

Paper No: 23PESGM1613



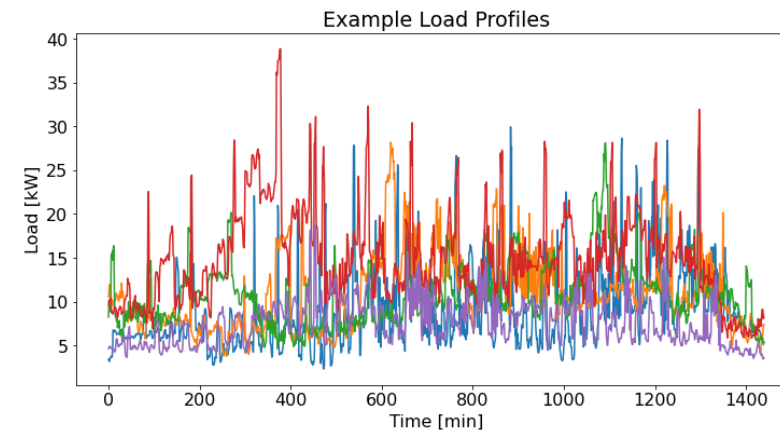
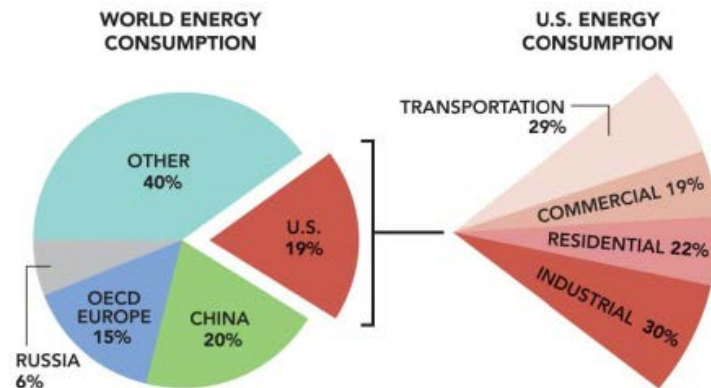
A Two-Step Time-Series Data Clustering Method for Building-Level Load Profile

Jiyu Wang, Xiangqi Zhu, Barry Mather
National Renewable Energy Laboratory
Jiyu.Wang@nrel.gov

