NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Forecasting DER Adoption: Electric Grid Planning

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The grid is decentralizing

Energy Decentralization is Growing

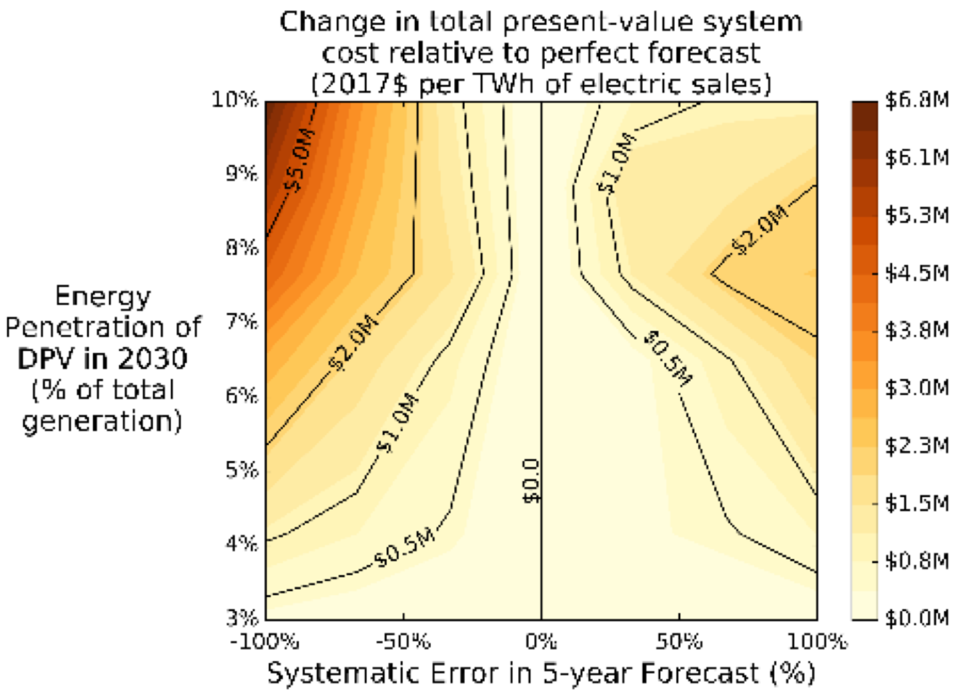
Several trends in energy decentralization:

- Distributed generation
- Rise of electric vehicles
- Price-responsive loads (e.g. demand response, smart home)
- Advanced sensors and controls

This has important electric grid planning implications:

- Forecasting net load
- Advanced Rate Design
- Distribution & Transmission Grid Integration

The Cost of Misforecasting DERs is High



System planning costs ($/TWh) due to systematic DPV misforecast for the Western Interconnection through 2030

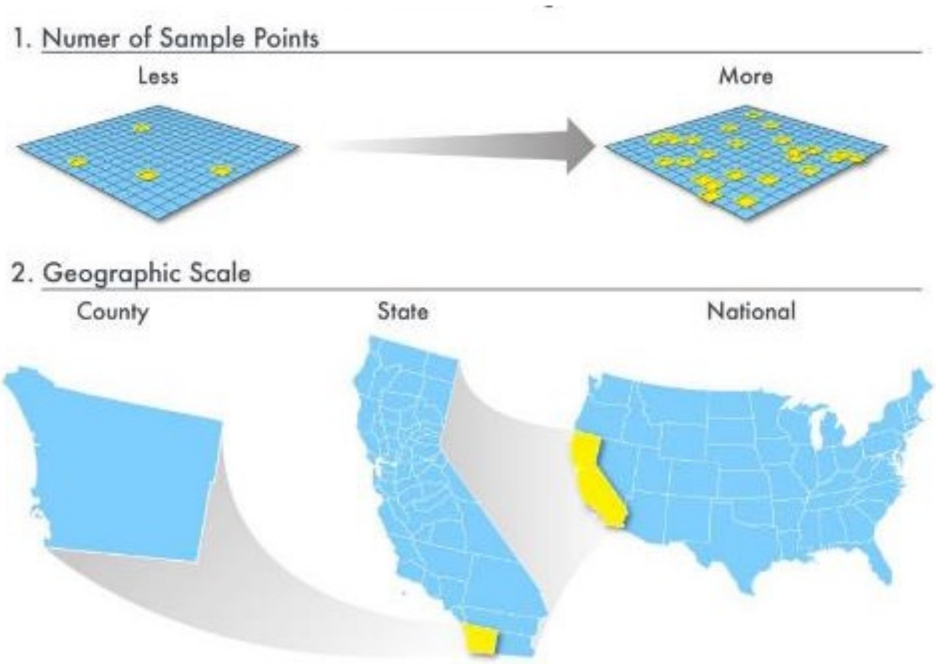
A recent study demonstrated the cost of mis-forecasting DPV capacity is high, with an average net present cost of **$2.3m/TWh** of utility sales

