

# Does Illinois have a better energy profile than California?

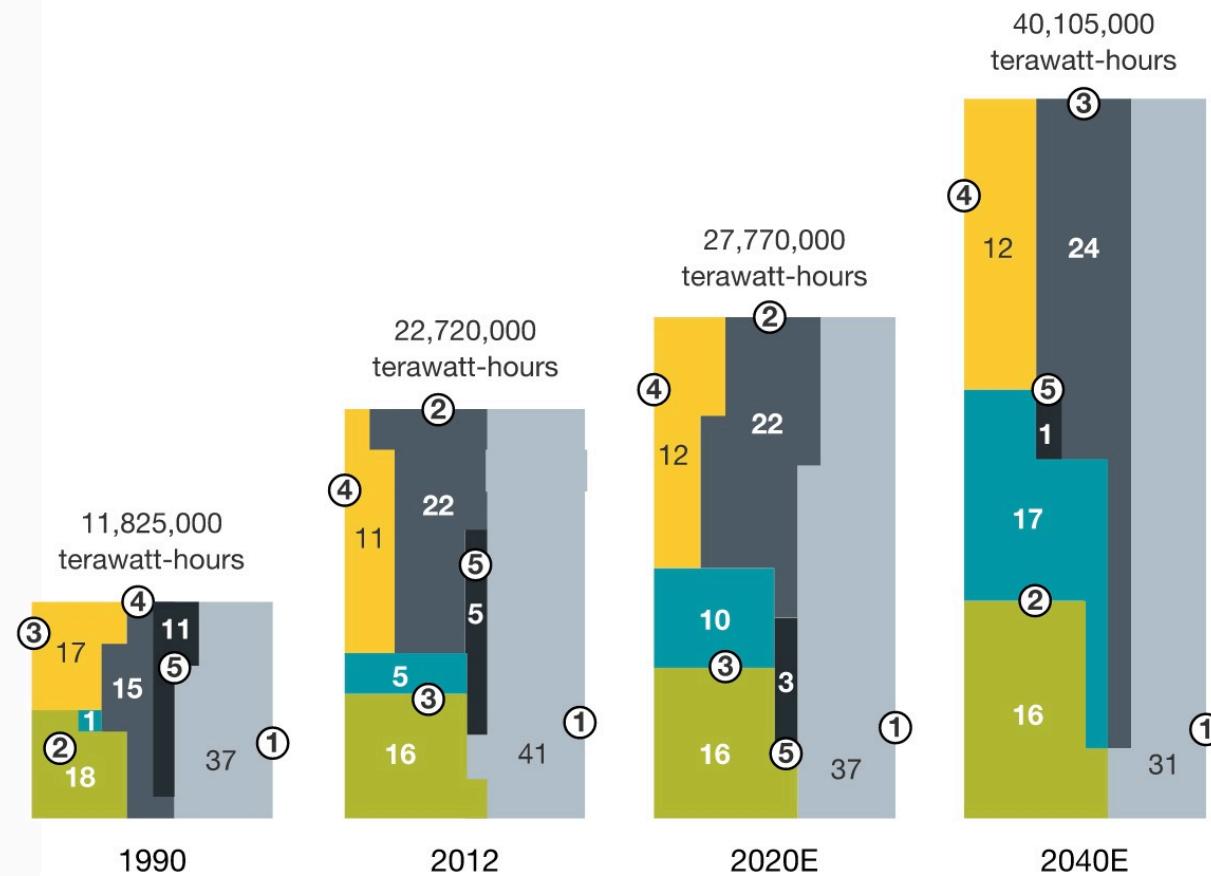
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# MOTIVATION

World electricity generation by source, 1990–2040, in thousand terawatt-hours, and in %<sup>1</sup>

Coal    Natural gas    Oil    Nuclear  
Hydro    Other renewables    Rank of source



- Energy is on a journey of important change. Inspired by the interstate cooperation between states, the renewable energy industry in the U.S. is riding some strong tailwinds that will likely promote longer-term growth.
- However, according to the information compiled by Looking Ahead: The 50 Global Trends That Matter, the majority of the planet's electricity needs will still be fueled by coal and natural gas in 2040.

- Can we quantify and compare the overall energy profiles in different states?
- How to achieve a better energy profile in the future?
- This study builds an Energy Profile Evaluation Model in light of Energy Transition Theory and creates a rule for the target decision on renewable energy usage in the future.

- [1] Smil, Vaclav. 2010. Energy Transitions. History, Requirements, Prospects. Praeger
- [2] Grübler, A. 1991. "Diffusion: Long-term patterns and discontinuities". Technological Forecasting and Social Change. 39 (1–2): 159–180.
- [3] Grübler, A; Wilson, C.; Nemet, G. 2016. "Apples, oranges, and consistent comparisons of the temporal dynamics of energy transitions". Energy Research & Social Science. 22 (12): 18–25.
- [4] Christopher F. Jones 2016 : Energy Transitions in the United States - Worker opportunities past, present, and future

Table Influential indicators

	MSN	Description
Expenditure per capita	GDPRX	Real gross domestic product
	TPOPP	Resident population including Armed Forces
Resources endowment	CLPRB	Coal production
	PAPRB	Crude oil production (including lease condensate)
	NGMPB	Natural gas marketed production
	NUETB	Electricity produced from nuclear power
	ROPRB	Renewable energy production, other than fuel ethanol
	TEMP	Temperature
	PPT	Precipitation
Consumer preference	CLTCD	Coal average price, all sectors.
	CLTCB	Coal total consumption
	NGTCD	Natural gas average price, all sectors (including supplemental gaseous fuels)
	NGTCB	Natural gas total consumption (including supplemental gaseous fuels)
	PATCD	All petroleum products average price, all sectors
	PATCP	All petroleum products total consumption
	ESTCD	Electricity average price, all sectors.

