How New “Smart” Temperature Control Technologies Reduce Energy Consumption in Homes

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Executive summary

Depending on the physical location of a home, up to 80% of overall household energy consumption is consumed for heating. Factors such as insulation, windows, and construction materials all impact how much energy is wasted. Home occupant behavior is also a contributing factor. This paper analyzes simulations of both French and Danish homes that demonstrate how zoned heating approaches can yield up to 30% in energy savings.

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Introduction

The residential segment in Europe accounts for 40% of total European energy consumption. Of that total, up to 70-80% of consumption is dedicated to the heating of the home dwelling. As a result, home owners are recognizing the need to enhance efficiency and control energy costs. Most home and apartment owners don’t realize that home energy costs can be reduced without making large investments. New affordable “smart” technologies are now available that are more effective at managing and controlling home heating consumption.

A number of factors influence energy consumption in homes. Insulation class and type of windows are recognized by most consumers as important drivers of home heating demand. Less commonly known causes of energy waste include inaccuracy of the heating system, which implies errors in temperature set points that are selected and reached, as well as the proper sizing of heating system capacities. The behavior of individual users and the methodology by which temperatures are turned up or down in different locations also have a significant impact.

Some of the new energy consumption reduction practices in homes involve information systems that regulate heaters when rooms are not in use, or that apply particular parameters on a room-by-room level to ensure comfort, while saving energy at the same time. These types of technologies fall under the broad category of what are called Home Energy Management Systems (see **Figure 1**).

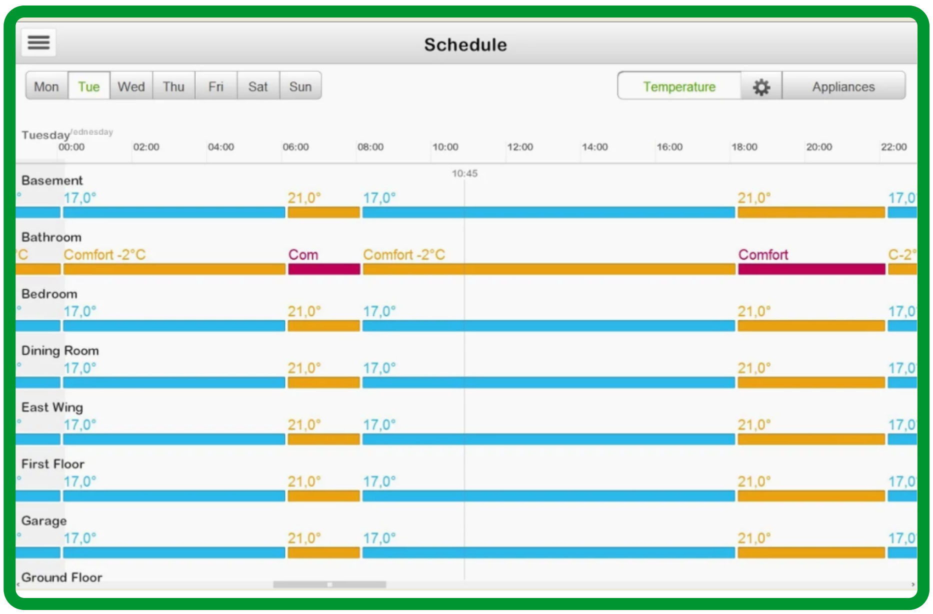

Figure 1
Home Energy Management Systems can be used to monitor temperatures in different “zones” and the energy consumed for heating (sample of Schneider Electric Wiser screen)

This paper presents data that has been gathered through a series of building simulations applied to various types of European homes with different energy ratings. Results from this study demonstrate that Energy Management Systems can generate savings of up to 30% thereby cutting energy bills through active temperature management practices (e.g., scheduled home control).

Background

Since the 1970’s, various organizations have conducted numerous studies around the topic of energy management in homes. These studies have determined that results are highly differentiated depending on the following factors: country, climate zone, and the energy rating. Early primitive measurement based on readings from programmable thermostats provided some of the initial data. However, recent advancements in technology now make it possible to gather much more accurate and relevant data in order to more broadly influence energy control within the home. For the purposes of the Schneider Electric study (whose results are presented in several tables later on in this paper), a validated building engineering tool called the IDA Indoor Climate and Environment (IDA ICE) tool was utilized.