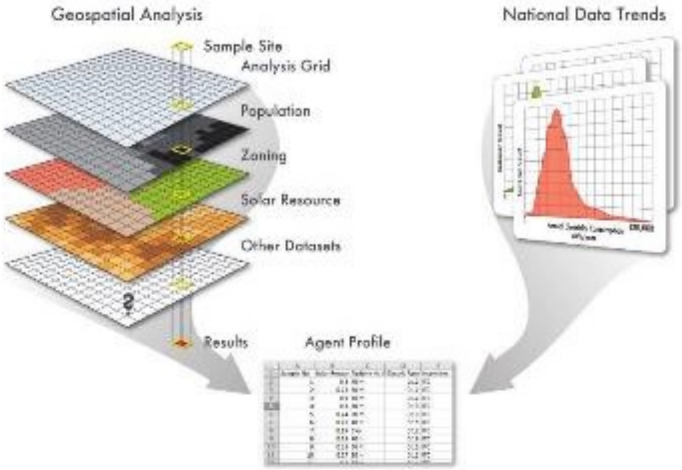
Misforecasting costs are created by either **overbuilding** generation and T&D resources, or **underbuilding** the system leading to lower resource adequacy.

Source: *Estimating the Value of Improved Distributed Photovoltaic Adoption Forecasts for Utility Resource Planning*, NREL, May 2018 (Gagnon et al. 2018)


How do we better plan for DERs?

