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GLOBAL MODEL BASED ANTICIPATIVE ENERGY MANAGEMENT OF A COMPLEX RAILWAY STATION

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ABSTRACT This paper deals with the energy management problem of a railway station. This problem comes out from the VEGEP project whose goal is to prove the benefit of an energy manager in railway stations. The project focuses on an existing railway station with electric appliances and complex HVAC composed of micro-cogeneration system, gaz boiler, thermal storage tank and heat spreaders. The model has been used to compute best energy management strategies that minimizes a compromise between dissatisfaction and costs. In the simulated scenario, a cost reduction of 25% has been obtained comparing to the case where no energy manager is used.

INTRODUCTION

French railway company SNCF is one of the biggest energy consumers in France. In the context of sustainable development, the group has several projects aiming to reduce energy consumption of its trains, industrial processes and buildings. The VEGEP (French acronym for "towards an energy-plus train station") project is lead by SNCF Innovation & Research (as an industrial partner) and G-SCOP, G2Elab (as an academic partner) and aims at optimizing energetic efficiency of SNCF buildings, in particular railway stations. It focuses on three main axes, which are: solutions for local energy production, optimum design and optimum energy management taking into account the specificity of railway stations' environment and process. This paper presents an energetic simulation with an energy management system including usages, local production and railway station building with its complex HVAC system. This complete railway station model has been used to develop and test an innovative tool for a scalable optimal energy management of standard building usages and specific railway station usages.

PROBLEM STATEMENT

This paper deals with the problem of modeling a special type of building i.e. a railway station with an energy management system. This problem came out from the VEGEP project whose goal was to prove the benefit of an energy manager in railway stations. The project focuses on an existing railway station with electric appliances. The heating system is an individual electric appliance that must be replaced. A proposal of centralized heating system was accepted providing the different behavioral modes of the system that can be managed. Energy management supposes to deal with multiple kind of control variables i.e. binary, integer and continuous. The problem was to identify acceptable and interesting degrees of freedom in the managed railway station. The energy manager is an adaptation of previous works (**?**). The global approach is based on a three layers mechanism. Firstly, an anticipative layer contains a virtual representation of the building system connected with predicted data concerning weather, particular usage, habits, etc. This layer generates an anticipative plan which is transmitted to another layer called reactive layer. The reactive layer adjusts the anticipative plan to the current situation. The error between predicted data and real data is taken into account and handled by this layer. Finally a third layer called local layer applies the set-points coming from reactive layer. This layer may be either a control system of an action advice mechanism.

RAILWAY STATION PARTICULARITIES

Railway system is a large grid enmeshed by railway stations. In France, railway stations are more than simple train nodes, they are multi modal transport hubs. For example, we could find taxi station, bus station, car parking, car rental agencies, shopping centers, external companies offices and at least rail company offices. Another particularity of the railway stations is the size and the unicity of each of them. In France, a lot of railway stations are registered under UNESCO heritage. Others are modern buildings designed by famous architects. Most of the railway stations are small and some are very small buildings. The very small stations are not used frequently because of their remoteness. However, these stations must be in use because of public utility contract signed by the railway company. These stations link small villages with other cities to let the people have an access to hospitals, schools, universities, employment pool,etc . . . Different kinds of appliances are installed in the railway station depending on its importance. For example, the platforms, in every railway station are equipped with lighting tubes or lamps, enlightened banners to inform passengers about the train timings or to do advertisement. In some special cases, stations are equipped with radiant heaters as well. Near the platforms, tunnels can also be found that link the station to the platform. Similarly, in big stations one can also found escalators and elevators. Due to this diversity of installed appliances in railway stations, the indoor station description cannot be generalized. It depends on the station architecture. The paper concerns. A station situated in Paris that hosts 100 000 travelers per day. Its infrastructure consists of a building of 800 square meters. It is composed of a large hall where travelers can transit. Around the hall, there are small shops that also include the train ticket shop managed by the owner. Small appliances like validators and automatic ticket dispenser and internal lighted advertisements are also installed.

