#### University of Kentucky

#### **UKnowledge**

Power and Energy Institute of Kentucky **Presentations** 

Power and Energy Institute of Kentucky

7-2021

#### Artificial Intelligence-Based Short-Term Electric Load Forecasts for Experimental Smart Homes Including HVAC and PV Components

Rosemary E. Alden University of Kentucky, rosemary.alden@uky.edu

Cristinel Ababei University of Kentucky

Dan M. Ionel University of Kentucky, dan.ionel@uky.edu

Follow this and additional works at: https://uknowledge.uky.edu/peik\_present



Part of the Power and Energy Commons

Right click to open a feedback form in a new tab to let us know how this document benefits you.

#### **Repository Citation**

Alden, Rosemary E.; Ababei, Cristinel; and Ionel, Dan M., "Artificial Intelligence-Based Short-Term Electric Load Forecasts for Experimental Smart Homes Including HVAC and PV Components" (2021). Power and Energy Institute of Kentucky Presentations. 1.

https://uknowledge.uky.edu/peik\_present/1

This Presentation is brought to you for free and open access by the Power and Energy Institute of Kentucky at UKnowledge. It has been accepted for inclusion in Power and Energy Institute of Kentucky Presentations by an authorized administrator of UKnowledge. For more information, please contact UKnowledge@lsv.uky.edu.



# Artificial Intelligence-based Short-term Electric Load Forecasts for Experimental Smart Homes including HVAC and PV Components



Poster Competition

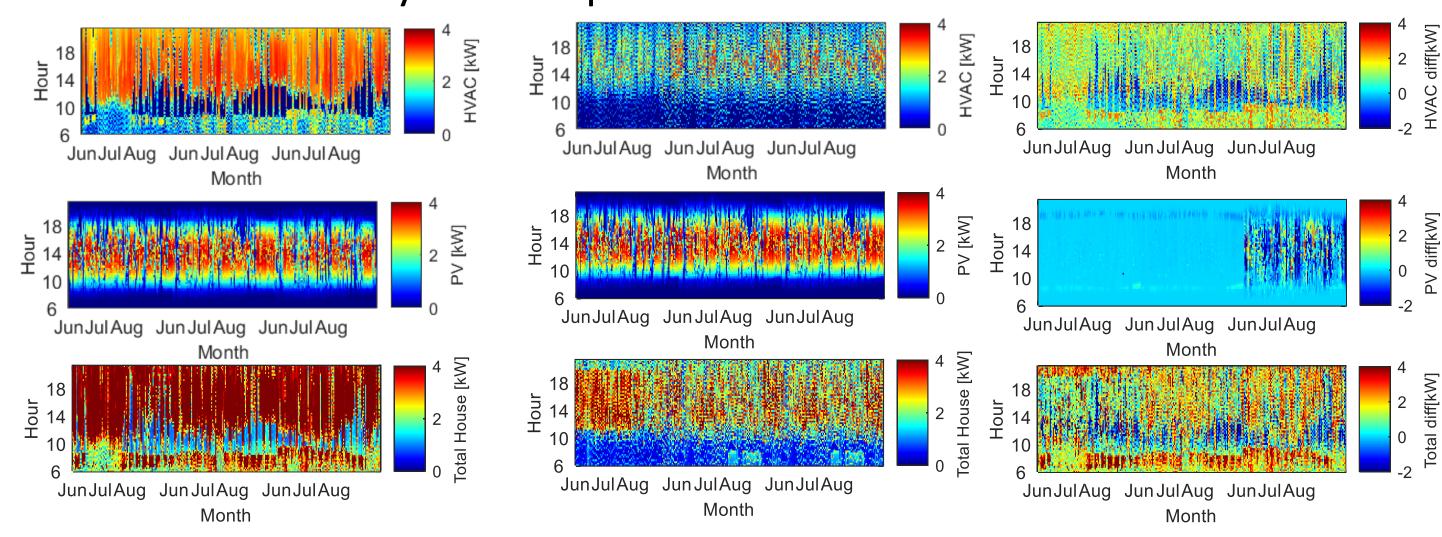
Rosemary Alden, Student Member, Cristinel Ababei, SMIEEE, and Dan M. Ionel, FIEEE

#### **Problem Formulation**

- To predict electric load of the total average power as well as individual components for two residencies from experimental data
- Individual residential forecasting is difficult due to high variability of appliance usage and random human behavior influences.
- Separate the HVAC load from total load as a desired profile using weather relationship and minimum HVAC load at night
- Data driven approach to reduce the amount of information about the home required.

