Technical Potential for Solar Photovoltaics in Illinois

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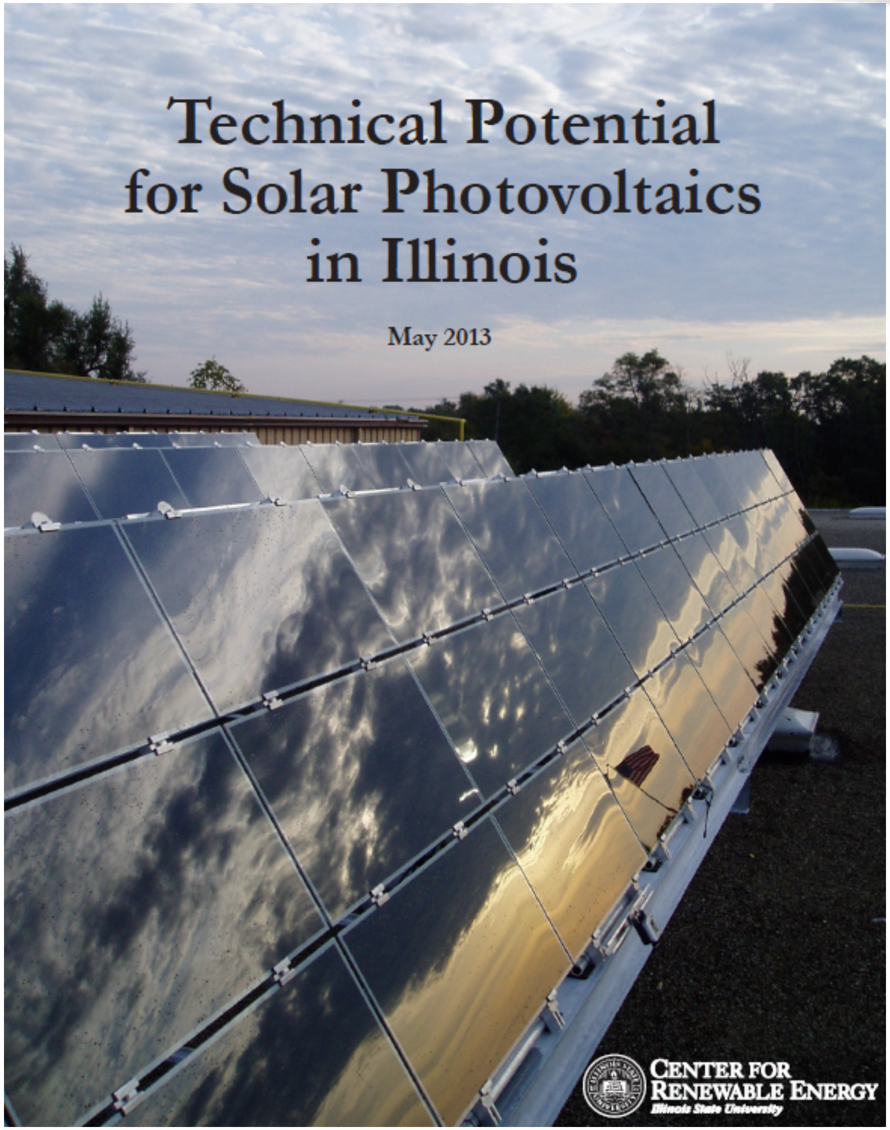
I. Project Overview



I. Project Overview

1) Acknowledgement

- Funded by Illinois Department of Commerce and Economic Opportunity to promote and support the IL solar energy market and industry.
- This study is co-authored with Dr. Dave Loomis and Matt Aldeman.

2) Background

- RPS in IL: 25% by 2025
- Solar carve-out : 6%
- Utility-scale solar projects in IL
  a) West Pullman Exelon City Solar: 10MW
  b) Streator, IL Invenergy Solar Project: 17MW

3) Objectives

- Determine the optimal solar penetration rate of large-scale deployment of grid-connected solar PV systems
- Evaluate the current RPS plan (solar carve-out)

I. Project Overview

4) Research Questions

1. Given the current solar carve-out of 6% specified in the state's RPS, how many Megawatts of capacity must be installed by 2025?