MODELING FOR SIMULATION

Electric modeling

With the installation of energy meters, data help us to understand and create an electric simulator of a railway station. The energy meters provide detailed data to know the electric consumption of the appliances that are used for the electric characterization. The electric model developed leads to understand and represent the electric behavior of a train station. It also aims at simulating the current consumption scenario and comparing it with future electric consumption scenarios based on energy management strategies between producers and end-users.

Model of electric end-users Electrical appliances use electricity as source of energy. After the identification of all the electrical appliances, they are classified in 12 categories. The categories of appliances have been characterized before creating their respective models. Characterization aims at determining all the characteristics required to construct electrical models: the maximal, minimal and nominal power, the parameters that influence the current consumption, the identification of degrees of freedom and additional parameters for the appliance management purposes. Therefore, the methodology consists of several steps:

1. Analysis of the current electrical consumption profile
2. Identification of parameters that influence on the consumption
3. Determination of degree of freedoms for future consumption scenarios

The first part is the analysis of the temporal consumption profile provided by energy meters. With these energy graphs, the characteristics of the electrical equipment as well as its utilization profile can be identified. The second step consists in identifying the parameters that influence the current consumption and the regulation system that is installed for each electrical end-users (**?**), (**?**). Currently, six external parameters have been identified:

- The human behavior
- The train station working hours
- The travelers flows
- The exterior luminosity (sun radiations)
- The temperature
- The air quality

This identification allows creating a consumption function with parameters as input and consumption profile as output.

The final step leads to find degrees of freedom for the control of appliances in order to optimize the electric consumption. These degrees of freedom depend on new external parameters that influence the future electric consumption of the appliance. This characterization leads to understand the behavior of an appliance and its current electrical consumption profile in order to find new strategies to manage it and reduce its consumption.

For the modeling of electrical appliances, the Energetic Macroscopic Representation has been chosen. With this representation, each appliance and its control system is modeled. All the electric flows of the system are represented. Each appliance can be materialized with a source and the control element with a conversion block (switch, dimmer). The consumption function determined in the characterization (depending on external parameters), is placed in a strategy block just below the conversion block. However, with the EMR, the representation of external parameters doesn't exist yet. It has been chosen to add this functionality to the existing representation in order to illustrate all the interactions. Therefore, an electrical appliance will be modeled with a source, a conversion block (control), a local strategy block (consumption profile) and external parameters in figure 1.

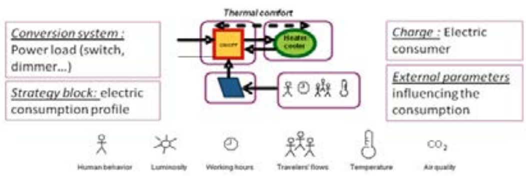

Figure 1: simple problem modeled with REM formalism

Global electric model The final EMR electrical model integrates all the electrical appliances, producers and network described below. Today, only the public network provides electricity to electrical appliances but in the future photovoltaic system as well as wind turbines and a part of a micro-cogeneration system energy will also provide electricity. It could be provided directly or used to charge batteries depending on electricity prices.

Figure 2: global modeling of electric appliances

For the electrical model of the railway station, the sources are connected to a coupling element that represents the distribution of the power among the 12 categories of appliances. The model has been developed for each kind of appliance at different levels of detail and is implemented in Matlab Simulink.

Thermal modeling

Railway stations are very specific buildings where different areas accommodating different activities with different thermal needs (**?**). There is generally one thermal heating system for the train station, providing heat for all the different heated areas. The modeling of the thermal envelop of train station with the nodal method (**?**), (**?**) as well as the thermal modeling of current and future thermal producers with state space representation are presented in the next section. These models are used to validate different energy management scenarios among thermal producers depending on the building characteristics.