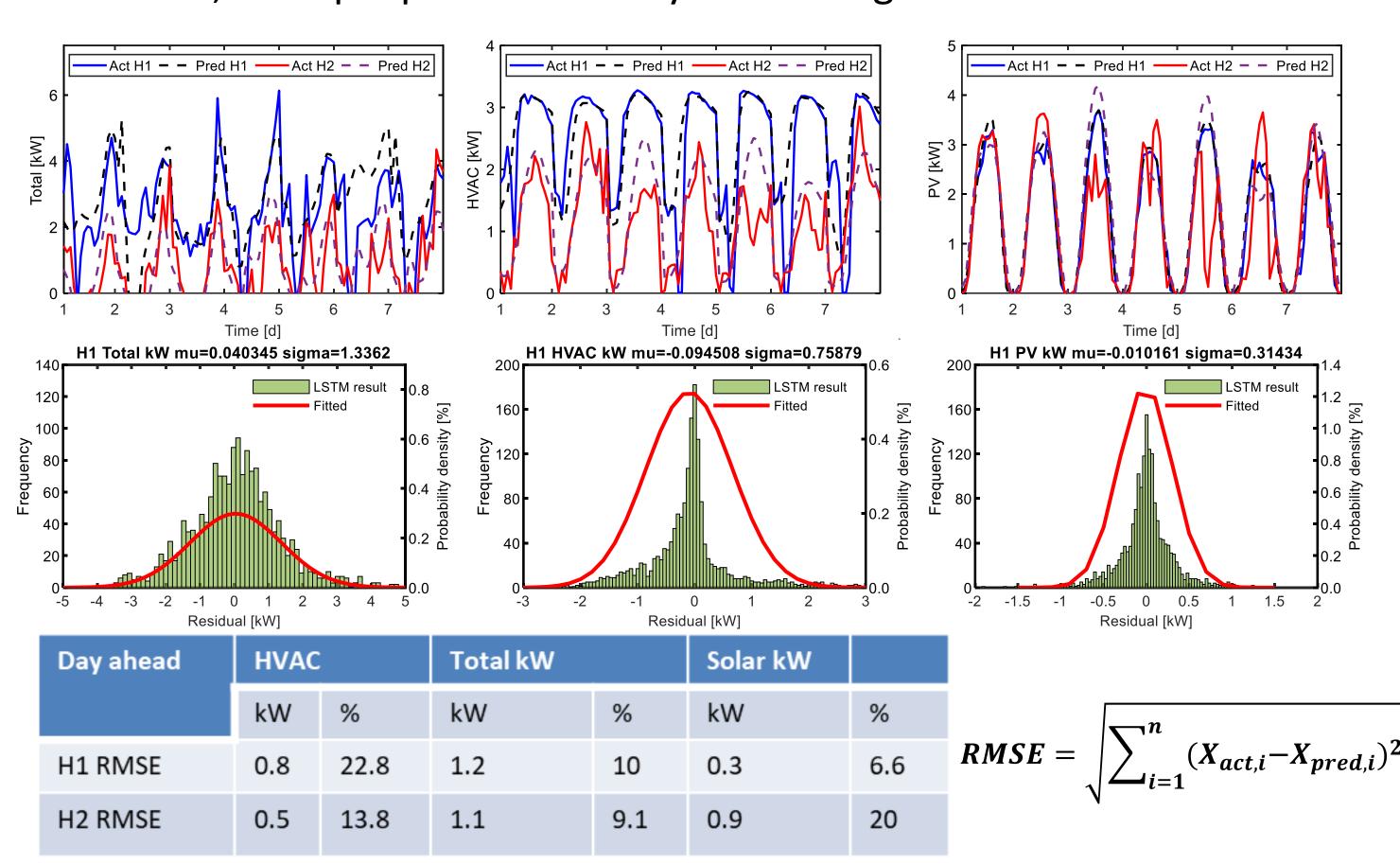
### **SHINES Field Demonstration Homes**