A single family house with an area of 150 m2 (1615 sq ft) was built into the simulation program with construction properties according to the existing European building regulations. The floor plan is taken from an existing construction in Denmark where the house’s yearly heat-related energy consumption is known. The measured data was used to verify that the simulation results were close to the actual measured data. The tool generates whole year energy results and takes into account building envelope parameters, weather information, and control systems. The data projected for the French homes is based on simulation using the same model but incorporating different building material properties, which are reflecting the European building energy classes in France, as well as different location, and weather profile.

The tables below summarize data gathered from the simulation as it pertains to efficiency performance and illustrate a number of home categories (A, B, C, D, E, F, and G). These various categories are defined as follows:

- Category A, B houses, newly built (2015), state of the art houses
- Category C houses, built around 2010
- Category D houses, typically built around 1990
- Category E, F, G houses, typically built in 1970 and before

The characteristics of these different energy categories of homes are taken from the building regulation codes in each country and the values utilized are illustrated in **Tables 1** and **2** below.

Table 1
Denmark home simulation characteristics

Denmark	Cat A Cat B	Cat C	Cat D	Cat E Cat F Cat G
Year of construction	2015	2010	1990	1970
External wall insulation (U)	0.08	0.106	0.36	1.7
Window insulation (U)	0.7	1.5	2.3	3.2
Infiltration rates	0.3	0.4	0.45	0.5

Table 2
France home simulation characteristics

France	Cat A Cat B	Cat C	Cat D	Cat E Cat F Cat G
Year of construction	2015	2010	1990	1970
external wall insulation (U)	0.21	0.4	0.52	2.4
Window insulation (U)	1.1	2.2	2.6	3.8
Infiltration rates	0.8	1.3	2	2

During the simulation process, the temperature set points were programmed separately for each room and followed schedules that reflected a user's occupancy patterns. The set point temperature was defined at 22° C (72° F) when the room was deemed as occupied, and 17° C (63° F) when the room was unoccupied, thus taking into account an average user's comfort levels.

As a baseline for measurement and comparison, a control (constant) comfort temperature of 22° C (72° F) was established as a reference point for the entire house during the duration of the heating season.

The tables below represent simulation results from houses located in Denmark (**Table 3**) and France (**Tables 4, 5, and 6**). As part of the data presented in these tables, the following descriptions apply:

- "Night set back" category implies a 7 hour temperature set back period to 17° C (63° F) during the night,
- "Night and Day set back", implies an additional 7 hours of set back period during the day, when there is no occupancy, (based on the assumption that occupants are leaving their homes for work).
- "Zone control" implies a room-by-room control where different temperature levels are set according to the occupancy of the zone (with the "zone" equaling a specific room). For example, if the living room is used only in the evening and not in the morning or afternoon, the temperature level is kept at 17° C (63° F) until 5 pm (17:00) when the occupants are coming home and are planning to occupy the living room. At that time the temperature set point automatically changes to 22° C (72° F).

The results in **Tables 3, 4, 5,** and **6** are shown as kWh/m2/year and annual percent savings compared to the baseline.

Observations and results: Denmark

Table 3
Heating consumption for different control strategies as well as the savings for the different energy class houses (Copenhagen example)

Copenhagen, Denmark Climate Zone Home					
		Cat A Cat B (2015)	Cat C (2010)	Cat D (1990)	Cat E (1970) Cat F Cat G
Baseline	Heating consumed [kWh/m2/year]	44	64	109	259
	Savings	0 %	0 %	0 %	0 %
Nigh set back	Heating consumed [kWh/m2/year]	44	63	106	223
	Savings	1 %	2 %	3 %	14 %
Night and day setback	Heating consumed [kWh/m2/year]	41	58	99	209
	Savings	6 %	9 %	10 %	19 %
Zone control	Heating consumed [kWh/m2/year]	38	53	91	186
	Savings	13 %	17 %	17 %	28 %

Observations regarding homes in the different categories

- In the E, F, and G category houses, even short thermostat set back periods show significant savings potential (e.g., 14% for only a 7 hour of night set back).
- In the C and D category houses with longer set back periods, the savings potential increases to 17% of heating energy savings when applying zone control.
- In A and B category houses with long set back periods the savings potential increases to 13% of heating energy savings with zone control
- Scheduling has a bigger influence in houses characterized by lower insulation and bigger capacity heating systems.