Model of the building The whole thermal flows in a structure follows the first principle of thermodynamics i.e. all the ingoing thermal flows are equal to the outgoing thermal flows:

$$\phi^{input} + \phi^{produced} = \phi^{output} + \phi^{stored}$$

In a building, the thermal flows produced represent the heat sources. The thermal flows are stored into walls, floors or roofs depending on storage capacities of materials and the coming and out-going flows. These flows consist on thermal gains and losses in the room with its environment. For example, heat gains could be provided by humans whereas the heat losses are due to the temperature difference between the interior and exterior and the insulation (thermal capacity) of the building. Therefore, in order to provide a thermal model in continuous state, thermal sources and thermal capacities and conductance of materials have to be considered. The equation below, from the first principle of thermodynamics, represents the final thermal balance in a structure:

$$[C_{th}] * \frac{\delta(T)}{\delta t} = [G_{th}] * (T) + (Q_{th})$$

where $[C_{th}]$, $[G_{th}]$, (Q_{th}) are respectively the thermal capacities matrix, the thermal conductance matrix, the temperature vector and the thermal source matrix.

The nodal method (**?**) consists of modeling the thermal structure with electrical analogies: the structure is modeled by electrical node network. The nodes represent the temperature in a specific material. Therefore, a heat flow is represented by an electric current, a resistance represents the thermal conductance of a material and the capacitor a thermal capacity. The equation associated is the same as for electric currents in a node. With this method, the description of the building is simplified, therfore simulation time are reduced. The purpose of the study is to split up the structure in isothermal volumes. All the nodes build up a system of space-temporal differential equations. With the thermal balance equation. A matrix system can be written as a state representation:

$$[C_{th}] * \frac{\delta(T)}{\delta t} - [G_{th}] * (T) = [Q_{th}]$$

In conclusion, the thermal laws expressed in each thermal node are determined by the equation:

$$[C_{th}] * \frac{dT_i}{dt} = \sum Gth_{ij}^{cond} * (T_j - T_i) + Q_{th}(t)$$

For the case study, a model of a train station (pilot site) has been used with four areas, two areas at the ground floor, one heated area representing the ticket sales' shop, the other non heated area representing the public hall and two other heated office area on the second and third floors. The building with all thermal conductance, capacities and sources between materials and spaces is represented in Figure 3.

For each node, there are interactions with other spaces (convection and conduction heat transfers) that are in contact and are made of other materials. There are also interactions with the exterior due to the ventilation system and opened spaces. These interactions are represented with thermal conductance between two spaces. With the interior environment, thermal reactions are also integrated i.e. thermal sources and heat storages (due to thermal capacity of materials), modeled in the schema with electrical sources and capacitors.

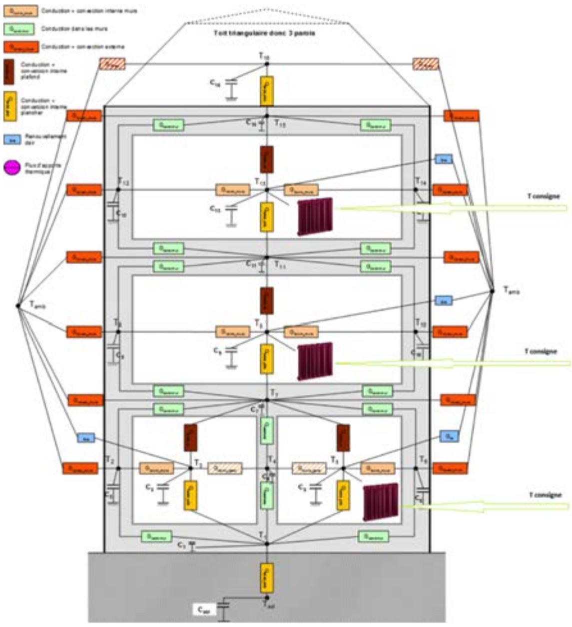

Figure 3: thermal building modeling

Applying the thermal balance equation to one node, for example T_5, the equation is given by:

$$C_{th}\frac{dT_5}{dt} = G_{T1T5}(T_5 - T_1) + G_{T4T5}(T_5 - T_4) + ...$$
$$...G_{T6T5}(T_5 - T6) + G_{T7T5}(T_5 - T_7) + \dots$$
$$\dots + G_{T_{amb}T5}(T_5 - T_{amb}) + \phi_5$$

