Planning for Solar at Any Scale:

GA's Model Solar Ordinance & Recent Rooftop Experience

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Georgia Tech Strategic Energy Institute

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Outline

- Why Scale Matters
- Georgia’s Model Solar Ordinance
- Recent Residential PV Experiences
- Q&A

U.S. Trend toward Grid Decentralization

Table 4.1. Count of Electric Power Industry Power Plants, by Sector, by Predominant Energy Sources within Plant, 2009 through 2019

Year	Coal	Petroleum	Natural Gas	Other Gases	Nuclear	Hydroelectric Conventional	Other Renewables	Hydroelectric Pumped Storage	Other Energy Sources
Total (All Sectors)									
2009	593	1,168	1,652	43	66	1,427	1,219	39	28
2010	580	1,169	1,657	48	66	1,432	1,355	39	32
2011	589	1,146	1,646	41	66	1,434	1,582	40	54
2012	557	1,129	1,714	44	66	1,426	1,956	41	64
2013	518	1,101	1,725	44	63	1,435	2,299	41	78
2014	491	1,082	1,749	43	62	1,441	2,674	41	94
2015	427	1,082	1,779	45	62	1,440	3,043	41	83
2016	381	1,076	1,801	45	61	1,451	3,624	40	117
2017	359	1,080	1,820	44	61	1,458	4,174	40	148
2018	336	1,087	1,854	46	60	1,458	4,667	40	171
2019	308	1,090	1,899	43	58	1,452	5,244	40	212