dGen: NREL's Agent-Based Model to forecast DER Adoption





https://www.nrel.gov/analysis/dgen/

Forecasting DER adoption for grid planning

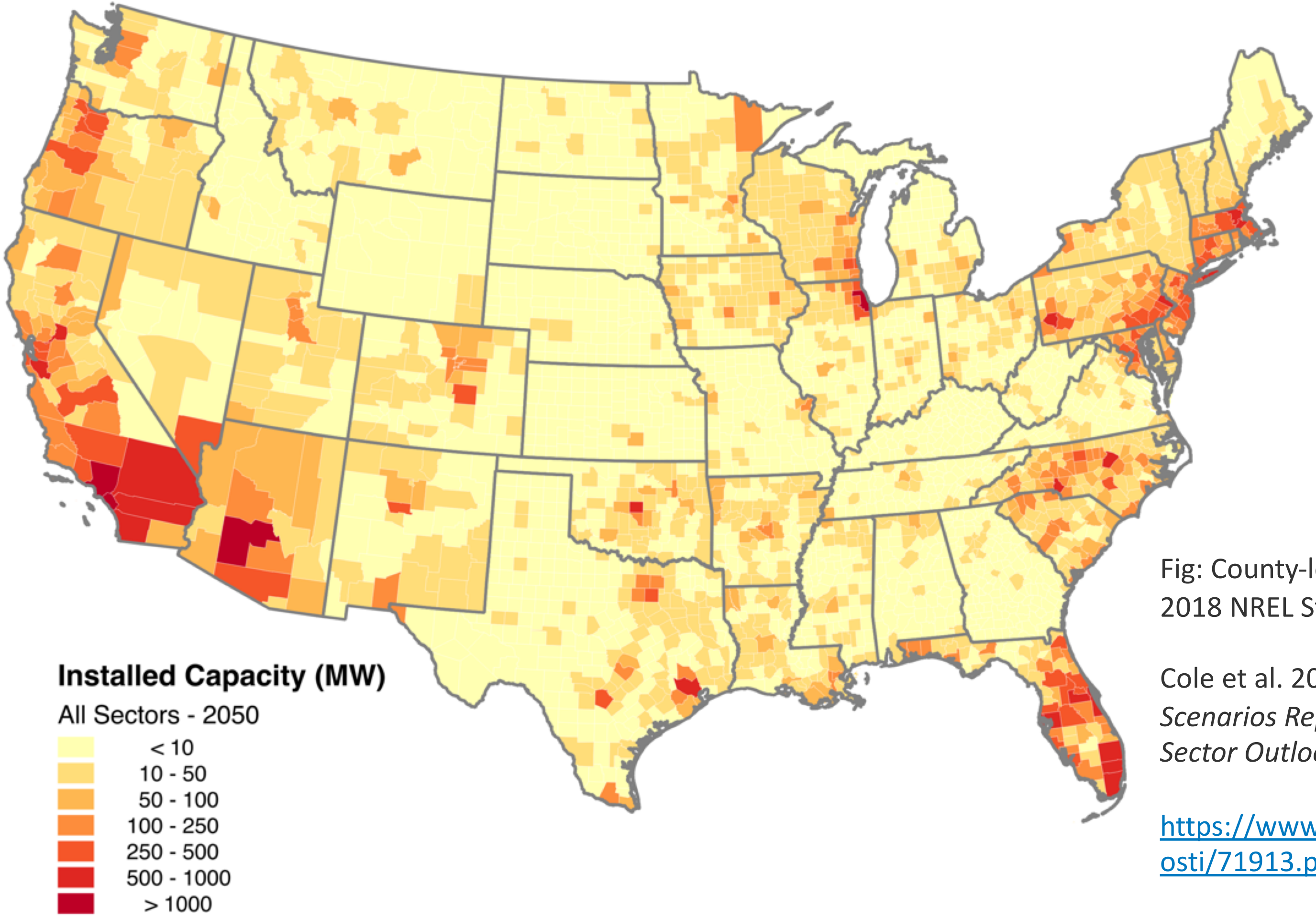
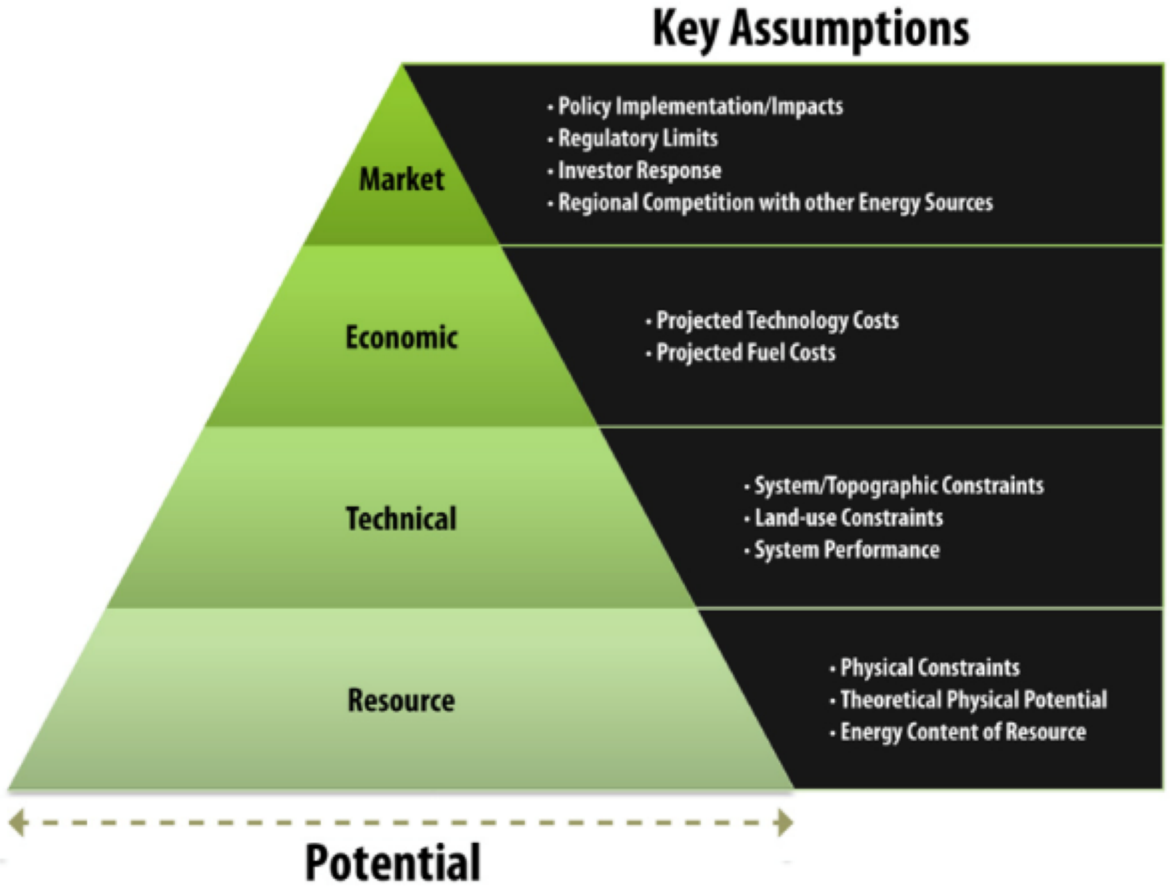