The same equation was applied for all the nodes in the building and a matrix system can be writted as a state equations, representing the thermal model of the railway station:

$$[C_{th}] * [\frac{dT}{dt}] - [G_{th}] * [T] = [Q_{th}]$$

with the vector of temperature derivatives:

$$\begin{pmatrix} \frac{dT_1}{dt} \\ M \\ \frac{dT_{15}}{dt} \end{pmatrix}$$

the temperature vector:

$$\begin{pmatrix} T_1 \\ M \\ T_{15} \end{pmatrix}$$

the thermal capacities matrix:

$$\begin{pmatrix} C_{th1} & & 0 \\ & 0 & \\ 0 & & C_{th15} \end{pmatrix}$$

and the thermal conductance matrix:
The vector of thermal sources is given by:

$$Q_{th} = \begin{pmatrix} Q_{th1} \\ M \\ Q_{th15} \end{pmatrix}$$

The natural sources (human heat) and heating systems satisfy:

$$Q_{th} = Q_{th_{loc}} + Q_{th_{lim}}$$

With all the identified parameters, the state equations corresponding to the model of the train station are easily determined. It can be implemented in Matlab Simulink for the simulation of the thermal behavior of the train station.

Model of thermal producers Today, a railway station generally has only one general heating system working with gas or sometimes fuel oil boiler. The heating system in a train station only provides heat for offices and sale areas. The public hall of a train station is not heated. The goal is to realize an energy environment for the simulation of different energy management scenarios. Therefore, future heating systems are integrated into the model. As the biggest part of the energy consumed in a railway station is electricity, it was decided to integrate a micro-cogeneration as heating system for a train station in order to produce heat and electricity (**?**). The model is composed of two heating systems: a gas boiler and a wood cogeneration. Moreover, a future heating system composed of the gas boiler, the wood micro-cogeneration, a hot water storage tank and a hot water exchanger are modeled.

To easily integrate a gas boiler into a whole heating system model, it was decided to model it by a gain equation. The equation of the gas boiler model is:

$$\phi_{gaz} = \rho * EP * Q_{gaz}$$

with ϕ_{gaz} the heat quantity produced by the gas boiler in KW , ρ the efficiency ratio,EP_{gaz} the mass energy of gas in KWh/m^3 and Q_{gaz} the volume gas flow of the boiler in m^3/h.

As for the gas boiler, it has been decided to model the wood micro-cogeneration heating system by a simple model i.e. a gain equation for an easy integration in the whole system. Therefore, the equation of the wood micro-cogeneration is given by:

$$\phi_{cogen} = \rho * EP_{wood} * m_{\dot{wood}}$$

with ϕ_{cogen}, the heat quantity produced by the wood micro-cogeneration in kw, ρ the efficiency ratio multiplied by the thermal ratio (production of heat and electricity), the mass energy of wood in kwh/kg and $m_{\dot{wood}}$ mass of the gas flow of the boiler in kg/h. A wood micro-cogeneration has a starting duration; it is a non-instantaneous heating system. That is why a delay has to be implemented in the model i.e. the starting duration of the wood micro-cogeneration is about 20 minutes.

A wood micro-cogeneration system and a gas boiler are two complementary heating systems. A wood

micro-cogeneration is scaled to provide the heat required by a railway station during coldest winter days whereas a gas boiler satisfy peak demand because of its flexibility. Moreover, it was also decided to add a hot-water storage tank, for heat storage that will be working depending on energy prices and train stations demand. The three components, the two heating systems and the storage tank are all linked by a general water heat exchanger where the heat is concentrated before supplying the heaters in the train station.
The schema of the whole heating system is represented in Figure4.