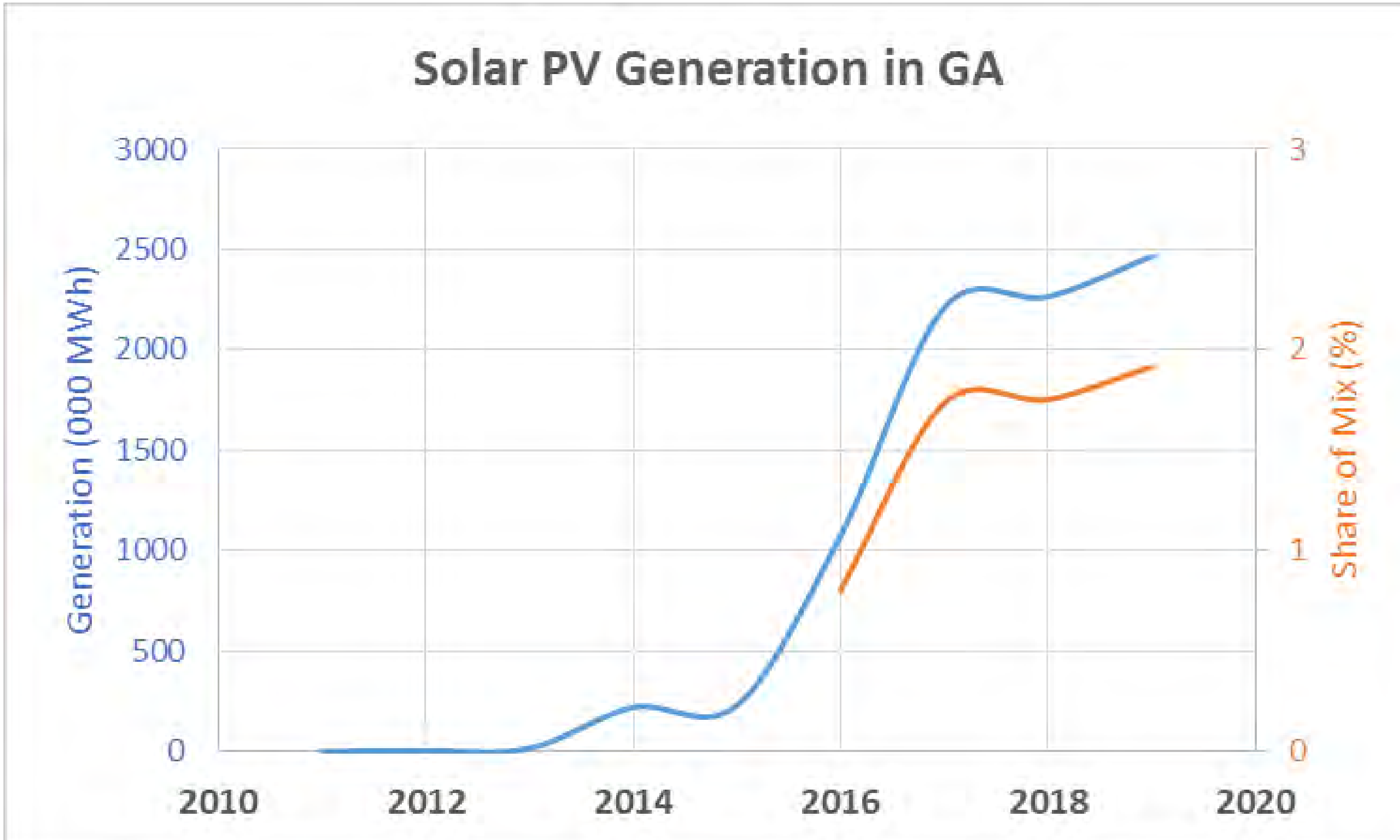
+15%

+330%

-48%

Source: US EIA, Electric Power Annual 2020 w/2019 data

https://www.eia.gov/electricity/annual/html/epa_04_01.html

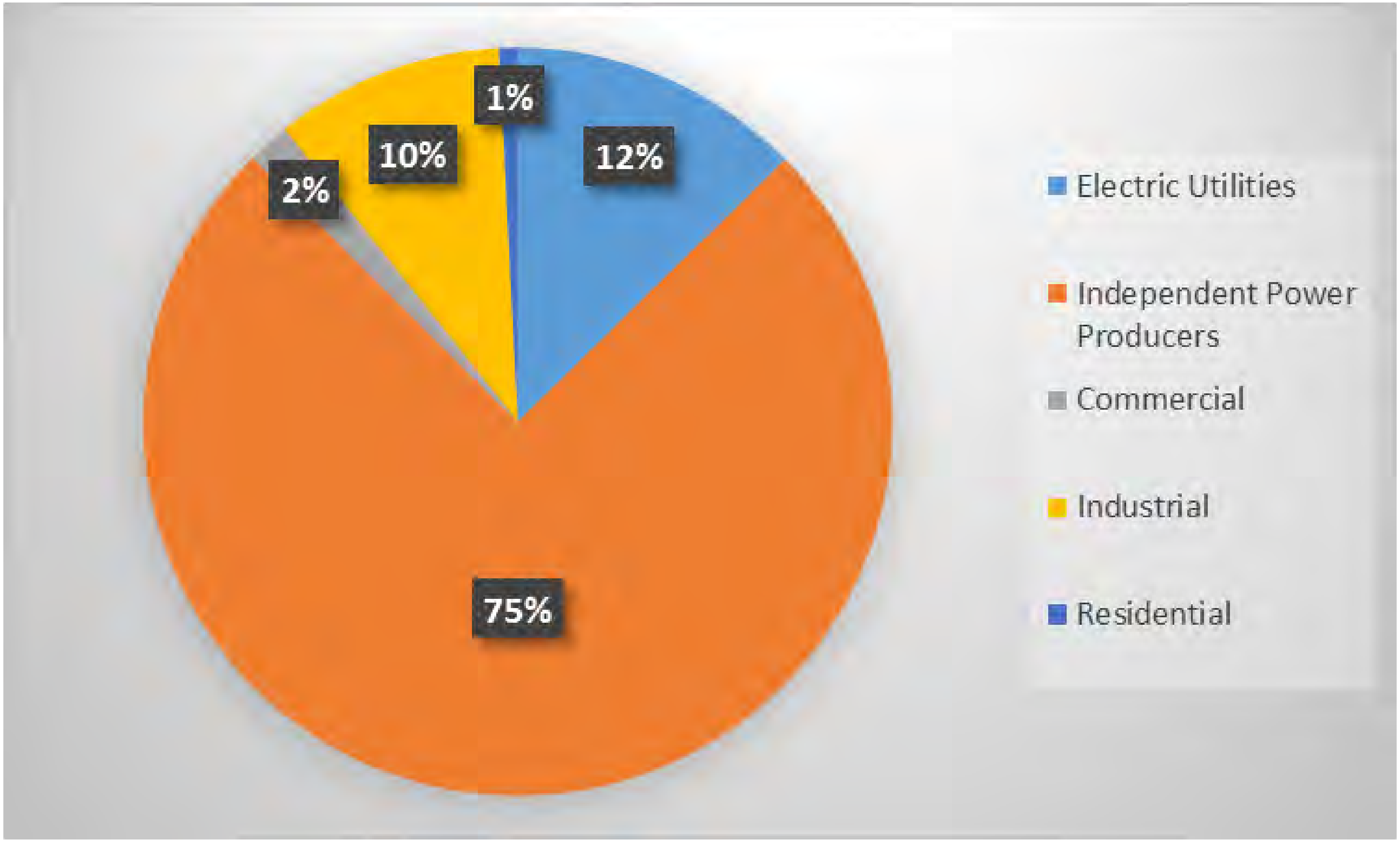


Total share of solar:

- 1.9% of generation in GA (as of end 2019)
- 2210 MW new solar PV to be added by 2025 (to add 2%)
    - C&I (1000 MW); Utility-scale (1000MW); Distributed Generation (210MW)
- 2200 MW new nuclear to be added by 2023 (to add 10%)

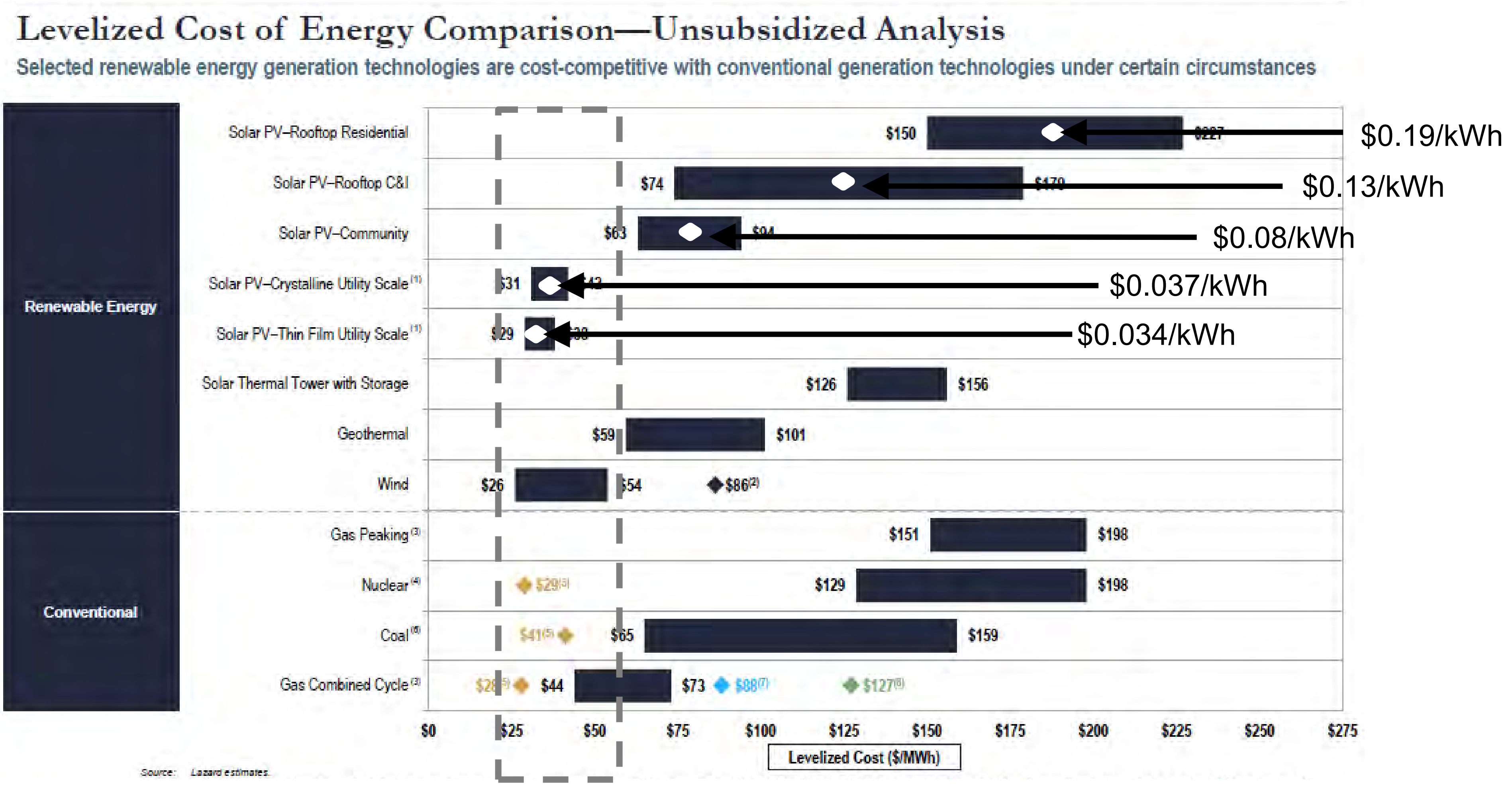
Source: US EIA, Electric Power Annual 2020 w/2019 data

