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Long-Term Electric Load Forecast for Urban Areas with an Energy Decomposition Model

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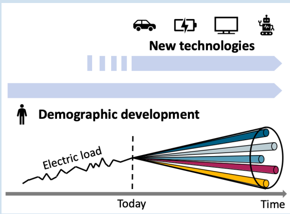
1 Introduction

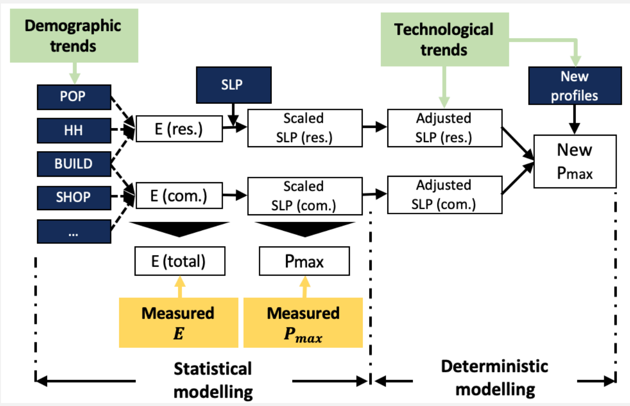
Due to the joint impacts of both **demographic** changes and **technological** trends, the development of urban electric load is increasingly uncertain. We propose a load decomposition model with **minimal data requirement** to conduct long-term load forecast considering the impacts from both perspectives.



2 Method

The model has the following key features:

- **Hybrid.** The model is composed of a **statistical** and a **deterministic** part to sequentially model the impacts of demographic and technological trends.
- **Minimal data requirement.** The model only uses commonly available datasets for the distribution system operators – **annual electricity consumption (E)** per consumption unit and **peak power (P_{max})** per substation per year.
- **Double dependent variables**. Since sector-specific data is not commonly available, they can't be directly used to train the model. Instead, we use two other dependent variables (i.e., the E and P_{max}) to achieve energy decomposition.
- **High interpretability**. The underlying algorithm is a linear regression. With this transparent model structure, we could understand in detail the impact of each variable.



The model is formulated as a **constrained elastic net regression**. Compared with the standard elastic net regression[1], this model allows a secondary dependent variable and bounds on the coefficients.

$minimize\ L(\beta) = \|\|\boldsymbol{E} - \boldsymbol{X}\boldsymbol{\beta}\|\|^2$	Accuracy control in E prediction
$+ \lambda_c \|\|\boldsymbol{P_{max}} - \lambda_{pf}\boldsymbol{X_c}\boldsymbol{\beta}\|\|^2$	Accuracy control in P_{max} prediction
$+ \lambda_{ridge}\|\|\boldsymbol{\beta}\|\|^2$	Part of elastic net regularization
$+ \lambda_{lasso}\|\|\boldsymbol{\beta}\|\|_1$	Part of elastic net regularization
$s.t.\ c_{j,lb} \leq \beta_j \leq c_{j,ub}\ (j = 1, \ldots, p)$	Bounds on the linear coefficients

3 Model evaluation

The model performs well in

- overall **annual electricity consumption** prediction,
- decomposition for the **suburb** electricity distribution network.

The bias in the **city center** network prediction can be explained by the **heterogeneity of the commercial consumers**, which can be further decomposed into 6 subsectors with different load patterns[2].

		Measured [kWh]	Predicted [kWh]	Deviation [%]
Suburb network	E_{Res}	798,840	822,973	+3.0
	E_{Com}	145,340	154,131	+6.0
	$E_{Res} + E_{Com}$	944,180	977,104	+3.5
City center network	E_{Res}	508,759	327,530	-35.6
	E_{Com}	747,972	900,107	+20.3
	$E_{Res} + E_{Com}$	944,180	1,227,637	-2.3

4 Conclusion

- The proposed energy decomposition algorithm with a minimal data requirement could sequentially model the impacts from demographic and technological developments.
- It achieves energy decomposition with a deviation of less than 6% for a suburb electricity distribution network.
- Enabled by the established model structure, future research or practical applications can focus on
  - further decomposing the commercial sector,
  - including more independent variables,
  - enriching the forecast scenario setups.

References

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