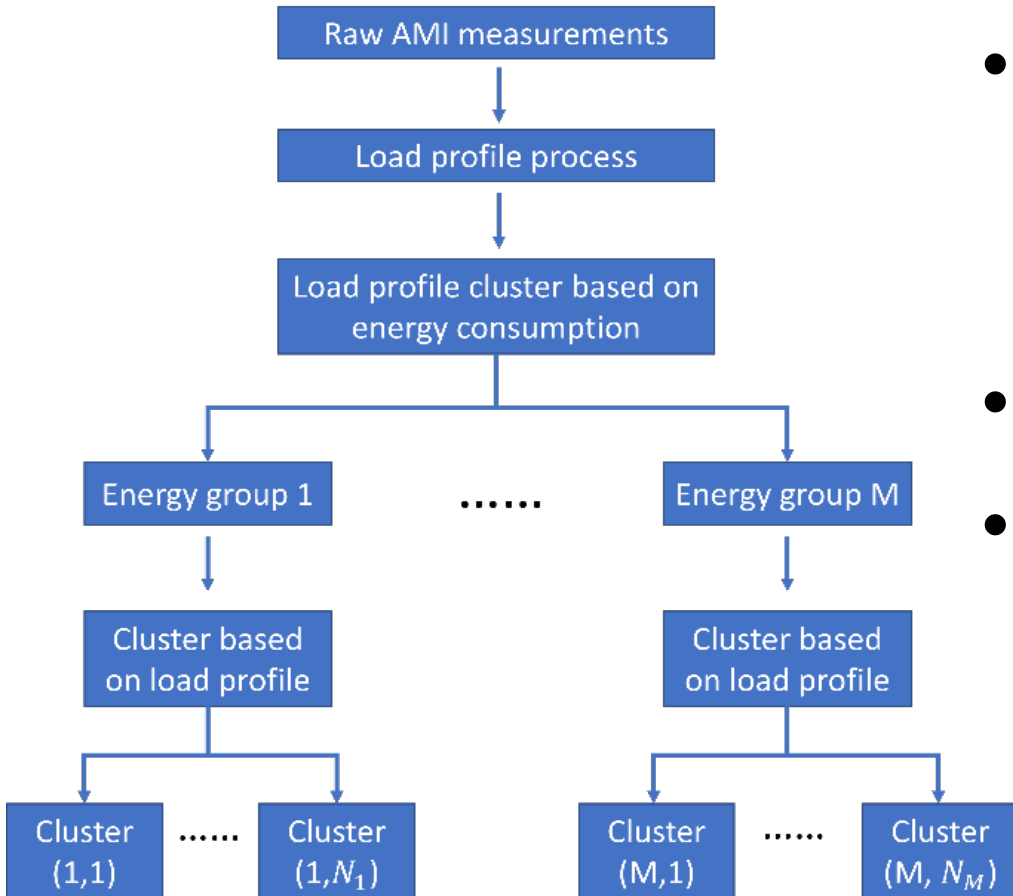
NREL/PR-5D00-86914

Background

- Buildings have great potential to participate in demand response in distribution system operation
- Cluster the load profiles into different groups by load patterns
- Grid operators can send demand response signal to the customer cluster with a higher chance to respond at different time



Proposed Solution



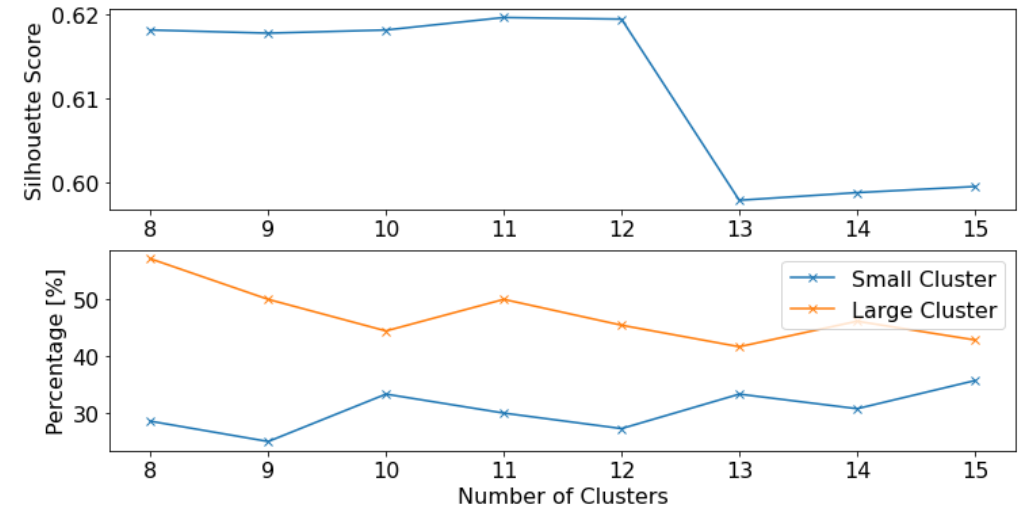
- Load profile clustering algorithm:
 - Energy consumption level clustering
 - Load pattern clustering
- K-Means clustering method
- Silhouette index

$$s(ii) = \frac{b(ii) - a(ii)}{\max\{a(ii), b(ii)\}} \quad a(ii) = \frac{1}{n_{C_i} - 1} \sum_{j \in C_i, ii \neq jj} d(i'ijj)$$

$$b(ii) = \min \left(\frac{1}{n_{C_j}} \sum_{j \in C_j} d(i'ijj) \right), j \neq i, j \in (1, \dots, k)$$