Fig: County-level forecast for 2018 NREL Standard Scenarios

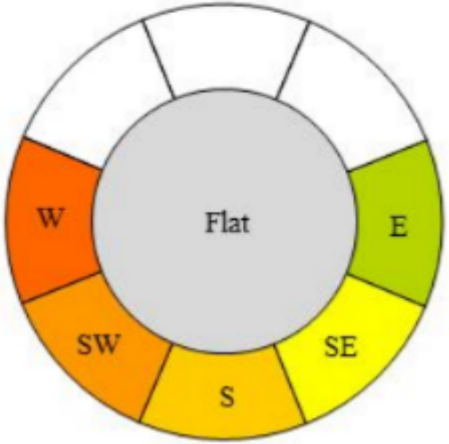
Cole et al. 2018. *2018 Standard Scenarios Report: A US Electricity Sector Outlook.*

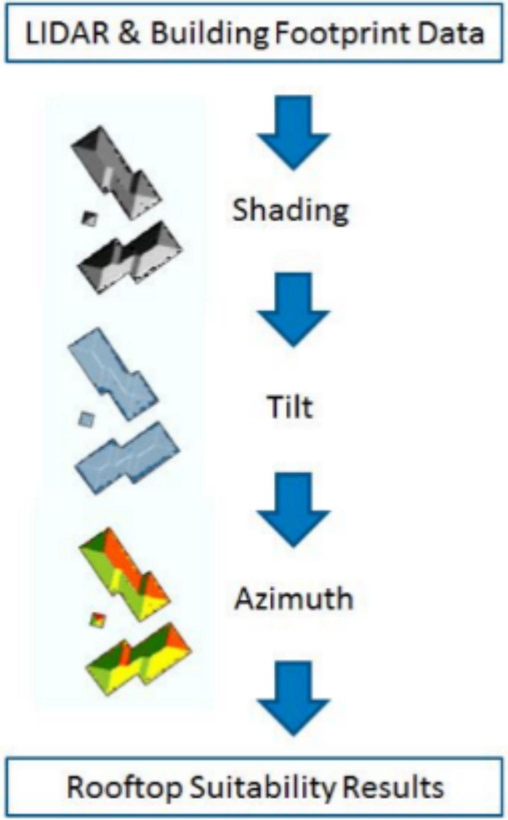
https://www.nrel.gov/docs/fy19osti/71913.pdf

Framework for Modeling DER Adoption



Assessing Rooftop Solar Technical Potential





Clockwise:

