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Subject: **IBM EcoGrid Direct-Price Agent Implementation Status**

1 Household Model

Choice of Model

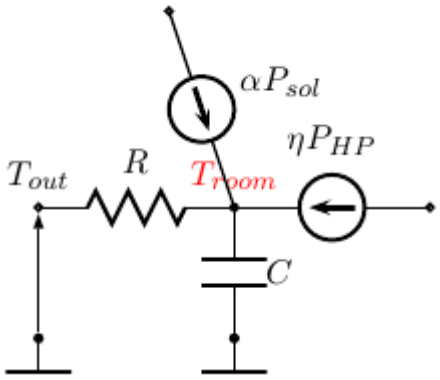


Figure 1 Single-state Ecogrid house model.

The building model currently used to describe the thermal behavior of EcoGrid houses is depicted in Figure. 1. The single system state is the indoor air temperature T_{room} which can be measured. System inputs are the outdoor air temperature T_{out}, the energy input due to solar radiation P_{sol}, and the energy input from the heatpump P_{HP}. The model parameters are

Symbol	Unit	Description
C	[J/°C]	Lumped thermal capacitance of the house
R	[°C/W]	Lumped conductive and convective heat transfer coefficient
α	[-]	Fraction of solar radiation power that enters the house
η	[-]	Coefficient of performance of the heat pump

Table 1: Model parameters.

The thermal dynamics can be written as

$$\frac{d}{dt}T_{\text{room}}(t) = \frac{-1}{CR}T_{\text{room}}(t) + \begin{bmatrix}\frac{\eta}{C} & \frac{1}{CR} & \frac{\alpha}{C}\end{bmatrix}\begin{bmatrix}P_{\text{HP}} \\ T_{\text{out}} \\ P_{\text{sol}}\end{bmatrix}$$

and the parameters considered in the identification are

$$p_1 = \frac{-1}{CR}\,[1/s], \qquad p_2 = \frac{\eta}{C}\,[°C/J], \qquad p_3 = \frac{\alpha}{C}\,[°C/J].$$

Identified Parameters

In the following we analyze the identified parameter values of 160 EcoGrid houses. Fig. 2 shows the position of each house in the model parameter space and Fig. 3 provides the individual parameter distributions. The parameter that exhibits the largest variance in the identified values is $p_3 = \alpha/C$. This suggests that the identified houses are similar with regard to their heat capacity and heat transfer resistance but differ significantly in how much the indoor temperature is influenced by solar radiation.

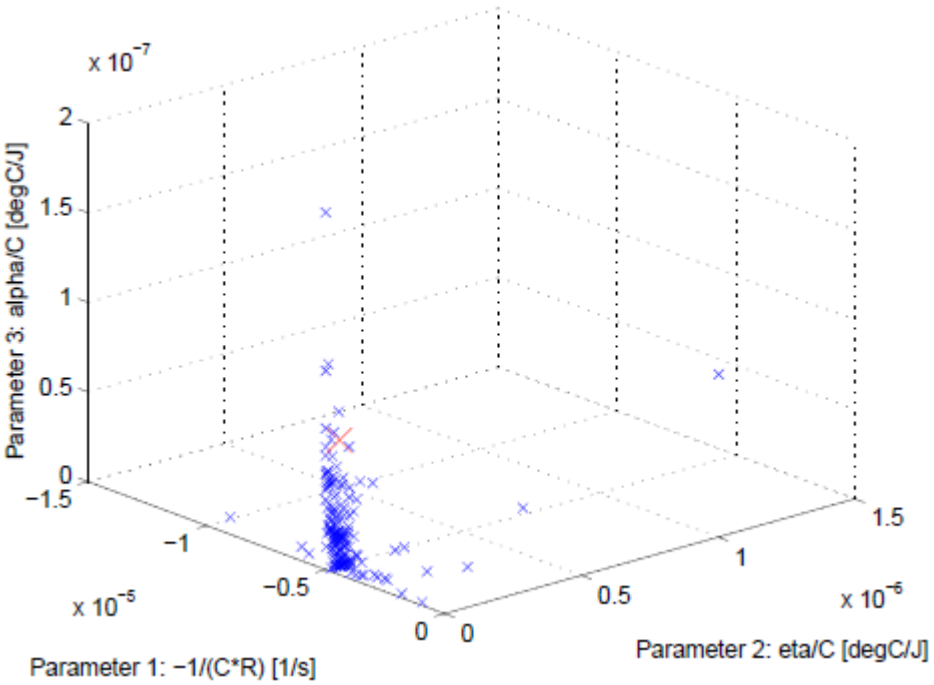


Figure 2: Identified models in the parameter space. The red x denotes the initial parameter guess.