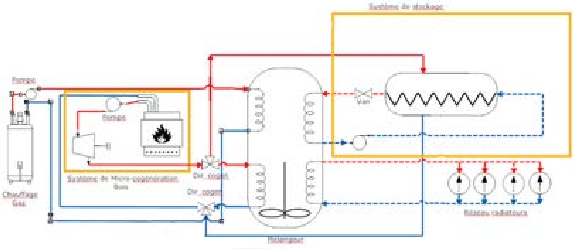

Figure 4: heatingsystem

The equations of the whole system, introducing the heat exchanger and the storage tank are defined by the thermal balance of the system:

$$eq1 : \phi_{gaz} + \phi cogen + \dot{m_{bal}} * C(T_{bal} - T_{ech}) * Van - \sum \phi_{rad}$$

$$.. = Masso_{ech} * C * \frac{dT_{ech}}{dt}$$

$$eq2 : Masso_{bal} * C * \frac{dT_{bal}}{dt} = ...$$

$$...\phi_{gaz} + \phi_{cogen} - \dot{m_{bal}} * C(T_{bal} - T_{ech}) * van$$

T_{bal} represents the temperature in the storage tank, T_{ech} the temperature in the heat exchanger, $\phi_{gaz} + \phi cogen$ the quantity of heat produced by the two heating systems, $\sum \phi_{rad}$ the quantity of heat needed in the heaters, $masso_{ech}$ the mass of the water in the heat exchanger, $masso_{bal}$ the mass of the water in the storage tank, $overset.m_{bal}$ the water flow at the exit of the tank and van the state of the valve at the exit of the tank (when $van = 0$ the valve is closed and when $van = 1$ the valve is opened and the tank restores hot water in the heat exchanger).

Global thermal model In order to create the final thermal model of the railway station, the thermal model of the train station's envelope is assembled with the thermal producers' model. A simplified thermal model (see figure 5) with the energetic macroscopic representation has been developed in order to get a visual model of the thermal part of the energy model and to realize a global model (thermal+electric) with the EMR.

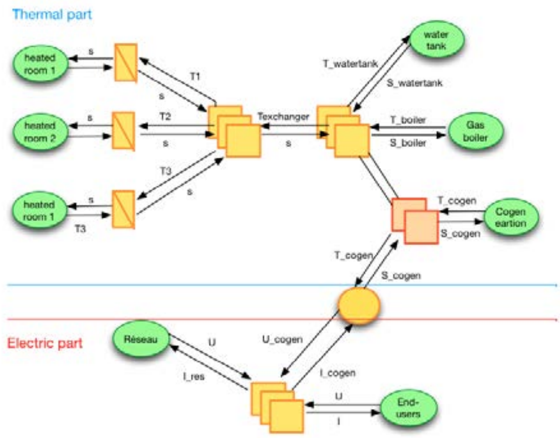

Figure 5: cogeneration REM model

MANAGEMENT SYSTEM

The energy management system cannot manage all the appliances because some of them are critical such as ticket sale machines. The folowing acceptable degrees of freedom had been identified:

- turn on/off cogeneration
- set-point of gaz boiler
- storage or direct injection of hot water
- indoor set-point temperatures

The system developed for this application needs dynamic and static data. Dynamic data concerns mainly weather forecasting, employees' planning for the appliance usage and train scheduling with the expected passenger flows. Static data concerns appliances characteristics, heating system and thermal envelop description. It yields a virtual representation of the railway station. It describes all the connections between the chosen variables. For scheduling in anticipative layer, the models are sampled with a 1 hour time step. It is determined by the time resolution of weather forecasts.

Predicted data

The predicted data used are:

solar irradiance, direct and diffuse irradiance taking into account the nebulosity. It makes it possible to estimate the energy provided by the sun on the building and prepare switching decision for the systems that takes time to start.

train station program. The building is occupied by train company employees during working hours and by passengers. These occupants do not stay in the building for a long time but still expect for some services. The management system should take into account these variations in passenger flows according to the train schedule prevision.