(1) Raw LiDAR imagery of buildings

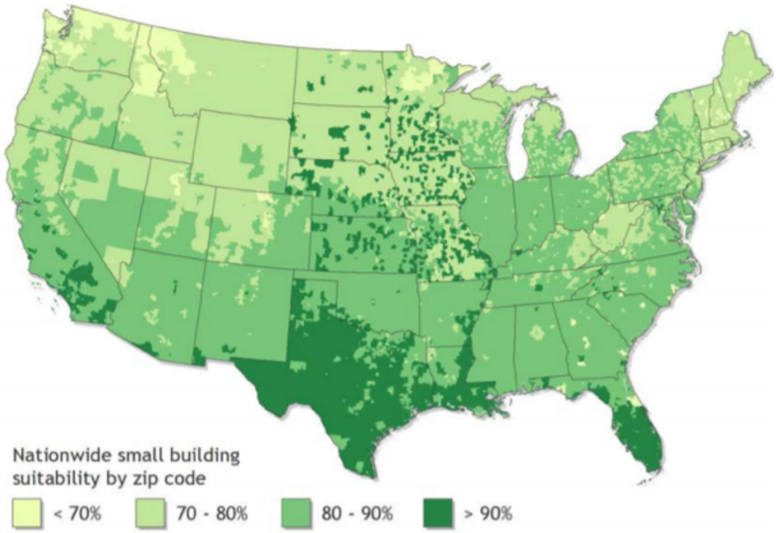
(2) Developable area estimated for each building in dataset, then aggregated at regional level

(3) Suitability based on roof plane orientations, tilt, size, and shading

Rooftop solar technical opportunity is large

Approximately 1.1 TW of technical potential, mostly in small buildings (i.e. residential homes)

Building Class (Building Footprint)	Total Suitable Area (Billions of m^2)	Installed Capacity Potential (GW)	Annual Generation Potential (TWh/year)
Small (< 5,000 ft^2)	4.92	731	926
Medium (5,000–25,000 ft^2)	1.22	154	201
Large (> 25,000 ft^2)	1.99	232	305
All Buildings	**8.13**	**1,118**	**1,432**



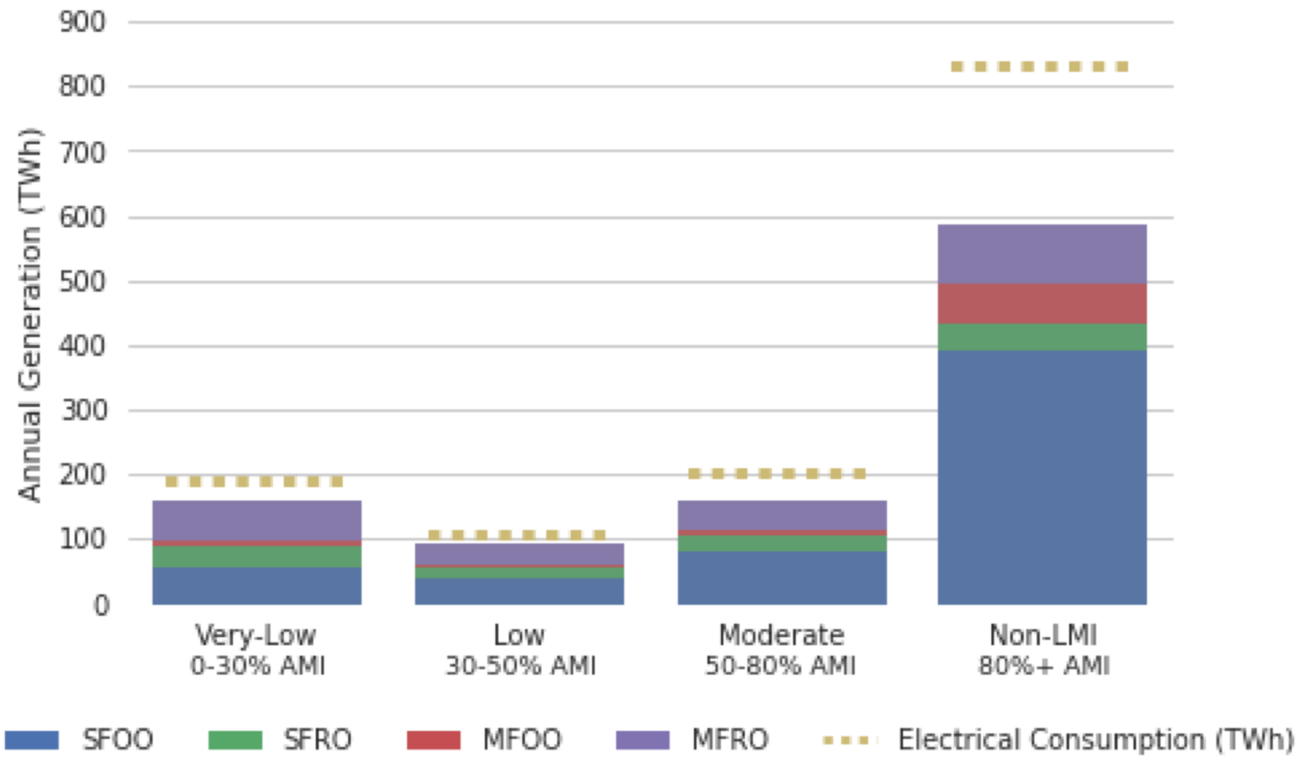
- The average **small building** had 52 m^2 (8.3 kW) of developable area, and 79% were "suitable"
- The average **medium building** had 952 m^2 (152 kW), and 52% were suitable
- The average **large building** had 4,178 m^2 (668 kW), and 52% were suitable