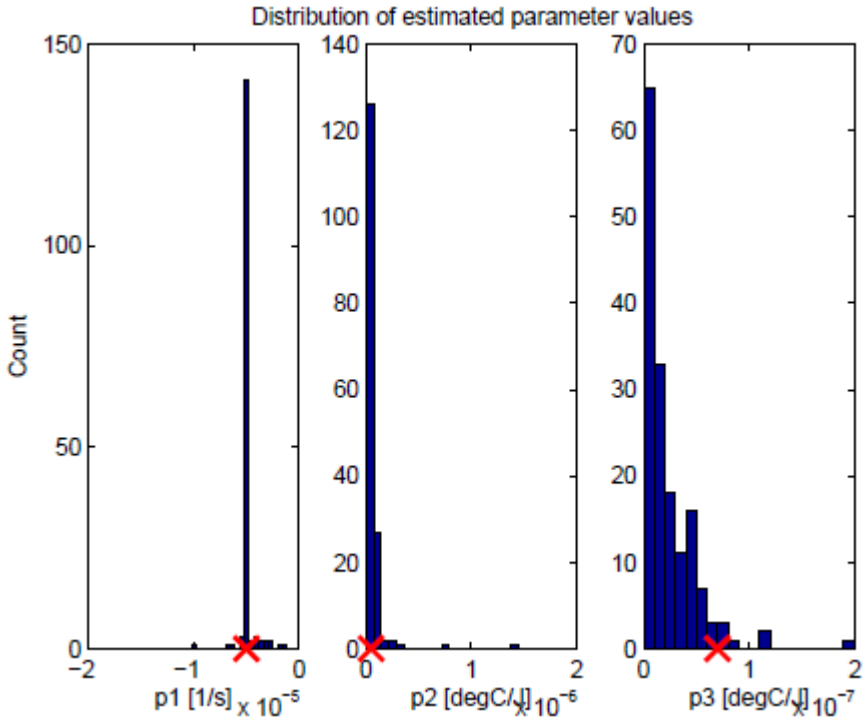


Figure 3: Distribution of model parameters. The red x denotes the initial parameter guess.

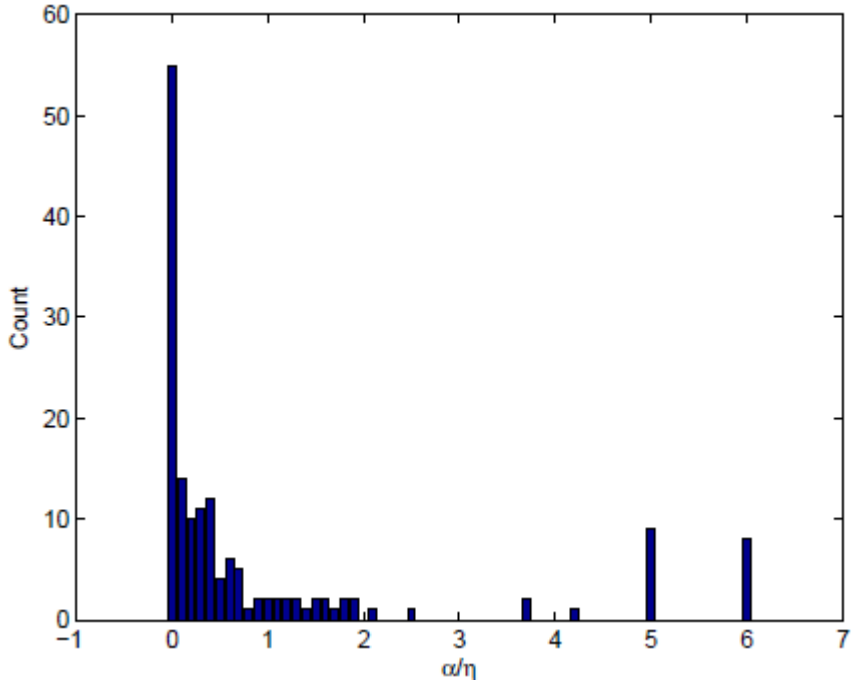


Figure 4: Distribution of the ratio α/η.