2. Can Illinois fully utilize all of the solar energy that will be produced as a result of the 6% carve-out without wasting a portion of the generated electrical energy?

If so, how much PV could be installed in IL while maintaining 100% utilization of the energy that is produced by the systems?

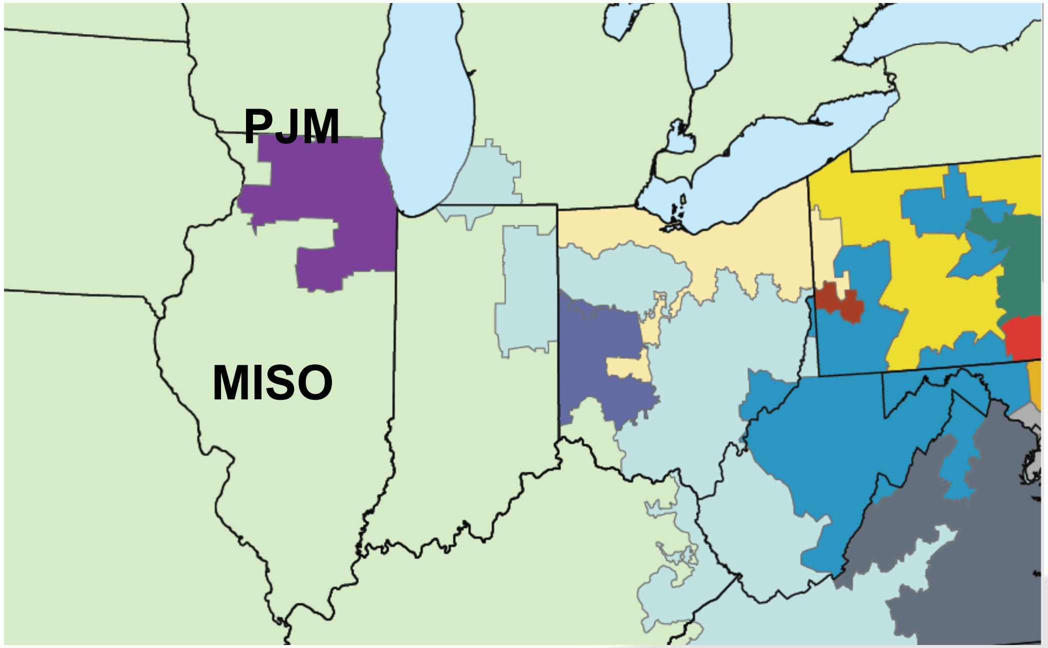
3. How much of Illinois' electrical energy could PV supply if curtailment of the PV output is occasionally permitted?