Gagnon, P. et al. (2016). *Rooftop Solar Photovoltaic Technical Potential in the United States. A Detailed Assessment* NREL/TP--6A20-65298.

Rooftop solar can meet most residential demand

In the residential sector rooftop solar can technically meet most electrical demand, especially low-income.

But, multi-family (MF) and renter-occupied (RO) buildings are a large source of the potential and are typically ineligible for solar adoption.



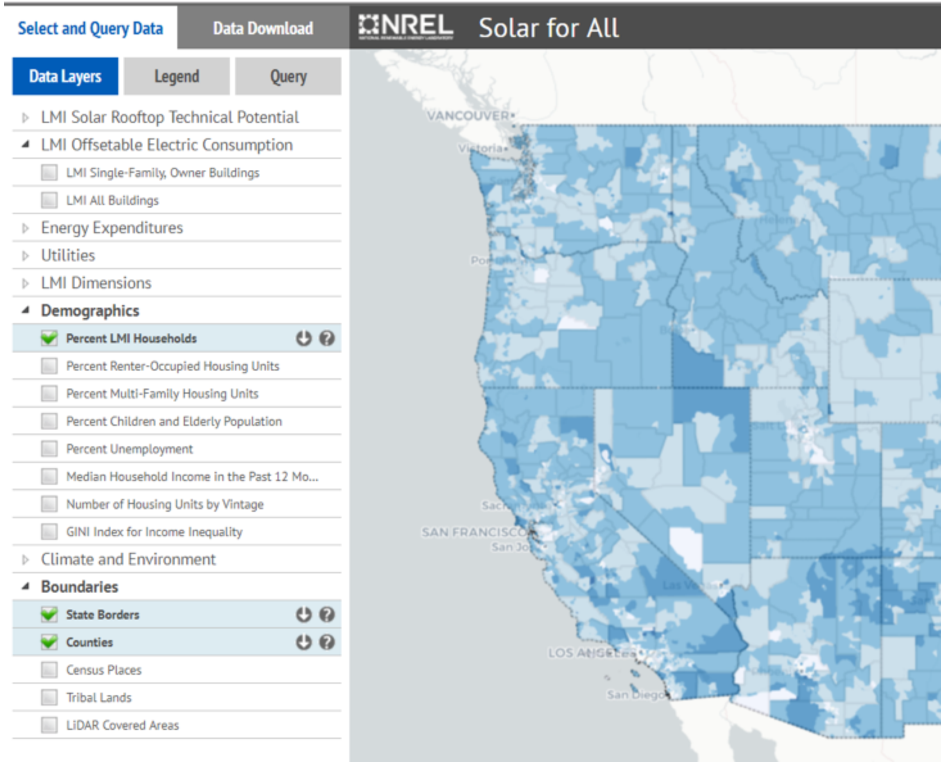
Sigrin, B., & Mooney, M. (2018). *Rooftop Solar Technical Potential for LMI Households in the U.S.*
https://www.nrel.gov/docs/fy18osti/70901.pdf