Share of GA Solar PV, by Sector, 2019



Source: US EIA, Electric Power Annual 2020 w/2019 data

Levelized Cost of Electricity (LCOE), 2020



Source: Lazard's LCOE Analysis- Version 14.0, Oct 2020

Solar Costs as a Function of Scale

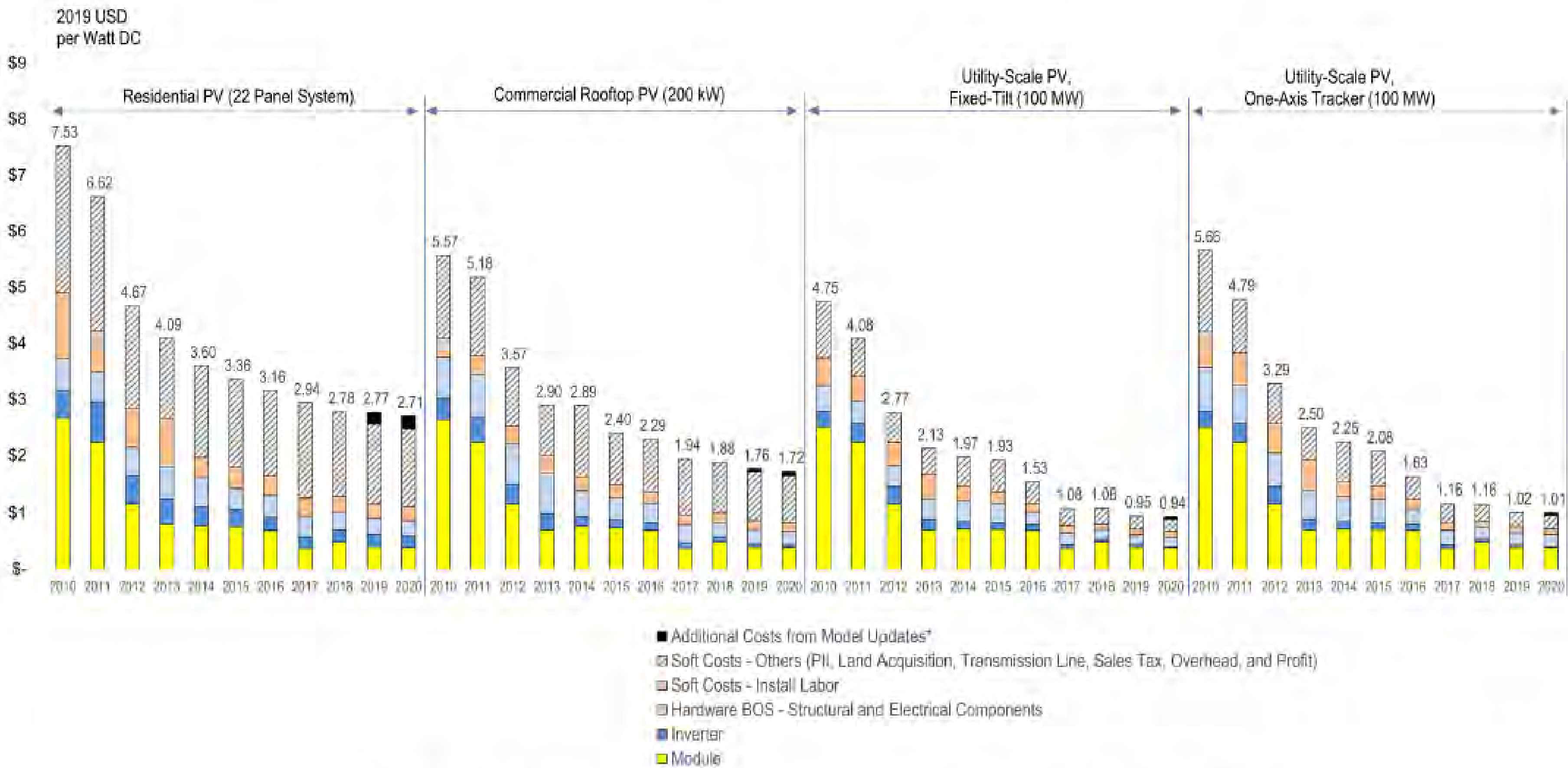
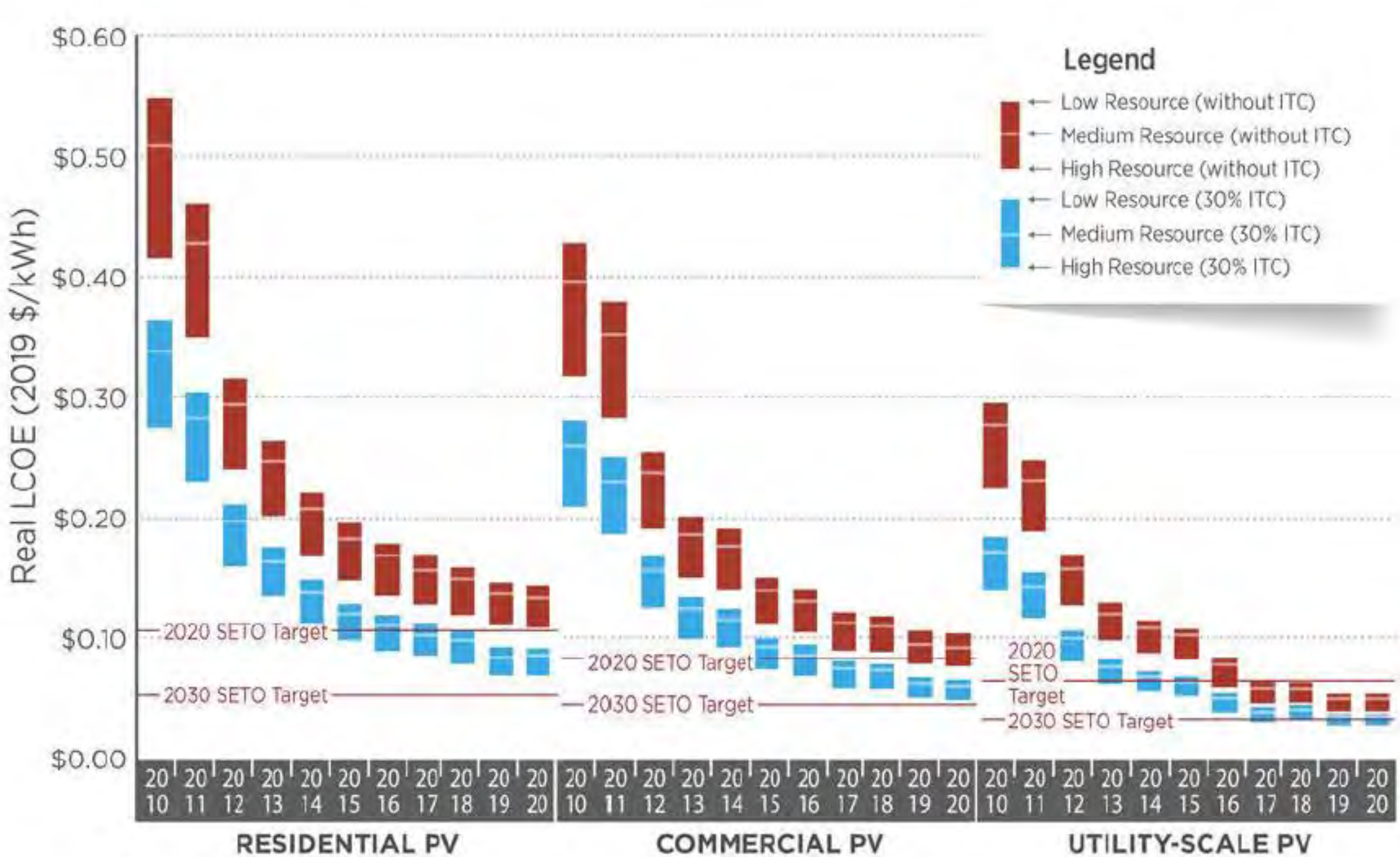


Figure ES-1. NREL PV system cost benchmark summary (inflation-adjusted), 2010–2020