Model Accuracy

The identified models were used to predict the indoor temperature over a period of 7 days using measured outdoor temperature, solar radiation and heat pump power consumption as inputs. The majority of models predict the indoor temperature with an average error lower than 3ºC, cf. Figure 4. However, the maximum prediction error can be significantly higher. While the maximum error of most models is below 6ºC, there still is a significant number of houses for which the maximum error is between 6ºC and 15ºC. Obviously, those models cannot be used for the purpose of demand response.

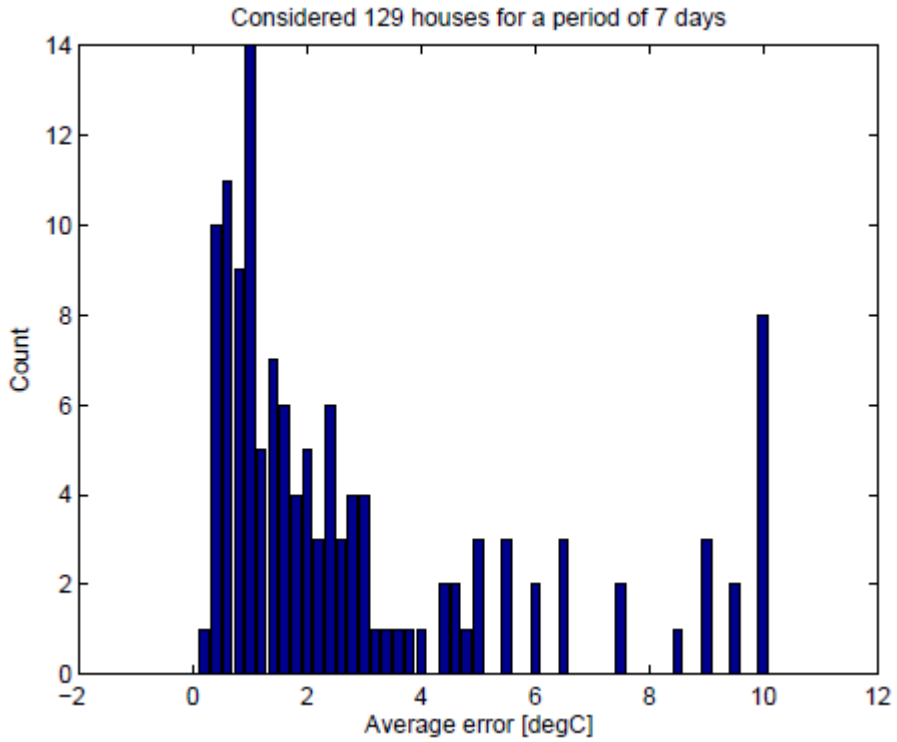


Figure 5: Distribution of the average room temperature prediction error over a period of 7 days.