Electrical appliance usage

The following model has been used to describe the consumed power:

$$P_{consumed} = (P^{usage}_{nominal} * usage + P_{Idle}) * on$$

with: $P_{consumed}$, the power consumed by the appliance
$P_{nominal}^{usage}$, the power depending on the appliance state
$usage$, the usage ratio. It represents the appliance control description. This variable can be continuous or binary one
P_{Idle}, It represents the minimum power used by appliance to be in idle mode, ready to be used. on, It is worth 1 if the appliance is turned on and 0 if it is off (parameter)

Because of the product, the model is nonlinear. According to the type of $usage$ (binary or continuous), a linearization can be applied.
If $usage$ is binary, it is used to model ticket checking machines and ticket distributors remotely controlled. They can be remotely turned on/off. When it is off, there is residual idle consumption. When it is on, the consumption depend on the state used/not used by passengers.

$$\delta_{result} = usage * on$$
$$\delta_{result} \leq usage$$
$$\delta_{result} \leq on$$
$$\delta_{result} + 1 \geq on + usage$$
$$P_{consumed} = P_{nominal}^{usage} * \delta_{result} + P_{Idle} * on$$

If the $usage$ is continuous, it is used to model radiative platform heaters that are in idle mode constantly. When a train arrives, the heater is turned gradually on according to the external temperature and the proximity of passengers.

$$z \leq us\hat{a}ge * on$$
$$z \geq us\check{a}ge * on$$
$$z \leq usage - us\check{a}ge * (1 - on)$$
$$z \geq usage - us\hat{a}ge * (1 - on)$$

$$P_{consumed} = P_{nominal}^{usage} * z + P_{Idle} on$$

Building

The representation of the building used in the energy management system is different from the one used by simulation part. A simplified model, considering the managed areas as single thermal zone has been used (**?**),(**?**). The representation is formalized as a state space representation where the state space variable represents the average wall temperatures:

$$T_w(k+1) = F.T_w(k) + G_o T_o(k) + G_i \phi_i(k) + ...$$
$$...G_w \phi_w(k) + G_a T_a$$
$$T_i(k) = H_w T_w(k) + H_o T_o(k) + H_i \phi_i(k)$$

avec

$$F = e^{\frac{-\Delta}{\tau}}$$
$$G_o = K_o \tau (1 - F)$$
$$G_i = K_i \tau (1F)$$
$$G_w = K_w \tau (1 - F)$$
$$G_a = K_a \tau (1 - F)$$
$$H_w = \frac{R_v}{R_v + R_i}$$
$$H_o = \frac{R_i}{R_v + R_i}$$
$$H_i = \frac{R_i R_v}{R_v + R_i}$$

xith : T_o, the outdoor temperature
T_i, the indoor temperature for the considered thermal zone
T_w, the average temperature of the walls in a thermal zone
T_a, the average temperature of the adjacent thermal zones
ϕ_i, the power provided directly inside the thermal zone
ϕ_w, the power provided directly inside the wall
$R_o; R_i$, the equivalent thermal resistances
R_v, the thermal resistance deduced from heat exchanger
C_w, the equivalent wall thermal capacity
R_a, the equivalent thermal resistance defining the power flow exchanged with adjacent rooms.

Heating system

The heating system is described in the same way than for simulation. For energy management purpose, we take the same model removing nonlinearities as it is done for appliances.
The heating system models used for management are the same as for simulation model except that they are discretized in time with a 1h sample time. The first system combines tank and heat exchanger system. The procedure used for discretization is detailed in (**?**) and the result is:

$$\dot{T} = A * T * van + B * U$$

Dicretization using a step time ΔT leads to:

- if van=1

  $$T(k+1) = e^{A*\Delta T} * T(k) + A^{-1}(e^{A*\Delta T} - 1) * B * U(k)$$

  with: $T = \begin{pmatrix} T_{ech} \\ T_{bal} \end{pmatrix}$

  $$A = \begin{pmatrix} -\frac{\dot{m_{bal}}}{Masso_{ech}} & \frac{\dot{m_{bal}}}{Masso_{ech}} \\ \frac{\dot{m_{bal}}}{Masso_{bal}} & -\frac{\dot{m_{bal}}}{Masso_{bal}} \end{pmatrix}$$

  $$B = \begin{pmatrix} 1 & 1 & 1 \\ 1 & 1 & 0 \end{pmatrix}$$

  $$U = \begin{pmatrix} \phi_{gaz} \\ \phi cogen \\ -\sum \phi_{rad} \end{pmatrix}$$