Source: US DOE, NREL, "U.S. Solar PV System and Energy Storage Cost Benchmark: Q1 2020

https://www.nrel.gov/docs/fy21osti/77324.pdf

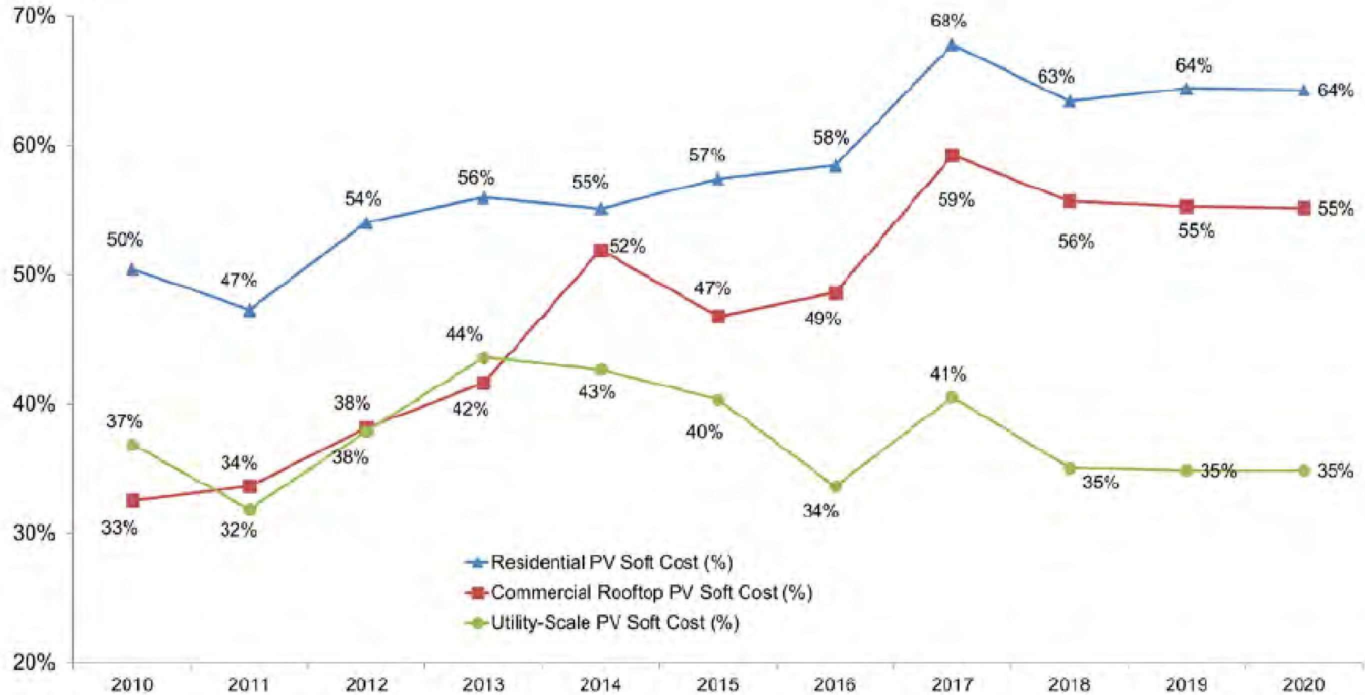
Solar Costs as a Function of Scale



Source: US DOE, NREL, "U.S. Solar PV System and Energy Storage Cost Benchmark: Q1 2020

https://www.nrel.gov/docs/fy21osti/78882.pdf

Solar "Soft Costs" as a Function of Scale



1. A "soft cost" in the benchmark report is defined as a nonhardware cost—i.e., "Soft Cost" = Total Cost - Hardware Cost (module, inverter, and structural and electrical BOS).
2. The residential and commercial sectors have larger soft cost percentages than the utility-scale sector.
3. Soft costs and hardware costs interact with each other. For instance, module efficiency improvements have reduced the number of modules required to construct a system of a given size, thus reducing hardware costs, and this trend has also reduced soft costs from direct labor and related installation overhead.
4. An increasing soft cost proportion in this figure indicates that soft costs declined more slowly than hardware costs; it does not indicate that soft costs increased on an absolute basis.

Source: US DOE, NREL, "U.S. Solar PV System and Energy Storage Cost Benchmark: Q1 2020

https://www.nrel.gov/docs/fy21osti/78882.pdf

Definitions for Scale

US DOE, NREL

Sector Category	Description	Size Range
Residential PV	Residential rooftop systems	4 kW–7 kW
Commercial PV	Commercial rooftop systems, ballasted racking	100 kW–2 MW
Utility-Scale PV	Ground-mounted systems, fixed-tilt and one-axis tracker	5 MW–100 MW

GA MODEL ORDINANCE

	Approximate Delineations of Size for Ground Mounted SES	Number of Acres*																												
	ILLUSTRATIVE	1	2	3	4	5	6	7	8	9	10	12	14	16	18	20	22	24	26	28	30	35	40	45	50	60	70	80	90	100+
1	**Small Scale Ground Mounted SES**	Lower				Upper																								
2	**Intermediate Scale Ground Mounted SES (Example I)**		Lower									Upper																		
	Intermediate Scale Ground Mounted SES (Example II)					Lower																			Upper					
3	**Large Scale Ground Mounted SES**												Lower																	NO Upper Limit
	***Not to scale**																													

Note: In general for ground mounted systems, 5-10 acres/MW is a reasonable rule of thumb
The lower end corresponds to the approximate land area required for a fixed tilt system, and the upper end corresponds to the approximate land area needed for single and multi axis tracking

Outline

- Why Scale Matters
- Georgia’s Model Solar Ordinance
- Recent Residential PV Experiences
- Q&A

Solar Ordinance: Key Accomplishments

- Creation and maintenance of an on-line repository for stakeholders in Georgia. References include:
  - Model ordinance information from other states (e.g., NC), land use guides, zoning/permitting information, actual ordinance documents, other legal documents, listing of state and local contacts, etc.
  - Technical resources including solar intensity maps (insolation by county), and availability and access to sub-station and grid resources
  - Economic planning tools for assessing financial viability and benefit cost for projects
- Development of a comprehensive stakeholder community to reflect diverse perspectives in solar developments
- Definitions of appropriate scope & scale
  - (E.g., utility scale, target generation amounts, >5MW, regions, etc.)
- Development of best practices
  - (E.g., provide direction for navigating/evaluating solar opportunities at the county level in GA, etc.)
- Draft model ordinance language, based upon precedent, existing ordinances
- Convened a series of stakeholder meetings to inform the draft language and address additional/related issues of interest to stakeholders
  - e.g., zoning, permitting, land use, environmental impacts, financial assessment tools, and other considerations

https://energy.gatech.edu/georgias-model-solar-ordinance

Ga Model Solar Ordinance Partners

Georgia Tech Strategic Energy Institute

EMORY LAW

UGA extension

Research Team Process

- Conducted background research on solar energy systems

Study

Engage

- Obtained stakeholder review and feedback

- Reflected on comments, conduct additional research, make substantive changes

Improve

University Effort

- Georgia Tech, Emory, and UGA collectively logged:
  - More than 1,200 total hours by faculty and staff
  - More than 575 total hours by students
- Georgia Tech, Emory, and UGA referenced:
  - 16 model solar ordinances
  - 34 existing and proposed Georgia solar ordinances
  - Hundreds of additional guides, whitepapers, and articles
- Georgia Tech, Emory, and UGA collectively held over 65 meetings:
  - Internal meetings
  - Public meetings
  - One-on-one meetings with stakeholders
- These efforts were entirely voluntary and pro bono