II. Data Collection

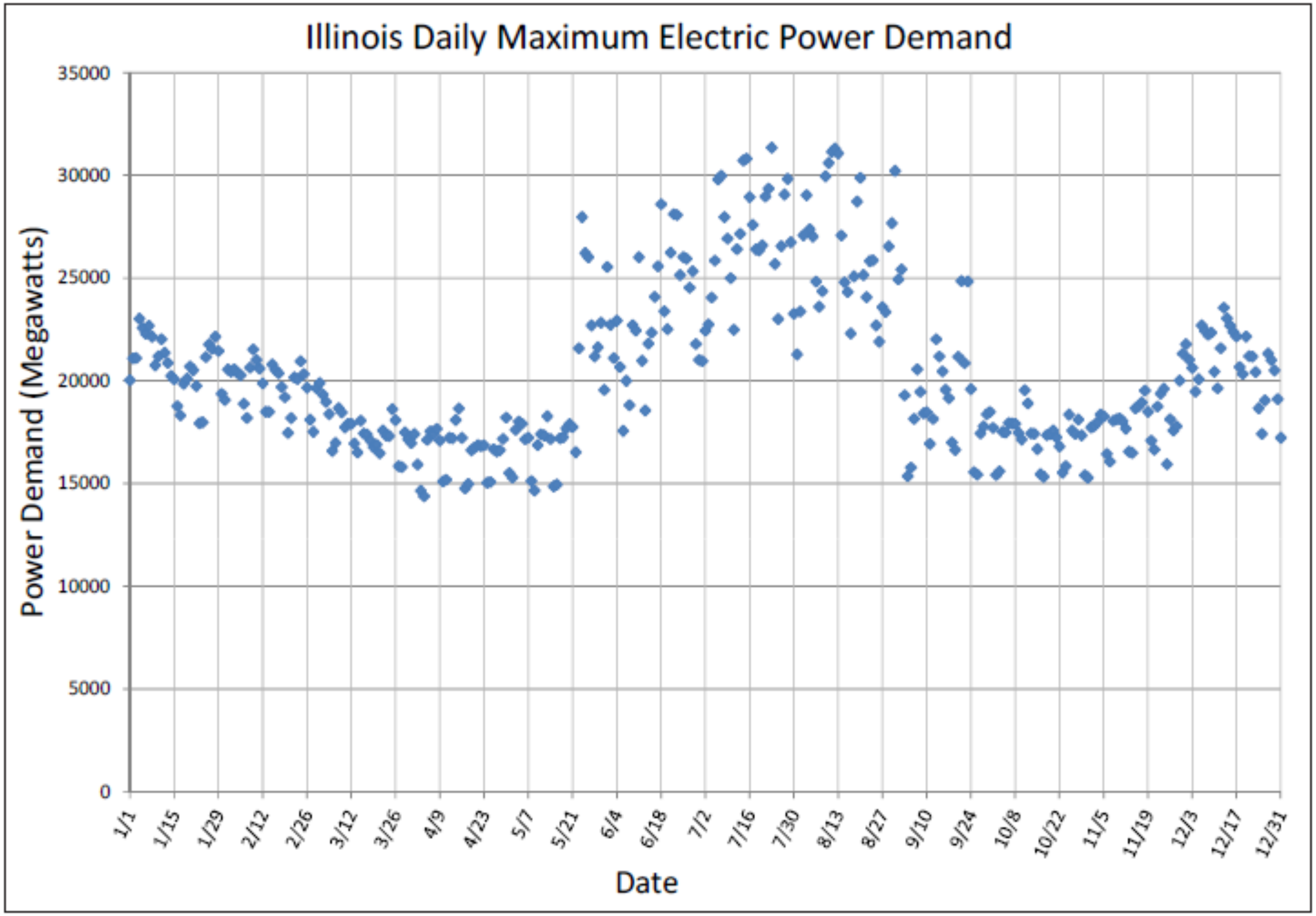
3) Data Collection

- Weather Data
  - TMY3 (Typical Meteorological Year3:1991-2005)
  - Chicago O'Hare Intl AP & Springfield Capital AP