- <https://www.eia.gov>

## Recent Data

### Carbon dioxide emissions by fuel *million metric tons*

	2018	2019	2020F	2021F
Petroleum and other liquid fuels	2,373	2,354	2,189	2,309
Natural gas	1,636	1,689	1,670	1,614
Coal	1,260	1,084	885	991
Total energy	5,280	5,138	4,755	4,925

Source: Short-Term Energy Outlook  
[Renewables and Carbon Dioxide Emissions](#)  
Note: F= Forecast.

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## METHODS

- Modified TOPSIS method

**Step1.** Introducing the concept of the positive and negative ideal solution  $Z_{ij}^+$ ,  $Z_{ij}^-$  into the model.

**Step2.** Normalizing the scores for each indicator with the following equation:

$$Z_{ij} = x_{ij} / \left( \sum_{i=1}^n x_{ij}^2 \right)^{1/2} \quad (2)$$

$$S_i^+ = \sqrt{\sum_{j=1}^m [ w_j ( Z_{ij} - Z_{ij}^+ ) ]^2} \quad (3)$$

$$S_i^- = \sqrt{\sum_{j=1}^m [ w_j ( Z_{ij} - Z_{ij}^- ) ]^2} \quad (4)$$

**Step4.** Computing relative closeness  $C_i$  and ranking the energy profiles.

- **Single-hidden Layer BP Neural Network**

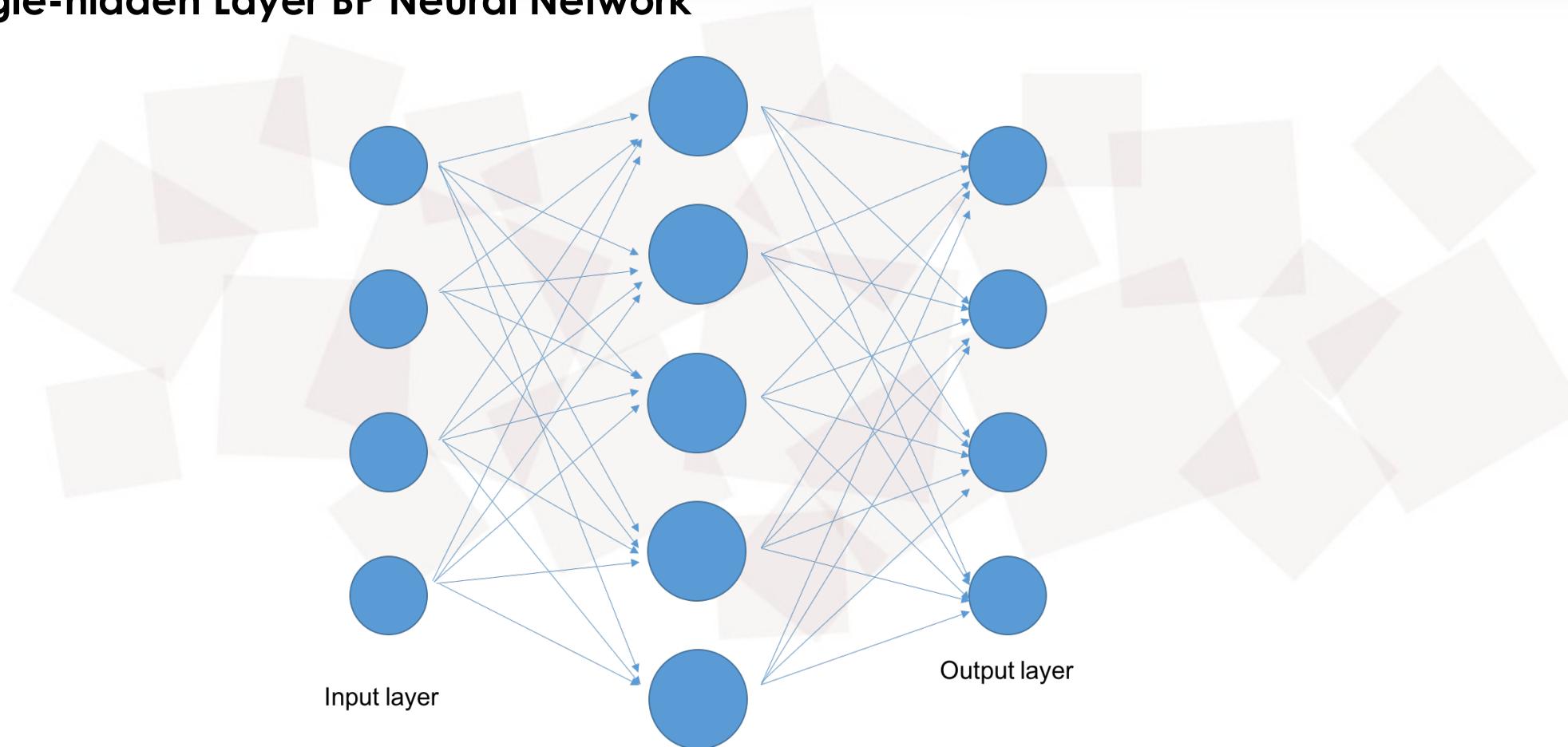


Fig The Diagram of Layers

## EXPECTED RESULTS AND FUTURE STUDIES

- Based on the energy transition theory, I will classify the variables to evaluate the energy profile and evolution. More specifically, I want to construct models to figure out the influential factors of renewable energy usage, estimate the energy utilization and finally predict the future optimal energy profile for different states.
- My future work will focus on taking other elements like topography and history events into consideration so that I can provide more pragmatic and realistic recommendations to state governments.