Methods and Considerations

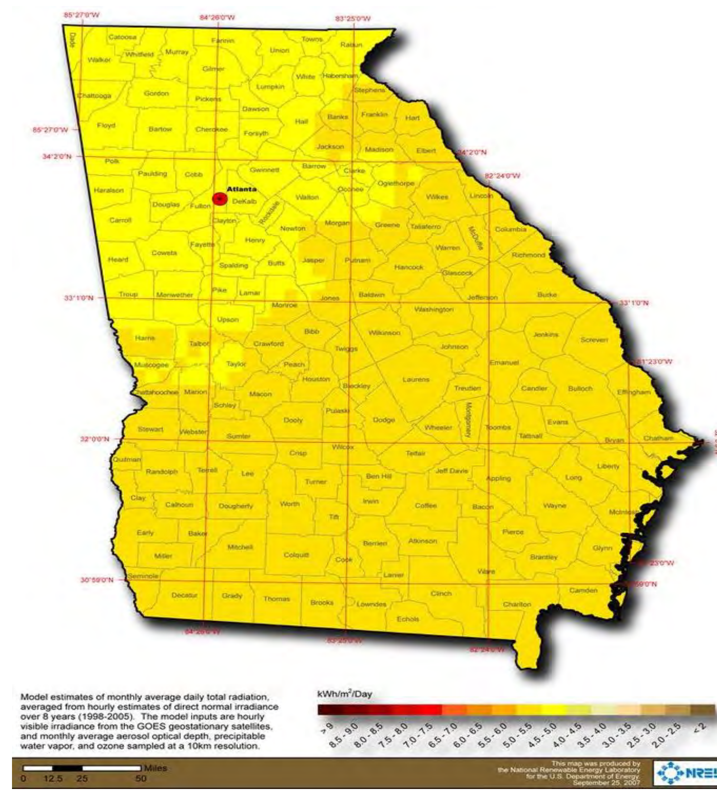
- Initial factors considered in state policy assessment
  - Insolation (solar resource quality)
  - Installed capacity (success metric)
  - Quality of existing policies
  - Concentration of electricity infrastructure

Insolation

- Relatively small range in GA, all suitable for solar
- ~4.5-5 kWh/m^2/day

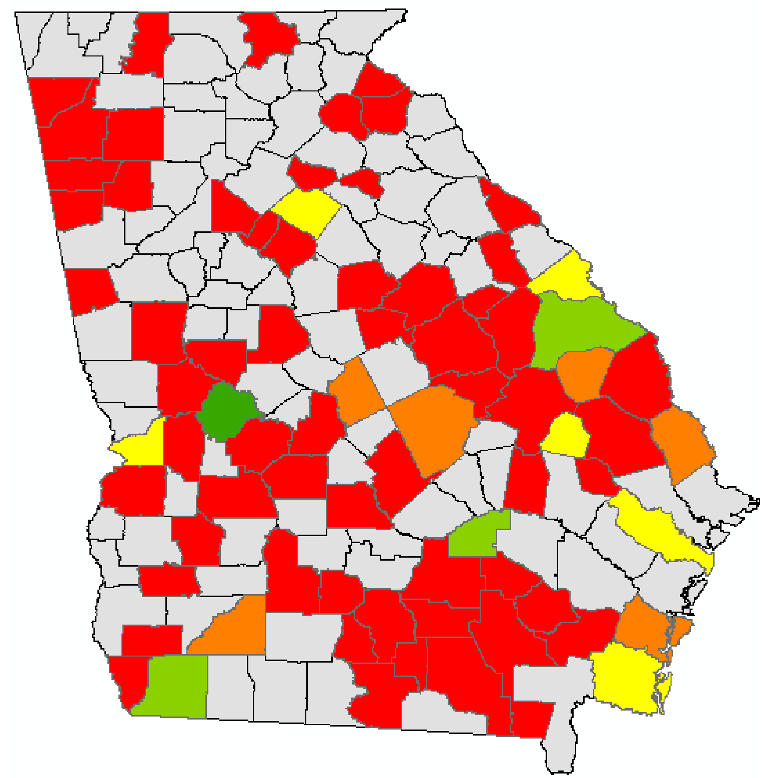
- Approximate range of Capacity Factors in US is:
  - 8-10% (New England)
  - 10-13% (typical for Southeast)*
  - 20% (Desert Southwest)

*Denotes “Medium Resource” wrt U.S. solar resources



Installed Capacity

- Installed capacity varies across the state, and may be installed in counties without ordinances



Installed MW

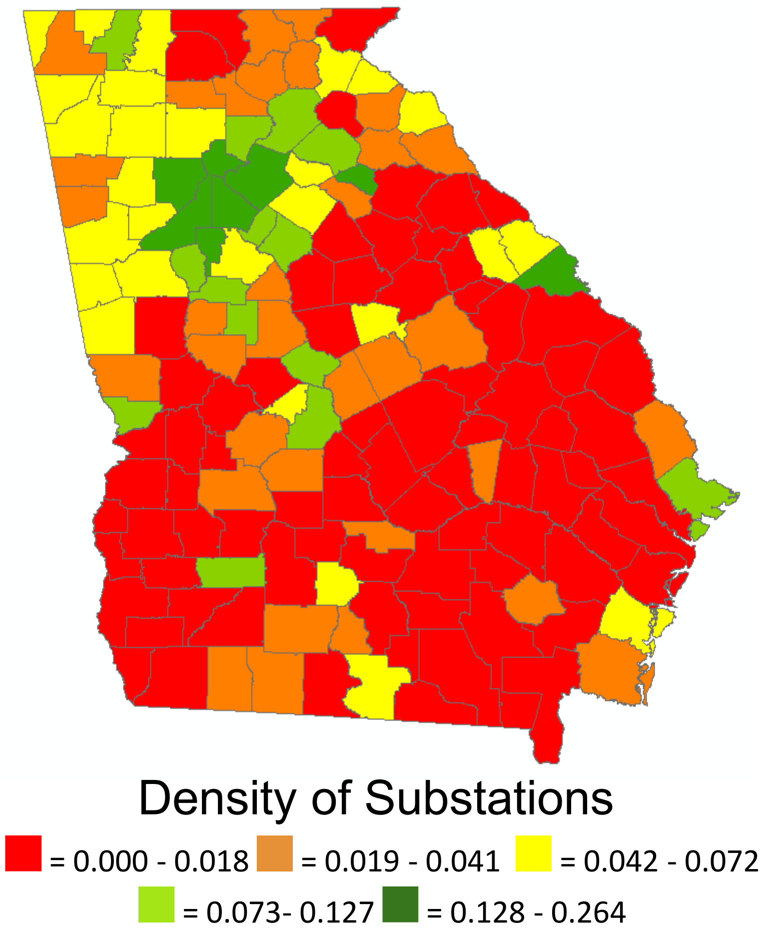
= no installed capacity = 0.30-7.70 = 7.71- 21.00 = 21.10 – 52.00
= 52.10- 107.00 = 107.10 – 403.40

“Quality” of Existing Policies

- NC Model Ordinance as “baseline”
- Conversation experts about policy features that affect developer’s will to site
- Comprehensive ordinances without prohibitive features scored “green”
- Incomplete, or comprehensive ordinances with prohibitive features scored “red”
    - Setbacks <100 ft
    - “Excessive” provisions for glare
    - Bonding requirements for decommissioning
- Some jurisdictions revert to existing zoning codes