- Electrical Load (PJM & MISO) 2010
  - 8760 Data Points X 2



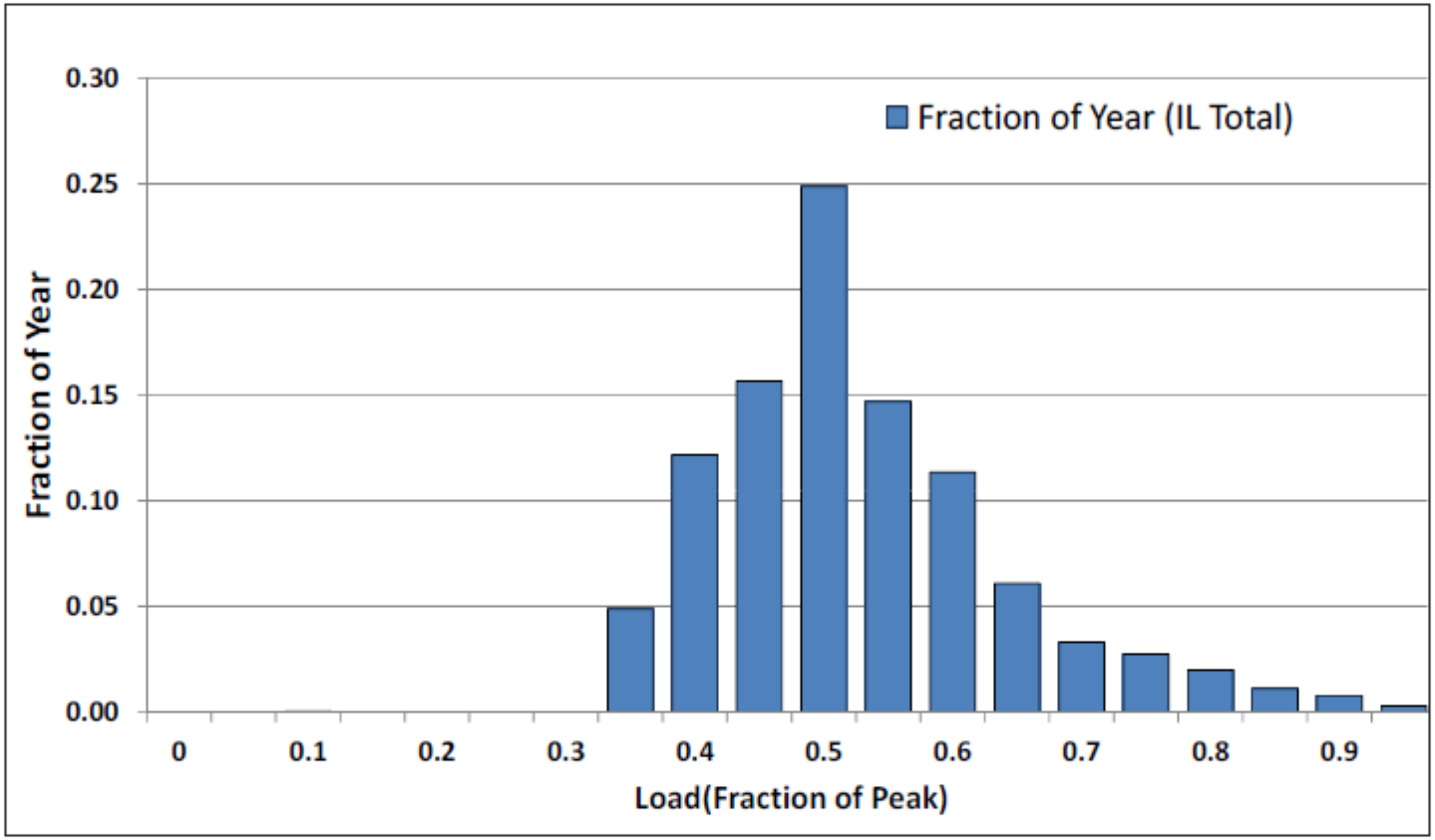
II. Data Collection



(Jo et al., 2013)

II. Data Collection

Histogram of the system load fraction (2010)



(Jo et al., 2013)