Proposed Solution

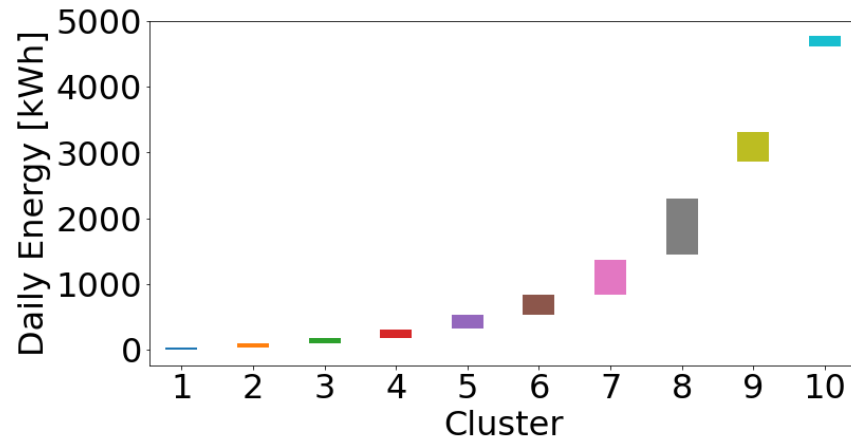
- K-Means parameter selection:
 - Silhouette score evaluation
 - Cluster size evaluation
- Multilayer perceptron (MLP):
 - New income data processing
 - Parameter selection



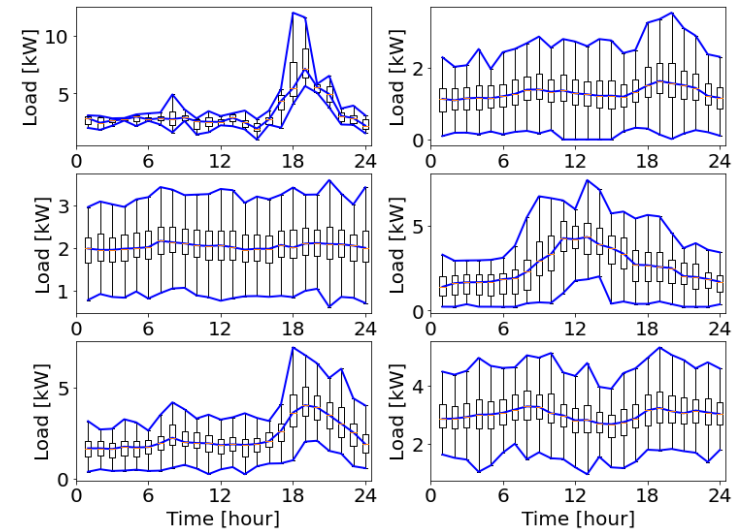
Silhouette score		Number of hidden layers			
		3	5	7	9
Number of cells in each layer	4	0.36	0.59	0.34	0.58
	5	0.16	0.25	0.25	0.26
	6	0.01	0.25	0.22	0.23
	7	0.23	0.24	0.15	0.19
	8	0.15	0.21	0.17	0.24
	9	0.11	0.25	0.15	0.28

Case Study

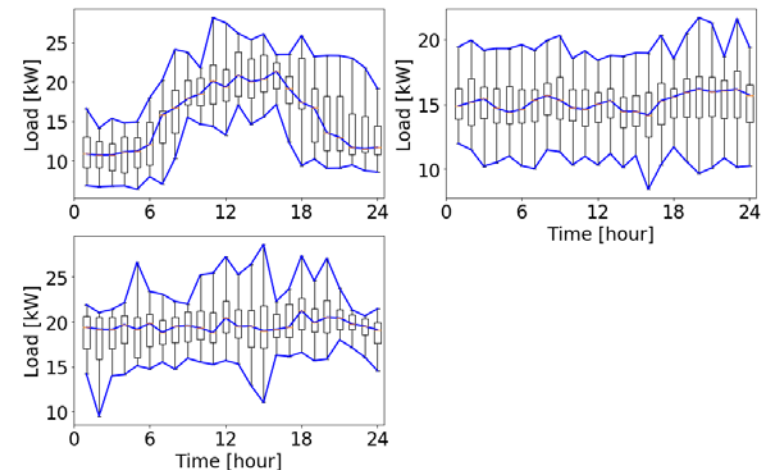
- Utility's actual AMI measurements:
 - 7000 building-level load profiles
 - Hourly resolution
 - Clustering for daily profiles