Concentration of Grid Infrastructure

- Intensity of substations
- Needs to be refined
  - perhaps with greater resolution
  - and additional grid resources
  - other balance of system considerations
  - include environmental considerations



Solar Ordinance Matrix, by County

County	Relative Solar Intensity	Relative Density of Substations	Relative Policy Strength	Installed Capacity (MW)
Bulloch	Dark green	Orange	Dark green	2.0
Burke	Dark green	Red	Yellow	76.5
Butts	Light green	Orange	Yellow	No data
Calhoun	Dark green	Red	Yellow	1.0
Camden	Dark green	Orange	Yellow	30.1

Circulated the Draft Model Ordinance to and Met with Hundreds of Stakeholders

- County and city officials
- Zoning and Planning experts
- Commission staff
- Legal experts
- Engineers
- Non-profits
- Project Developers
- Industry associations
- Civil society

Deliverables and Resources

https://energy.gatech.edu/georgias-model-solar-ordinance

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Georgia's Model Solar Ordinance

Georgia is one of the fastest-growing solar energy producers in the country. To develop this resource in a smart and pragmatic way requires a multi-step, multi-stakeholder process, of which a critical first step is determining how and where to site different types of solar projects.

The Georgia Institute of Technology, Emory University, and the University of Georgia have come together to develop a model solar zoning ordinance to provide county and city officials and other decision-makers in Georgia access to best practices and a common baseline from which to work. We have produced a comprehensive document that addresses multiple scales and types of solar energy systems that counties and cities can adopt and adapt to their needs.

- MSO Home Page
- Ordinance and Guide Preview Presentation
- Model Solar Ordinance
- Model Solar Guide
- Solar Policy Repository
- Tools for Policy Makers and Developers

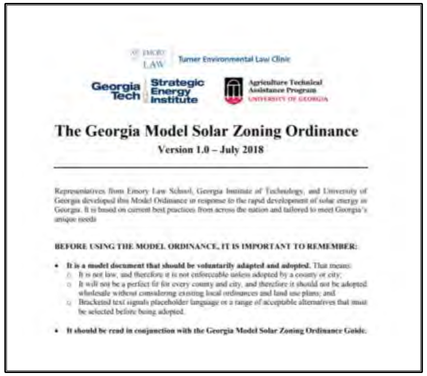
Example Ordinance (10 pages)

Comprehensive Guide (81 pages)

Tools & Resources

https://energy.gatech.edu/georgias-model-solar-ordinance

Resources


The Georgia Model Solar Zoning Ordinance

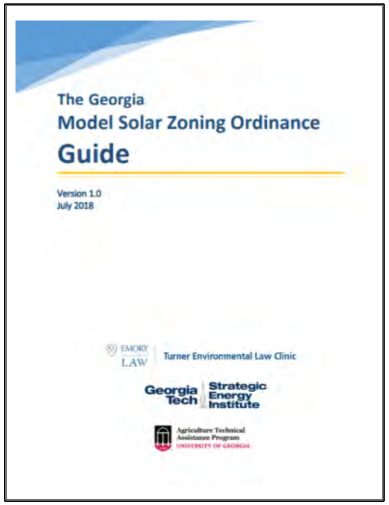
Version 1.0 – July 2018

Representatives from Emory Law School, Georgia Institute of Technology, and University of Georgia developed this Model Ordinance in response to the rapid development of solar energy in Georgia. It is based on current best practices from across the nation and tailored to meet Georgia's unique needs.

BEFORE USING THE MODEL ORDINANCE, IT IS IMPORTANT TO REMEMBER:

- **It is a model document that should be voluntarily adapted and adopted.** That means:
  - It is not law, and therefore it is not enforceable unless adopted by a county or city;
  - It will not be a perfect fit for every county and city, and therefore it should not be adopted wholesale without considering existing local ordinances and land use plans; and
  - Bracketed text signals placeholder language or a range of acceptable alternatives that must be selected before being adopted.
- **It should be read in conjunction with the Georgia Model Solar Zoning Ordinance Guide.**

Model Ordinance


The Georgia

Model Solar Zoning Ordinance

Guide

Version 1.0

July 2018

Guide


STORMWATER AND SOIL EROSION

Georgia Stormwater Management Manual, 1: Stormwater Policy Guidebook (Atlanta Reginal Commission)

Maryland Department of the Environment, Stormwater Design Guidance – Solar Panel Installations

Minnesota Stormwater Manual, Stormwater Management for Solar Projects and Determining Compliance with the NPDES Construction Stormwater Permit

North Carolina Department of Environmental Quality, Stormwater Design Manual, Solar Farms (Apr. 5, 2017)

Pennsylvania Department of Environment Protection Information to Use in the Determination of Stormwater Management Impacts for Solar Projects (Oct. 4, 2011)

Manual for Erosion and Sediment Control for Georgia (Georgia Soil and Water Conservation Commission)

DECOMMISSIONING

Solar PV Resource Recovery (Illinois Sustainable Technology Center)

Working Paper: State Regulation of Solar Decommissioning (North Carolina Clean Energy Technology Center)

OTHER MODEL SOLAR ORDINANCES

Guidance for Creating a Solar Friendly Ordinance (Sustainable Jersey)

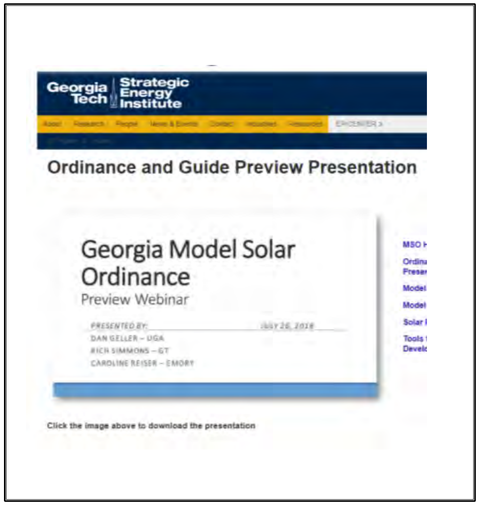
New York State Model Solar Energy Law (Sustainable CUNY of the City University of New York)

Model Solar Energy Facility Permit Streamlining Ordinance (California County Planning Directors Association)

Model Small-Scale Solar Siting Ordinances (Center for Climate Change Law at Columbia Law School)

Integrating Solar Land Uses (Central Savannah River Authority)

Tools



Webinar Presentation

Possible Next Steps

- Conduct an economic assessment to complement the zoning and siting resources
  - E.g., to include incentives, installation cost and electricity prices
  - To consider in detail characteristics of specific locations, areas
  - To consider alternate uses for land (e.g., ag, forestry)
- Update the database of county policies
- Develop best practices and lessons learned for various decision makers and stakeholders
  - E.g., tax incentives/abatements, bonds, decommissioning
  - Scale and proximity to electricity infrastructure
- Enhance tools for C&I, residential scale projects
- Identify resources (e.g., funding, personnel, expertise)

Disclaimer: Any possible next steps are subject to availability of resources, partnering opportunities, and priorities.