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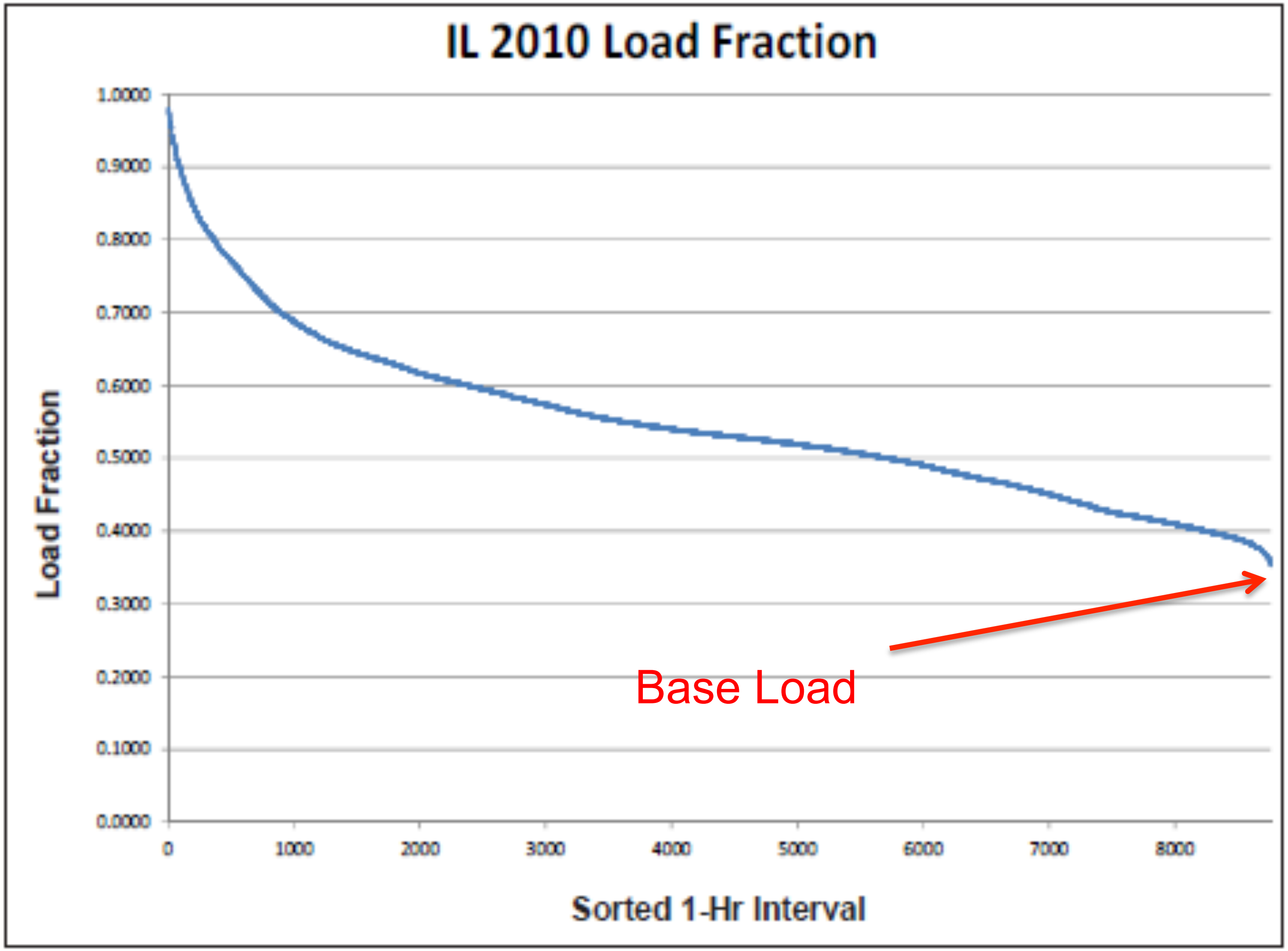


(Jo et al., 2013)