All data used in the study is publicly available

Download the REPLICA dataset!– Tract-level solar technical potential by income, tenure, and building type, joined with 10 additional datasets to provide socio-demographic and market context (e.g. energy expenditures, demographics, etc.). https://data.nrel.gov/submissions/81

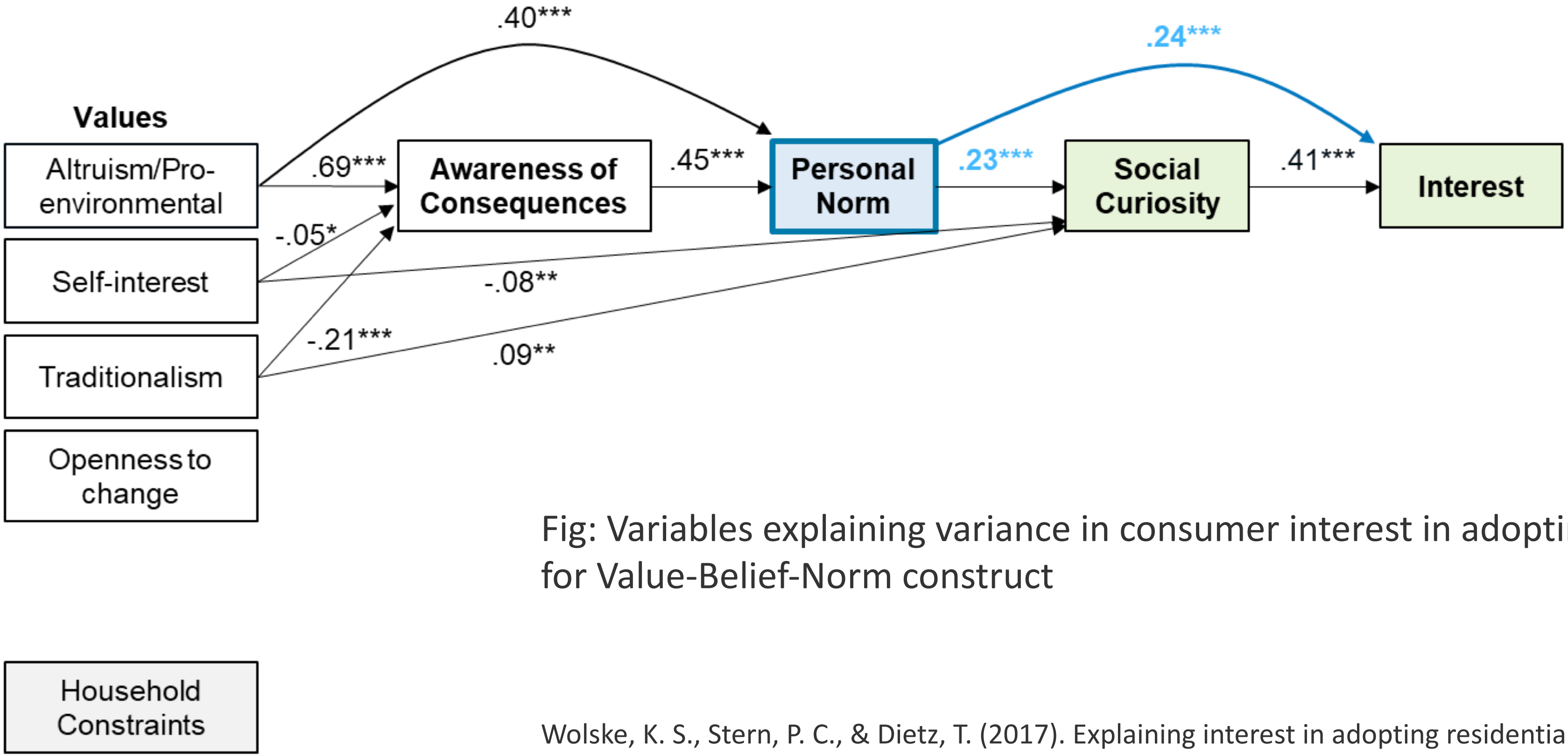
SolarForAll web application - Explore, download, and intersect data in interactive web application

https://maps.nrel.gov/solar-for-all/



Screenshot of SolarForAll app

What predicts adoption decisions?