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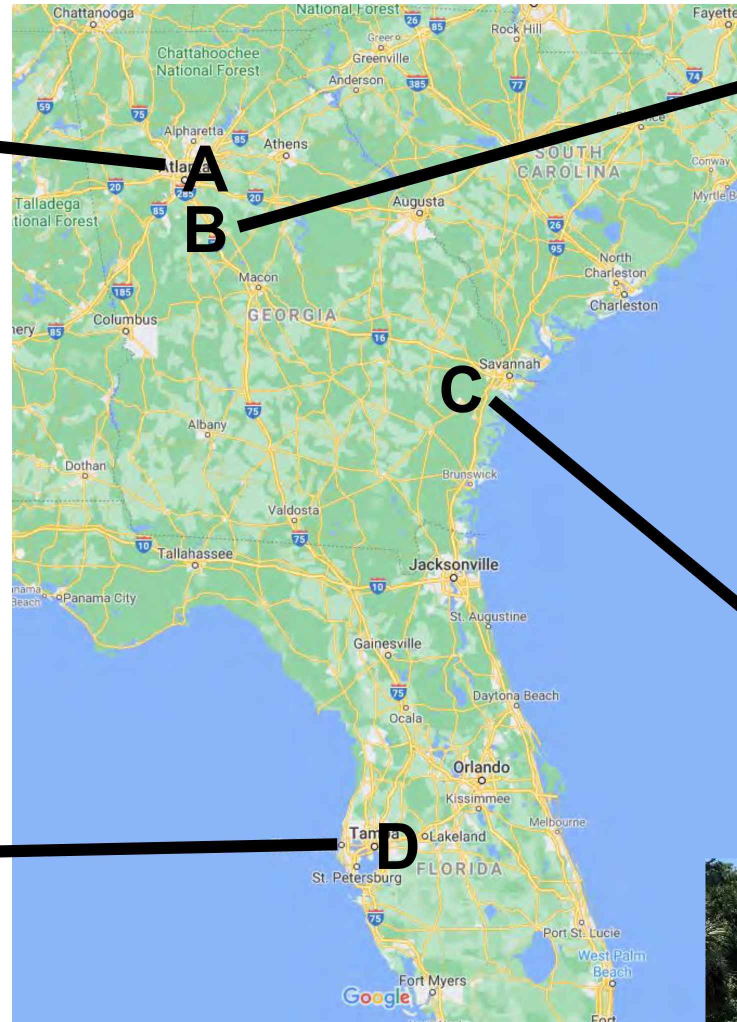
Residential Solar- Anecdotal Examples

A

- Suburban
- Rooftop
- 10 kW



B

- Semi-Rural
- Stand-alone
- 11 kW

C

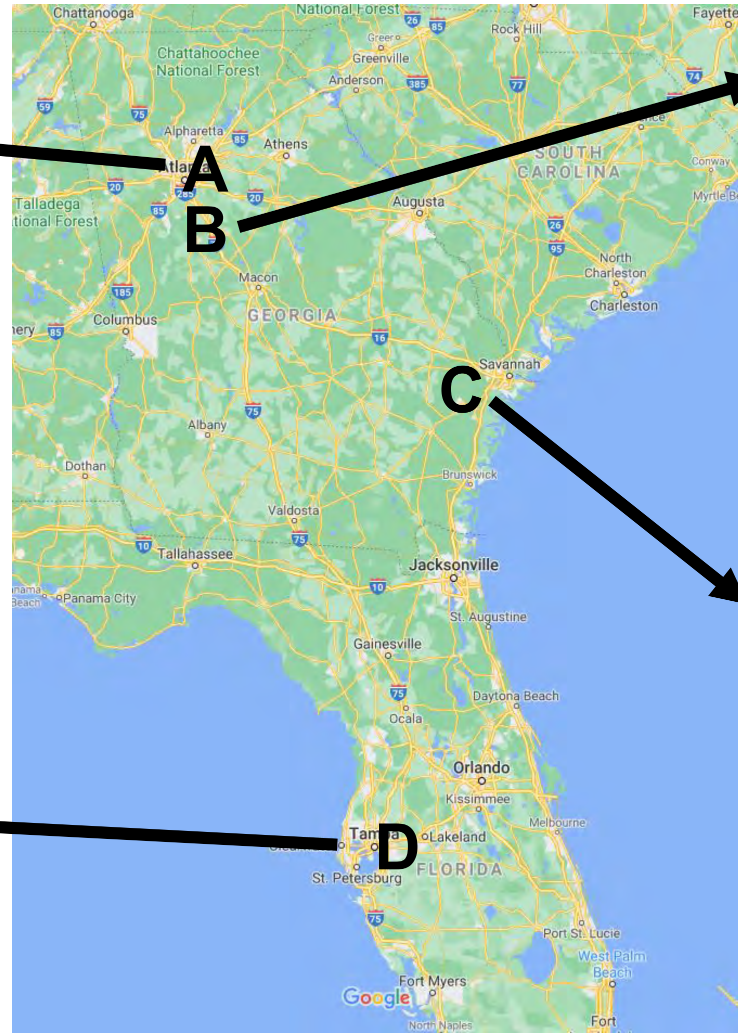
- Rural
- Stand-alone
- 9 kW

- D
  - Suburban
  - Rooftop
  - 10 kW

Source: R. Simmons, Georgia Tech
Disclaimer: This solar survey is illustrative and anecdotal. It may not reflect accurate trends or insights for similar residential PV configurations.

Residential PV Project Highlights

A
- Efficient home
  - 8400 kWh annual demand
- 50% from solar
- 20 year payback



B
- No natural gas
- High demand:
  - 9600 kWh annual demand
- 80% from solar
- EMC build credit
- 10 year payback

C
- Low energy demand
  - 4000 kWh annual demand
- 80% from solar
- 15 year payback

D
- High energy consumption
  - 13,800 kWh annual demand
- 32% from solar
- 10 year payback
- Utility net metering at retail rate

Source: R. Simmons, Georgia Tech
Disclaimer: This solar survey is illustrative and anecdotal. It may not reflect accurate trends or insights for similar residential PV configurations.

Residential PV Anecdotal Comparison

Rough comparison of individual residential PV projects in a variety of contexts

ID	Setting type	Mounting type	In service date	Rated PV Capacity	% of Demand from PV	Est. Payback	Implied PV LCOE	Comment
				kW	%	Years		
A	GA Suburban	Rooftop	May 2019	10	50	20	Higher than retail rate	Efficient home. Battery storage.
B	GA Semi-Rural	Stand alone	Apr 2020	11	80	10	Close to parity	No natural gas service.
C	GA Rural	Stand alone	Apr 2019	9	80	15	Higher than retail rate	Low energy consumption.
D	FL Suburban	Rooftop	Dec 2018	10	32	10	Close to parity	High energy consumption. Net metering at retail.