- if van=0

$$\begin{cases} T_{ech}(k+1) = T_{ech}(k) + \frac{\Delta T}{masso_{ech} * C} * U(k) \\ T_{bal}(k+1) = T_{bal}(k) + \frac{\Delta T}{masso_{bal} * C} * U(k) \end{cases}$$

For energy producers, the management models are similar to simulation models for gaz boiler. There is another particularity in the appliances composing the heating system. Indeed, cogeneration system can be turned on or off but with significant time delay because of the fuel based heating process. The cogeneration system used is based on sterling cycle fed up with an external combustion. The fuel used is wood pellets. To be operational, the combustion chamber must reach about 120C using an electric resistor, after this, the wood pellets begin the combustion and the system starts producing energy.This delay is modeled as shown in Figure 6.

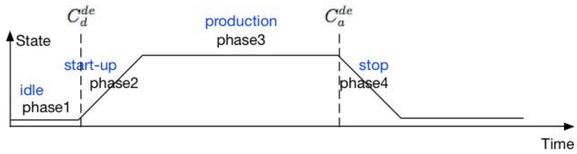

Figure 6: delay representation

The considered time delay for the simulation is 20 minutes. It is less then one hour but it can not be neglected because of pumping phenomenon that is difficult to manage practically. A multi-phase model has been used to solve the scheduling problem:

$$\begin{aligned} phase_1(j) - C_d^{de} &\leq phase_1(j+1) \\ phase_1(j) - C_d^{de} - 1 &\leq phase_2(j+1) \\ phase_2(j) &\leq phase_3(j+1) \\ phase_3(j) + C_a^{de} - 1 &\leq phase_4(j+1) \\ phase_3(j) - C_a^{de} &\leq phase_3(j+1) \\ phase_4(j) &\leq phase_1(j+1) \\ phase_1(1) &= 1 \\ \forall j / \sum_{i=1}^{4} phase_i(j) &= 1 \end{aligned}$$

$$\eta_{cogene}(k) = \sum_{i=1}^{3} phase_3(3 * (k-1) + i)$$

Each $phase_i(j)$ represents different cogeneration system possible states with step time of one third of an hour j. $phase_3(j)$ corresponds to the production phase where the system produce thermal and electrical energy. $\eta_{cogene}(k)$ represents one third of a one hour period when the system is completely turned on, it allows to return to the chosen global step time i.e one hour. It varies between 0 and 3, 0 corresponds to the absence of production during the current hour k and 3 corresponds to continuous production during the current hour.

Comfort representation

The comfort representation is a model that links a variable to a occupant dissatisfaction user level. It is used for the ambient temperature in a thermal zone. This model is the evolution on dissatisfation according to the current temperature as it is shown in the figure 7.