III. Methodology

1. Renewable Energy Optimization Matrix

$$E_{T2010} = \sum_{i=1}^{8760} (P_i \times 1\ hr) \qquad \text{Eq. 1}$$

$$E_{T2025} = E_{T2010} \times (1 + \alpha)^{15} \qquad \text{Eq. 2}$$

$$P_B = (Peak\ power) \times 35\% \qquad \text{Eq. 3}$$

$$P_{R_i} = P_i - P_B \qquad \text{Eq. 4}$$

III. Methodology

1. Renewable Energy Optimization Matrix

$When\ P_{R_i} \geq P_{PV_i}$:

$$P_{PV\ utilized_i} = P_{PV_i} \qquad \text{Eq. 5}$$

$$P_{PV\ rejected_i} = 0 \qquad \text{Eq. 6}$$

$When\ P_{R_i} < P_{PV_i}$:

$$P_{PV\ utilized_i} = P_{R_i} \qquad \text{Eq. 7}$$

$$P_{PV\ rejected_i} = P_{PV_i} - P_{R_i} \qquad \text{Eq. 8}$$

III. Methodology

1. Renewable Energy Optimization Matrix

$$E_{PV} = \sum_{i=1}^{8760} (P_{PV_i} \times 1\ hr) \qquad \text{Eq. 9}$$

$$E_{PV\ utilized} = \sum_{i=1}^{8760} (P_{PV\ utilized_i} \times 1\ hr) \qquad \text{Eq. 10}$$

$$E_{PV\ rejected} = \sum_{i=1}^{8760} (P_{PV\ rejected_i} \times 1\ hr) \qquad \text{Eq. 11}$$

III. Methodology

1. Renewable Energy Optimization Matrix

$$PV\ Utilization\ Rate = \frac{E_{PV\ utilized}}{E_{PV}} \quad \text{Eq. 12}$$

$$IL\ Load\ from\ PV = \frac{E_{PV\ utilized}}{E_{T\,2025}} \quad \text{Eq. 13}$$

$$IL\ RPS\ from\ PV = \frac{E_{PV\ utilized}}{0.25 \times E_{T\,2025}} \quad \text{Eq. 14}$$

III. Methodology

2. Energy Performance Model

Energy Performance Model

- System Advisor Model (NREL)

Reference PV system

- Efficiency: 15.57% (2009)
- Penetration (1-30% of peak load)
- PJM Area 1%-219MW
- MISO Area 1%-100MW
- Delivered vs. Wasted ♪

IV. Findings

RQ1. Given the current solar carve-out of 6% specified in the state's RPS, how many Megawatts of capacity must be installed by 2025?

	PJM	MISO
System Capacity	1577MW	715MW
IL PJM Load met by PV	1.5%	1.5%

IV. Findings

RQ2. Can Illinois fully utilize all of the solar energy that will be produced as a result of the 6% carve-out without wasting a portion of the generated electrical energy? YES!

6% Carve-Out	**PJM**	**MISO**
System Capacity	1,577MW	715MW
Utilized Elec. from PV	99.9%	100%

