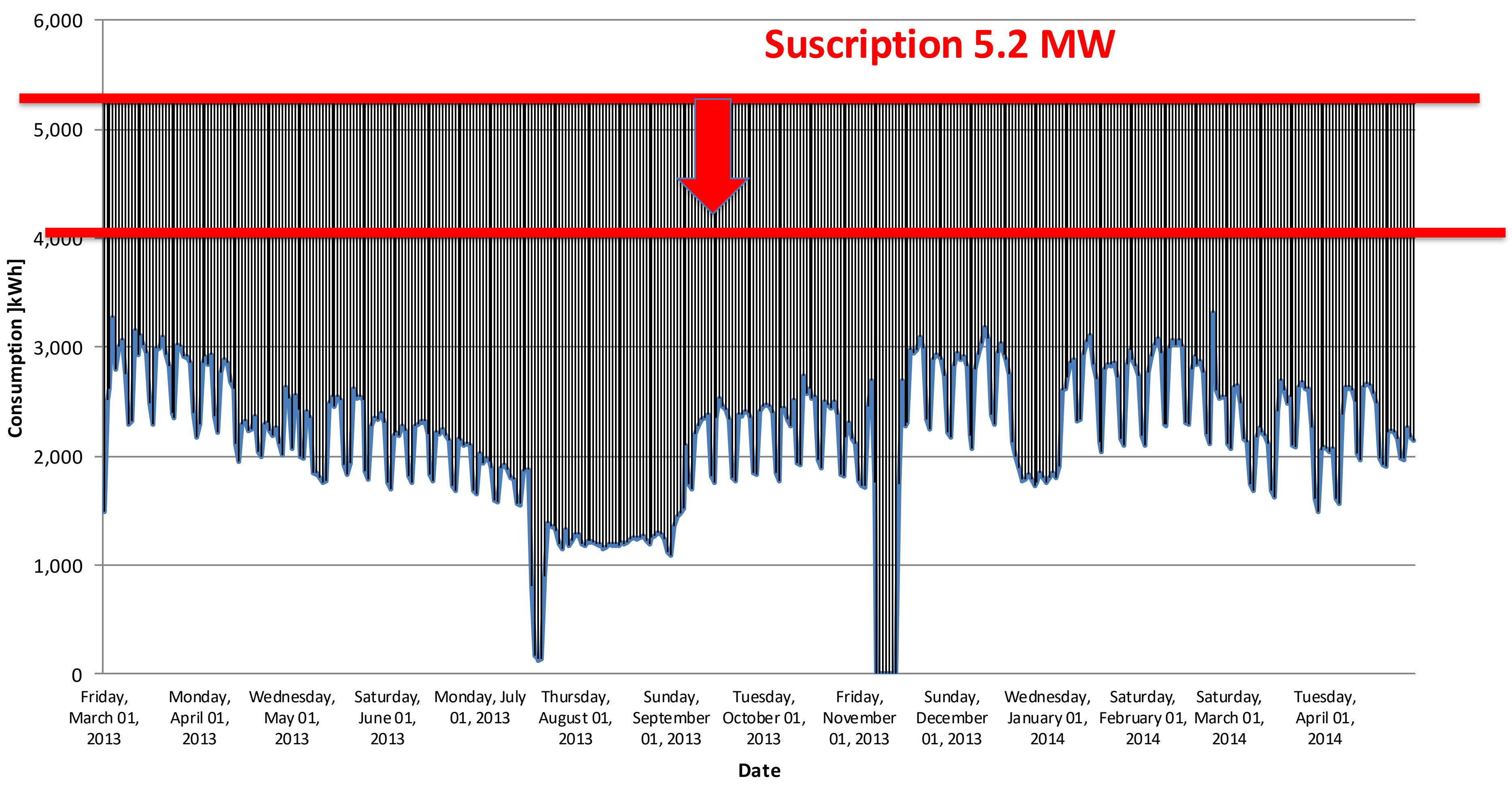


Figure 3.19. Analysis of the hourly consumption – Comparison of Working day (17/12/13) and Weekend (14/12/13)

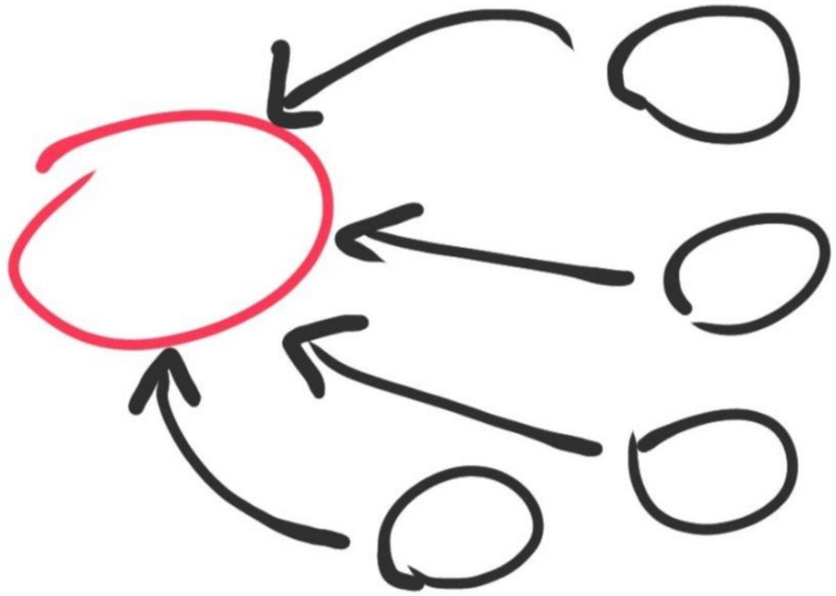
Table 4 – Consumption data for a working day and a weekend day – December 2013

Consumption (kWh)	(Tuesday, 17 December 2013)	(Saturday, 14 December 2013)
Total	60 454	47 764
Mean	2 628	2 077
Max	3 404	2 582
Min	1 961	1 915
St-Dev	559	151
St-Dev/Mean (%)	21,27	7,27

Total Consumption



Summary & Conclusion



Conclusion - Electrical Smart Grid

Major Challenges, because :

- Critical infrastructure (ensure the electrical supply)
- Aging infrastructure
- Increasing demand (population growth and increase in the comfort)

Conclusion - Electrical Smart Grid

Expectations :

- Increase in the security (reduce the outage)
- Reduce the peak demand (pricing)
- Use of renewable energy
- Energy storage
- Improve the system efficiency
- Users information and awareness

Conclusion - Electrical Smart Grid

The Smart Grid is the solution:

- Better understanding of the demand and available resources
- Optimal management (production, transport ,distribution and consumption)
- Increase in the security (real-time control, self healing)

Conclusion - Electrical Smart Grid

The Smart Grid is the solution:

- Integration of renewable Energy
- Integration of energy storage
- Dynamic pricing (reduction of the peak demand and reduction of the customers expenses)
- Optimization of the investment (upgrade, modernization, extension,..)

Conclusion - Electrical Smart Grid

The Smart Grid solution: Mature Technology

- Already used around the world
- Very good experience in the implementation

Yet, we still need more experience in

- The interaction with customers
- Dynamic pricing (economic model)

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