Energy clustering results

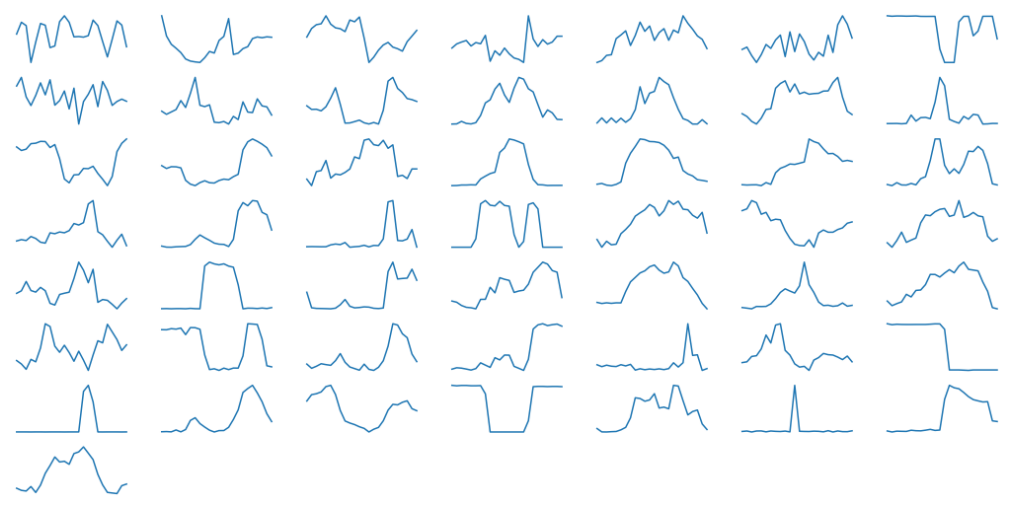


Load pattern cluster for energy group 1



Load pattern cluster for energy group 2

Results



50 representative profiles are selected

ALSAT Tool V1.0

1. Instruction and Status

Status Window | Information Display Window

Instruction

1. Upload Data
2. Generate Library
3. Set Profile Parameter
4. Select Library
5. Generate Profiles
6. Plot Center Profiles
7. Advanced Analysis
8. Take Survey

2. Library and Profile Generation

Data Upload Module

Data Upload

Generate Library

Set Parameter

Number of Profiles: []

Resolution in Minute: []

Number of Days: []

Set

Generate Profiles

Default Library

Generated Library

Save Results

Generate Profiles

3. Results Analysis

Y upper limit: []

Y lower limit: []

Set

Plot Center

Enter Center Profile Number: []