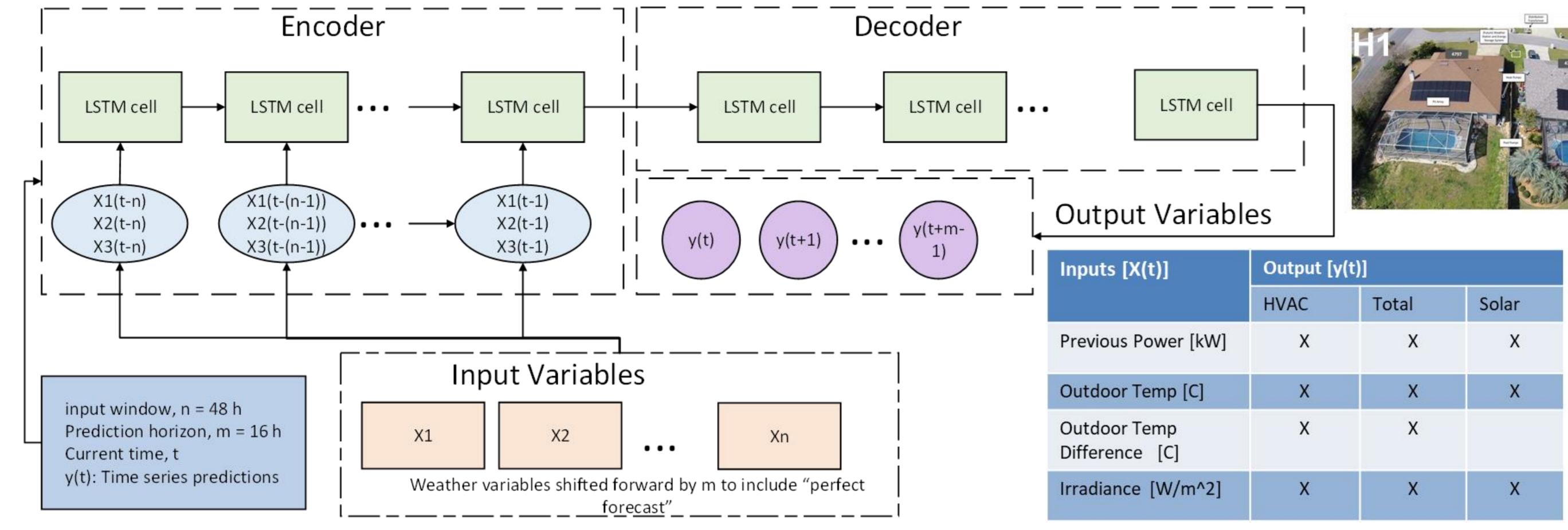
Experimental 15-minute data in the summer integrated to hourly timestep and isolated the daylight hours from 6am to 9pm only to reduce variability of ML inputs



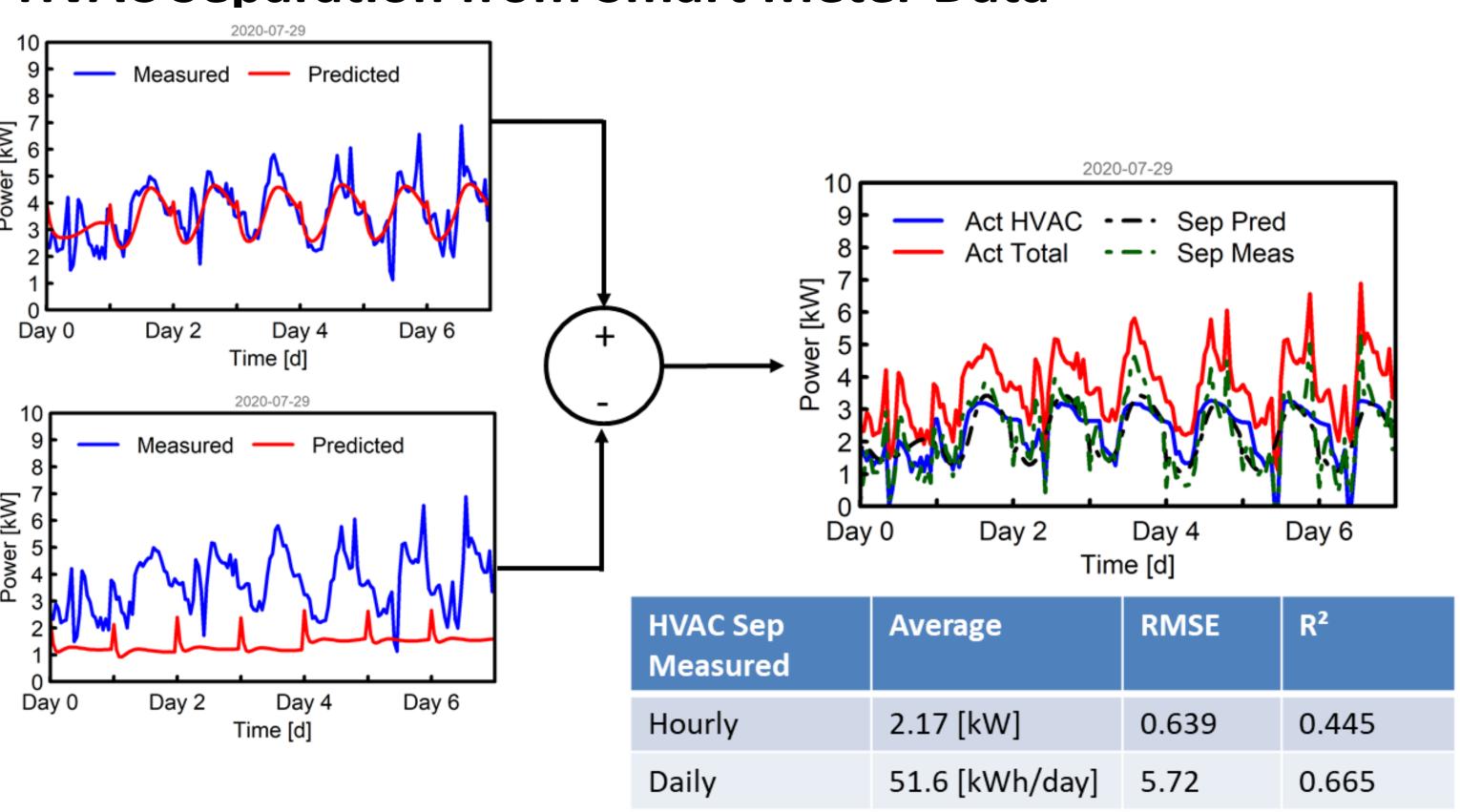
#### LSTM Encoder-Decoder Model with "Perfect Forecast"