Observations and results: France

Tables 4, 5, and **6** below reflect test results from climate zones in France (Nancy, Nice, and Bordeaux). The same method and control strategies were utilized as in the Danish simulations; however, building codes, energy ranking, climate zones, and building material properties were customized to the French market conditions.

The tables demonstrate the heating consumption for different energy rating building types in France (3 climate zones). The baseline consumption, followed by different control strategies such as night setback and zone control is compared. The results are shown as kWh/m2/year and annual percent savings compared to the baseline.

Table 4
Simulation data results for the Nancy, France example

Nancy, France Continental Climate Zone Homes					
		Cat A Cat B (2015)	Cat C (2010)	Cat D (1990)	Cat E (1970) Cat F Cat G
Baseline	Heating consumed [kWh/m2/year]	44	70	97.5	261
	Savings	0 %	0 %	0 %	0 %
Night set back	Heating consumed [kWh/m2/year]	43	69	95.3	246.4
	Savings	2 %	2 %	2 %	6 %
Zone control	Heating consumed [kWh/m2/year]	39	60	81	194
	Savings	11 %	14 %	17 %	26 %

Table 5
Simulation data results for the Bordeaux, France example

Bordeaux, France Oceanic Climate Zone Homes					
		Cat A Cat B (2015)	Cat C (2010)	Cat D (1990)	Cat E (1970) Cat F Cat G
Baseline	Heating consumed [kWh/m2/year]	42.2	67.5	92.6	250
	Savings	0 %	0 %	0 %	0 %
Night set back	Heating consumed [kWh/m2/year]	41.7	66.4	91.7	230
	Savings	1 %	2 %	1 %	8 %
Zone control	Heating consumed [kWh/m2/year]	38	58.4	79	191
	Savings	10 %	17 %	19 %	24 %

Table 6
Simulation data results for the Nice, France example

Nice, France Mediterranean Climate Zone Homes					
		Cat A Cat B (2015)	Cat C (2010)	Cat D (1990)	Cat E (1970) Cat F Cat G
Baseline	Heating consumed [kWh/m2/year]	26.7	40	55	152
	Savings	0 %	0 %	0 %	0 %
Night set back	Heating consumed [kWh/m2/year]	26.5	39	54	137
	Savings	1%	1 %	2 %	9 %
Zone control	Heating consumed [kWh/m2/year]	25.4	36	47	108
	Savings	5 %	10 %	15 %	29 %

The data collected from these simulations of French homes suggests that the largest savings obtained for all 3 climate zones are inevitably with zone control applied to a home with energy ranking E, F, or G.

For energy categories E, F, G there are also efficiency gains to be made at short set-back periods (night set back) with a 6-9% savings potential between the climate zones.

The results also show the influence of climate zone on savings, with colder climates driving the need for more heat. A typical home in Nice, which is located in the Mediterranean Climate Zone, consumed a lot less energy for heating than did either Bordeaux or Nancy.

Conclusion

Significant energy savings in homes are possible if scheduled temperature control schemes are deployed. The amount of savings will vary depending upon the location (climate) and building envelope properties (energy class) as well as heating system characteristics. User behavior, which varies from person to person, also plays a significant role.

Deployment of home energy management systems to manage scheduled heating appears to have a major impact on reducing home heating energy bills.

Variable temperature scheduling will have to be deployed and will have to take into account energy sources and efficiency of both heating and cooling systems. Maximum benefits are observed when using room-by-room control (zone control). Furthermore, homes characterized by short time constants (the time required by a particular building material to adjust between its initial and final temperature) have bigger potential for savings than buildings with long time constants (where the temperature drop and increase is slower). A long time constant implies that longer pre-heating periods are needed (thereby increasing energy consumption).

About the author

Eszter Körtvélyesi is a Marketing Project Engineer working within Schneider Electric’s Connected Home department. She holds a Master’s graduate degree from the Technical University of Denmark, with specialization in building services and energy engineering. She is an experienced user of building simulations tools and is familiar with energy efficient design of HVAC systems. Her technical expertise includes heating, ventilation, lighting, plumbing and thermodynamics.