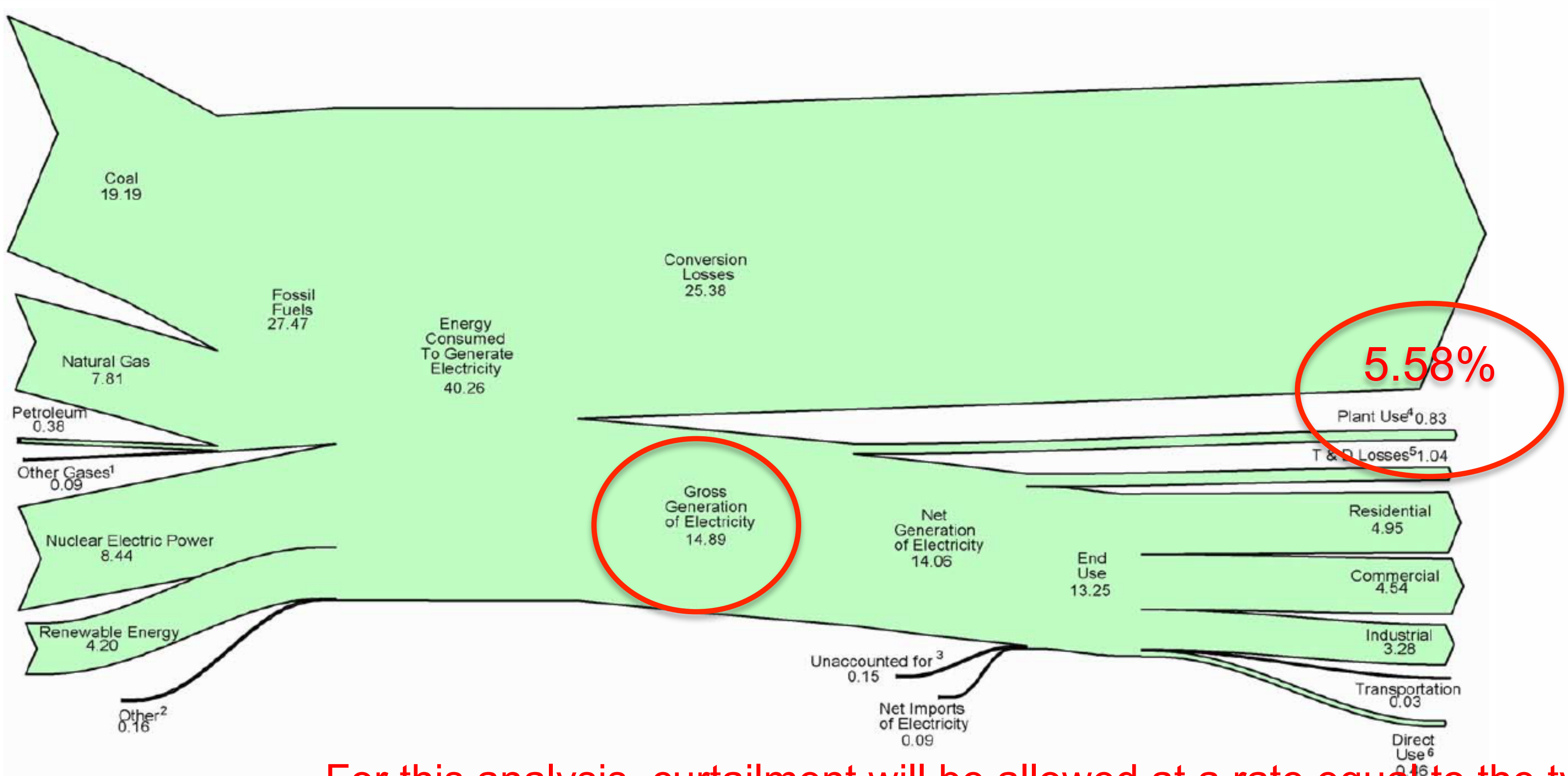
IV. Findings

RQ2 (Continued). If so, how much PV could be installed in Illinois while maintaining 100% utilization of the energy that is produced by the systems?

100% Utilization	**PJM**	**MISO**
System Capacity	1,314MW	1,400MW
Utilized Elec. from PV	100%	100%

IV. Findings

RQ3. How much of Illinois' electrical energy could PV supply if curtailment of the PV output is occasionally permitted?



(DOE, 2011)

For this analysis, curtailment will be allowed at a rate equal to the typical internal energy consumption at thermal generation facilities.

IV. Findings

RQ3. How much of Illinois' electrical energy could PV supply if curtailment of the PV output is occasionally permitted?

94.4% Utilization	**PJM**	**MISO**
System Capacity	7,665MW	3,660MW
Utilized Elec. from PV	94.4%	94.4%
Load Demand met	6.9%	7.2%

IV. Findings

		6% Carve-Out	100% Utilization (None Wasted)	94.4% Utilization (Thermal Plant Use Match)
Total	System Capacity (MW)	2,292	2,714	11,265
	Electricity Delivered (MWh)	2,685,763	3,234,147	13,209,754
	Load Demand met in IL (%)	1.5	1.8	7.5
	RPS met in IL (%)	6.0	7.3	29.8

Questions?

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