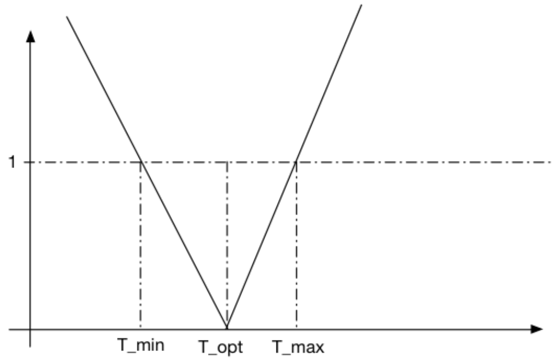

Figure 7: Dissatisfaction model

RESULTS

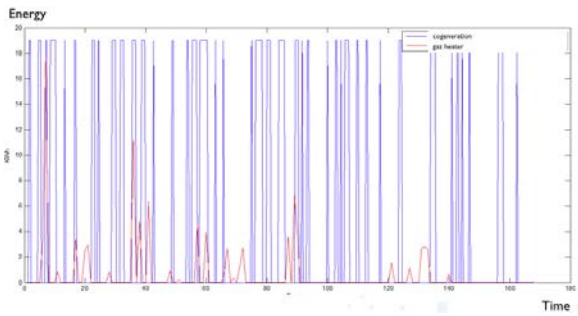

Figure 8: Heating system producers

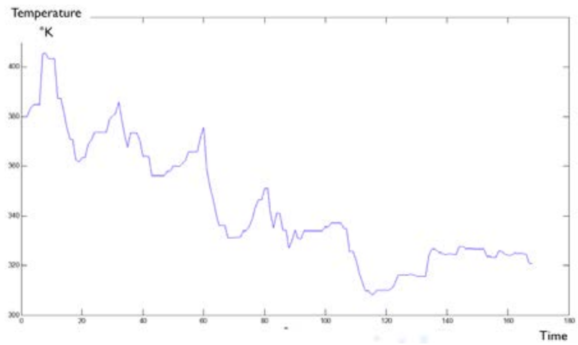

Figure 9: Tank temperature

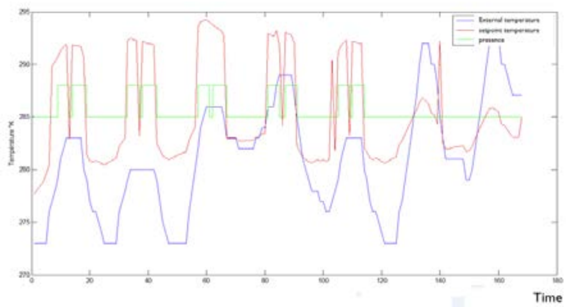

Figure 10: Inside and outside temperature

Figures 8,9,10 present the results of the global management of the cogeneration, gaz boiler and temperature set-points. This management plan is generated by linear programming solver where problem description is introduced. It corresponds to the the anticipative layer in (**?**). Optimization objective is defined as a compromise between dissatisfaction and cost assuming a French "hc/hp" pricing. An interesting phenomenon can be seen when analyzing the three curves. In the storage tank, peaks and hollows of temperature can be observed. It corresponds to switching on and off the cogeneration system. It points out that the storage strategy for the tank. It amounts to maximize the interest of the cogeneration system usage. Actually, the cogeneration system produces both thermal and electrical energy with cheaper primary energy than gaz used by the boiler but the thermal energy produced by cogeneration system can not be absorbed continuously by diffusers. Therefore, the cogeneration is turned off sometimes taking into account starting duration and required energy for start up. When necessary, the necessary energy for diffusers can be provided by the tank and the gaz boiler.

The results presented in this paper has been compared with a simulation without energy management system. The bill gain is around 25% when an energy management system is used assumming a "hc/hp" French pricing, which was the actual electricity pricing in the railway station chosen for experiments.

The bill gain is related to the time usage of cogeneration system. The cogeneration system based on stirling cycle works around nominal point of wood pellets consumption, thermal and electric energy production. If the heat produced by the co-generator cannot be used, it has to be switched off. The management system help to maintain on the cogeneration longer because of primary energy price. The wood pellets energy considering efficiency of cogeneration is cheaper than gaz used by gaz boiler. This consideration is taken into account by the solver through models, it takes into account the turning on/off cost of the cogeneration system.

CONCLUSION

In this paper, a model for simulation and energy management of a railway station has been proposed. It covers building thermal behavior, heating system based on a gaz boiler, a storage tank and a wood pellet cogeneration system, ticket checking machines, tickets distributors, radiative platform heaters, train scheduling and, of course, people including staff and passengers. The model has been used to compute best energy management strategies that minimizes a compromise between dissatisfaction and costs. Results point out that the usage of the cogeneration system can be increased by 15% (in simulated scenario) by properly using the storage tank and the gaz boiler. For the simulated scenario, a cost reduction of 25% has been obtained comparing to the case where no energy manager is used.