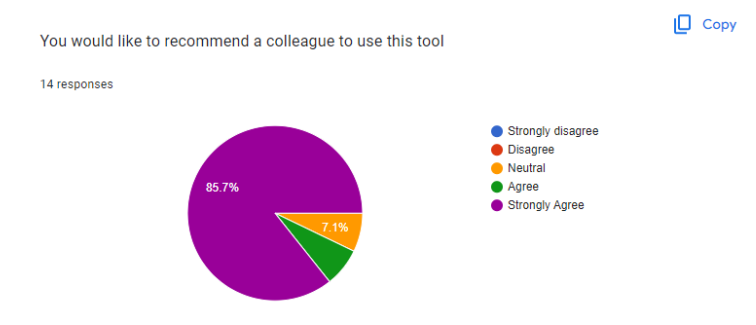
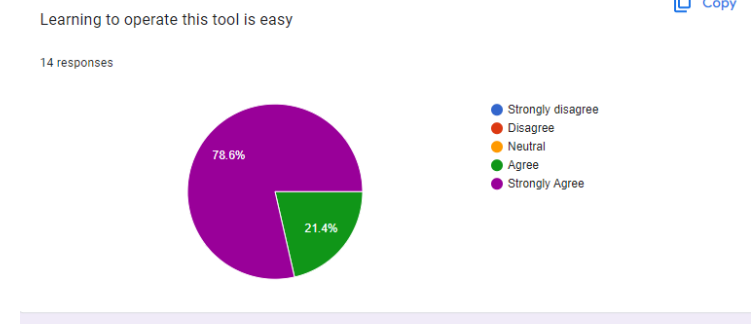
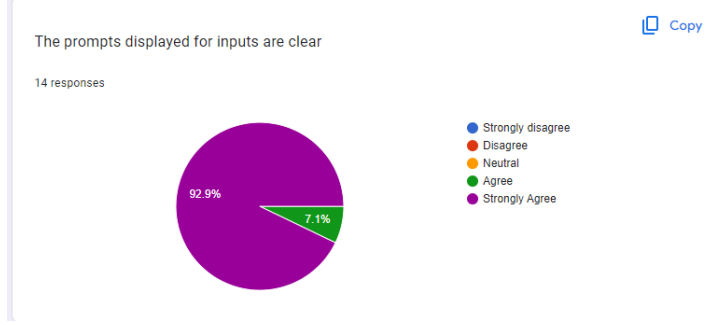
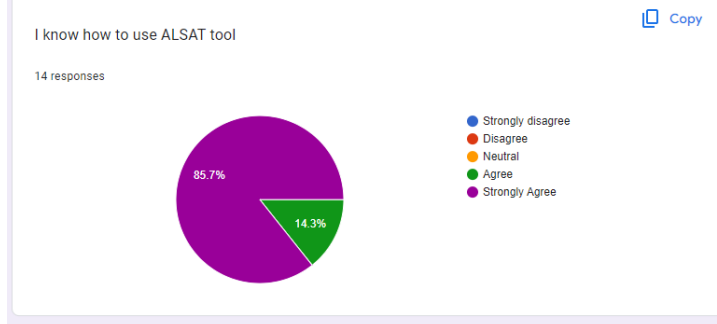
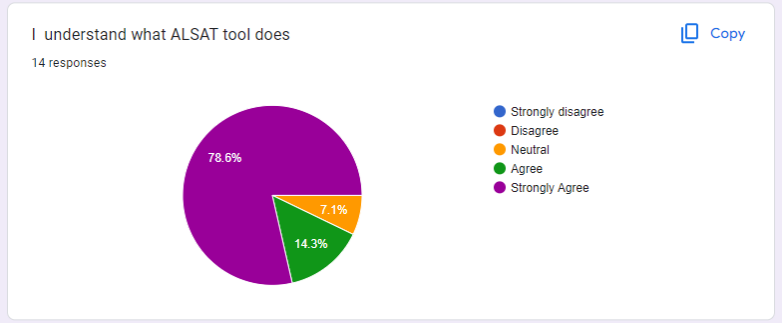
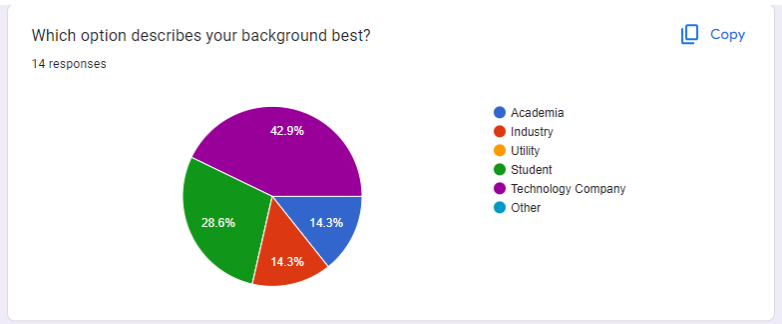
Plot

Advanced Analysis

Survey

Graphic user interface for this tool

Future Work



- Improve the graphic user interface based on feedback
- Develop methods to quantify the demand response capability in each load profile cluster

This work was authored [in part] by the National Renewable Energy Laboratory, operated by Alliance for Sustainable Energy, LLC, for the U.S. Department of Energy (DOE) under Contract No. DE-AC36-08GO28308. Funding provided by the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Solar Energy Technologies Office. The views expressed in the article do not necessarily represent the views of the DOE or the U.S. Government. The U.S. Government retains and the publisher, by accepting the article for publication, acknowledges that the U.S. Government retains a nonexclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this work, or allow others to do so, for U.S. Government purposes.