(Significant paths not shown)

Fig: Variables explaining variance in consumer interest in adopting solar for Value-Belief-Norm construct

Wolske, K. S., Stern, P. C., & Dietz, T. (2017). Explaining interest in adopting residential solar photovoltaic systems in the United States: Toward an integration of behavioral theories. *Energy research & social science*, *25*, 134-151.

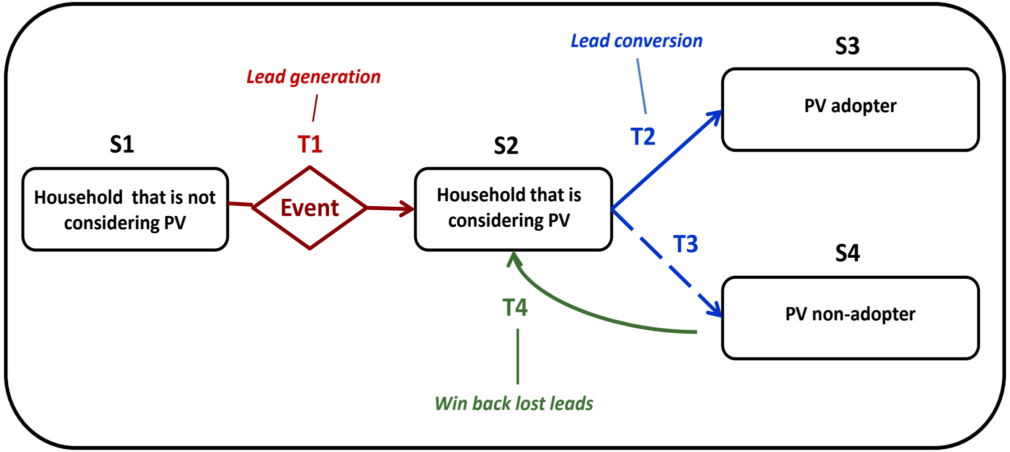
What do we know about DER adoption?

- Most consumers are primarily motivated by savings on utility bills (Sigrin et al. 2014; Moezzi et al. 2016)
  - Modeling prices and policies is important

- Consumers are influenced by spatial and social “peer effects” (Bollinger & Gillingham 2012; Wolske et al. 2017)
  - Motivates spatially-granular modeling

- Many of the variables that predict adoption decisions are non-demographic, e.g. pro-environmental norms, innovativeness, social support (Wolske et al. 2017)

Survey data is publicly available



Survey	Survey Responses				
	AZ	CA	NJ	NY	Total
General Population Survey	351	338	315	337	1341
Considerers Survey (non-adopters)	113	187	109	182	589
Adopter Survey	109	1181	185	187	1587
	573	1706	607	706	**3592**

Download the survey data: https://data.nrel.gov/submissions/68

Learn more about the study: https://www.nrel.gov/solar/seeds/

Sigrin et al. (2017): Understanding the Evolution of Customer Motivations and Adoption Barriers in Residential Solar Markets: Survey Data. National Renewable Energy Laboratory. https://dx.doi.org/10.7799/1362095

Open Sourcing dGen Model

The RiDER project seeks to advance the state-of-art of long term resource planning by open sourcing **NREL's dGen model**, an agent-based model of DER customer adoption.

- Model release scheduled for September 2020
- Develop county-level projections of distributed solar and storage deployment for each of the ISO/RTO participants' service territories

Want to learn more?

Contact: Benjamin.Sigrin@NREL.gov


Substantial research gaps remain

Ongoing research needed

- Developing granular data sets (i.e. premise-level) and computational methods to simulate adoption and effects on the distribution system
- Anticipating how consumers will use DER technologies and their combinatorial possibilities, e.g. DPV + EV + DR
- Integrative modeling to including DERs in load forecasting and resource and infrastructure planning
- Understanding the value of DERs and how this changes with grid evolution
- Continuing to develop and refine methods to conduct Integrated Distribution Planning