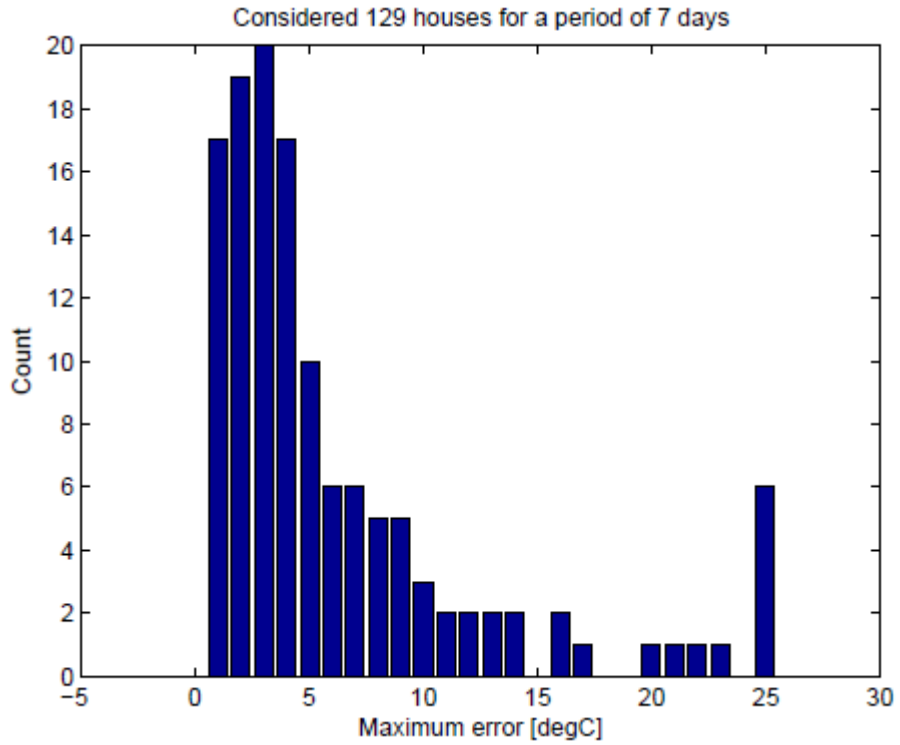
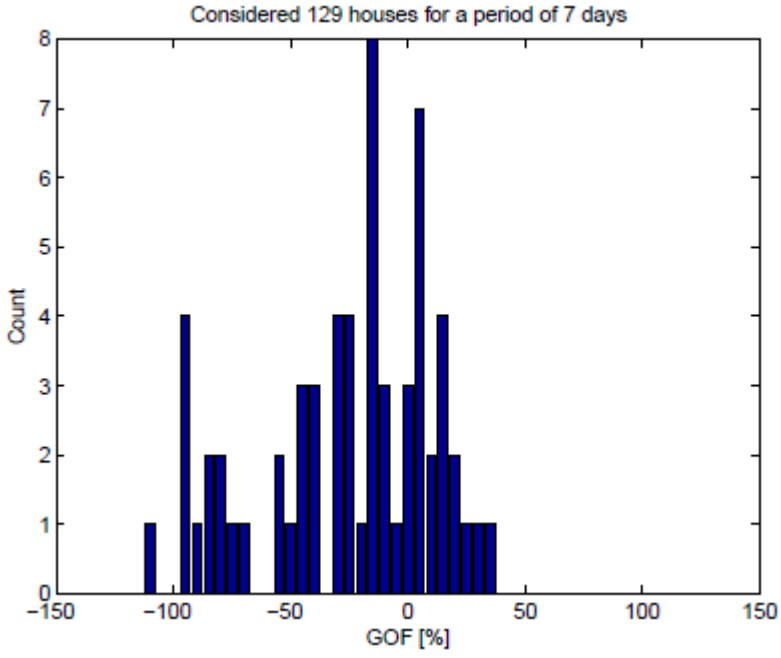


Figure 6: Distribution of the maximum room temperature prediction error over a period of 7 days.

An important measure of the goodness of fit of a model is the coefficient of determination defined as

$$R^2 = 100 \cdot \left(1 - \frac{\|y - \hat{y}\|_2}{\|y - \bar{y}\|_2}\right),$$

where y denotes the measured system output, i.e. the measured indoor temperature in our case, the y with a hat denotes the model predictions, and the y with a bar is the mean of y. As shown in Fig. 6, many models have a negative R^2 value which means that prediction errors exceed the variance of the signal the model aims to predict.



2 Price Agent

Table 2 provides the implemented room temperature bands relative to the GWR UI user-selected lower temperature limits (comfort settings).

Disable control below = Tc	*everything is in deg C*						
Range is given in [min, max] relative to Tc							
***Example:** Tc=22, morning, medium*		Comfort priority					
gives Tmin=22, Tmax=24 if it is morning		Morning		Daytime		Evening	
*and Tmin=21, Tmax=26 if it is **not** morning*		06:00-09:00	09:00-06:00	09:00-18:00	18:00-09:00	18:00-23:00	23:00-18:00
Temperature flexibility	Low	0 1	0 2	0 1	0 2	0 1	0 2
	Medium	0 2	-1 4	0 2	-1 4	0 2	-1 4
	High	0 4	-2 8	0 4	-2 8	0 4	-2 8

Table 2: Temperature bands for different degrees of flexibility and comfort priorities.