- Model selected is a Recurrent Neural Network (RNN) that is known for identifying long term dependencies
- Structured to predict the next day-time period based on the previous 3 days of energy average power usage, the previous two days of weather data, and one future day of weather parameters
- Future day of weather data is the "perfect forecast"
- Model trained on the two previous summers to predict the 2020 season, example predictions July 31st to August 6th:



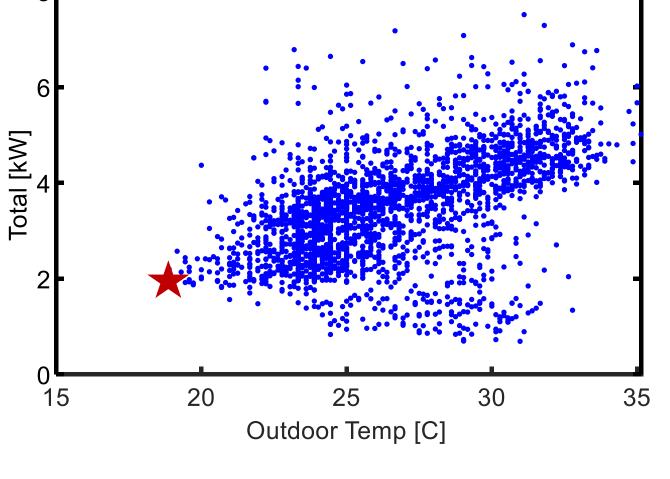


### **HVAC Separation from Smart Meter Data**



A method to separate the HVAC load from total smart meter data:

- 1. For a given residence, establish the LSTM model for the relationship between total load, temperature and solar irradiance
- 2. Determine the "Temperature for the minimum HVAC load" (TmHVAC) ≦ from hourly load "V-shape curve"
- Estimate using LSTM model the baseload corresponding to TmHVAC and 0 irradiance
- 4. Separate HVAC power from the total, forecasted, measured subtracting the predicted baseload from step 3.



## **Connection to HEMS Applications**

- Electric load forecasts such as these can be used with HEMs to schedule appliance loads such as HVAC to be during times of renewable energy generation
- HVAC separation serves to estimate for both users and the utility when a large portion of residential use occurs
- It also would allow for demand response to be implemented in more common homes without dedicated circuits for HVAC energy monitoring

#### Conclusions

- HVAC and solar predictions are satisfactory with the most frequent error near zero.
- Each prediction distribution of residual error for the Total, HVAC, and PV predictions are centered around zero
- The influence of human behavior can be seen in the Total predictions as the distribution is much more spread out and loads such as lighting are considered
- Novel two-step HVAC separation method to predict HVAC load based only on smart meter data performs as well as forecasting from historical HVAC measured data, and may represent a significant contribution to field deployment.

# **Future and Ongoing Work**

fine tune the mathematical method for selecting the TmHVAC and publish a full paper to provide other researchers an opportunity to verify HVAC separation method with addition homes and climates

# Acknowledgement

This work was supported by the NSF, grant ECCF 1936494. Any findings and conclusions expressed herein are those of the authors and do not necessarily reflect the views of the NSF.