Selected Commonalities

- 25 year life
- Retail rates: $0.11-$0.12/kWh
- 30% Federal ITC on all projects
- Solar insolation (roughly equal)

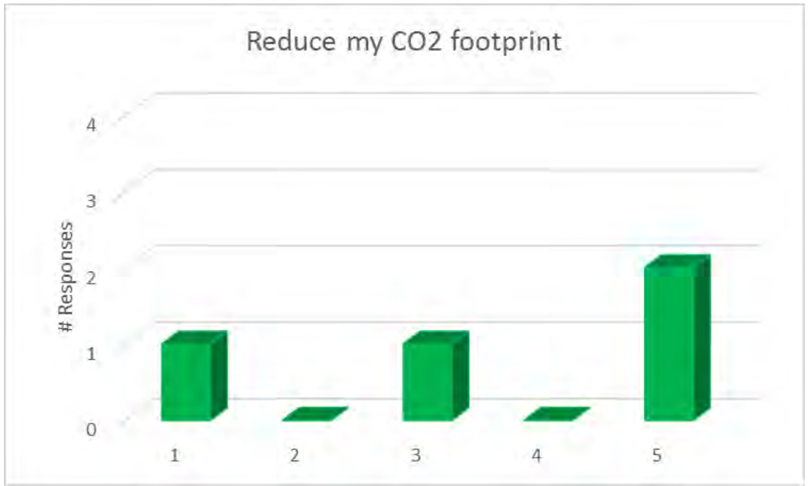
Selected Disparities

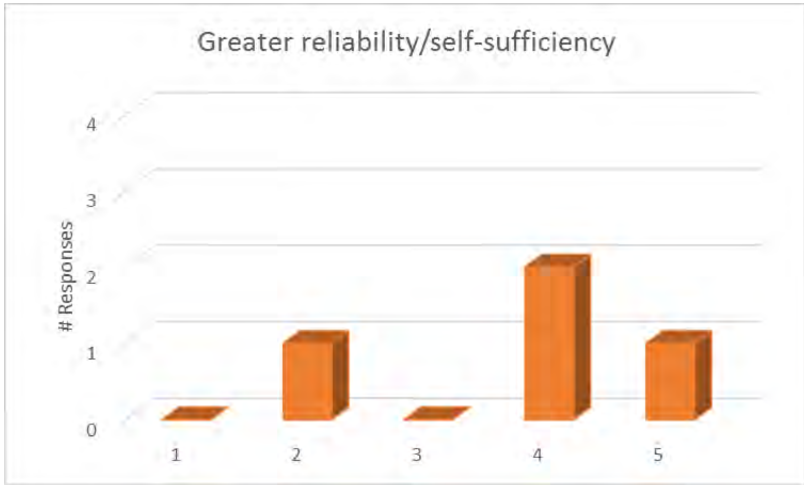
- Time to permit: 1 week to 3 months
- Energy demand
- Net metering rate and rules
- EMC tax credit and no NG service in B
- Rooftop vs. Stand-alone Balance of System Costs
- Capacity Factor (esp. GA vs. FL, coastal vs. inland)

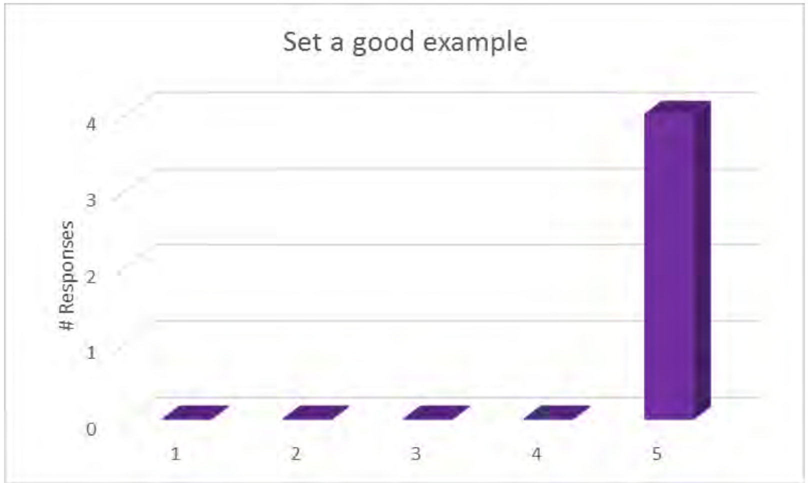
Source: R. Simmons, Georgia Tech
Disclaimer: This solar survey is illustrative and anecdotal. It may not reflect accurate trends or insights for similar residential PV configurations.

Residential PV Survey Feedback

Respondents reported rankings for selected motivations







Survey legend:

1= Unimportant

2= Marginally important

3= Of moderate importance

4= Very important

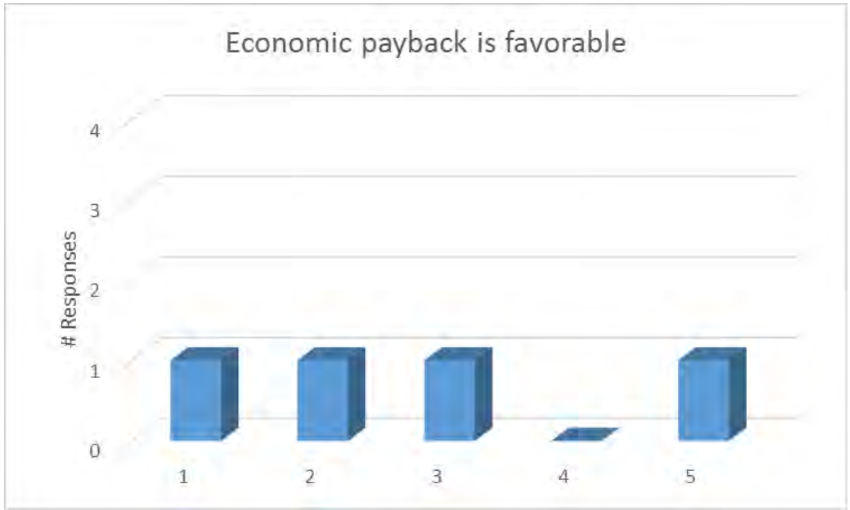
5= Of utmost importance

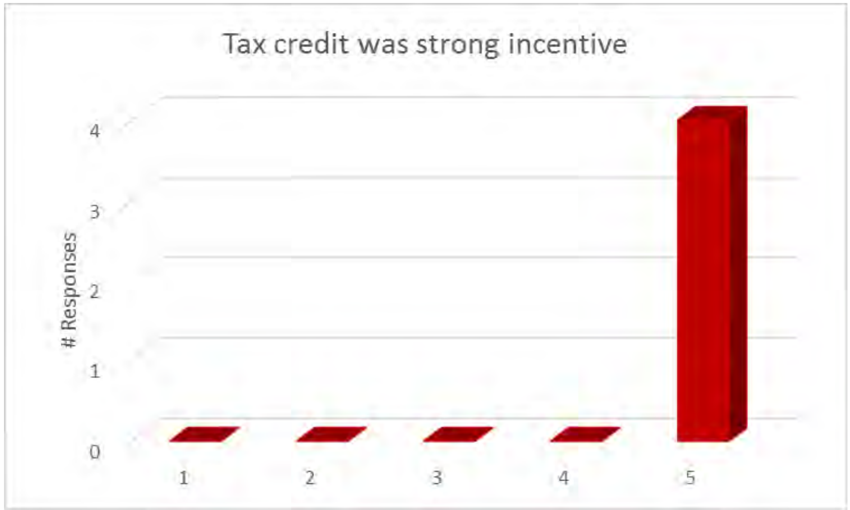
Source: R. Simmons, Georgia Tech

Disclaimer: Respondents provided voluntary, aggregated responses about their experiences for high level insights and conversation purposes. Survey was not statistically significant.

Residential PV Survey Feedback

Respondents provided some financial feedback





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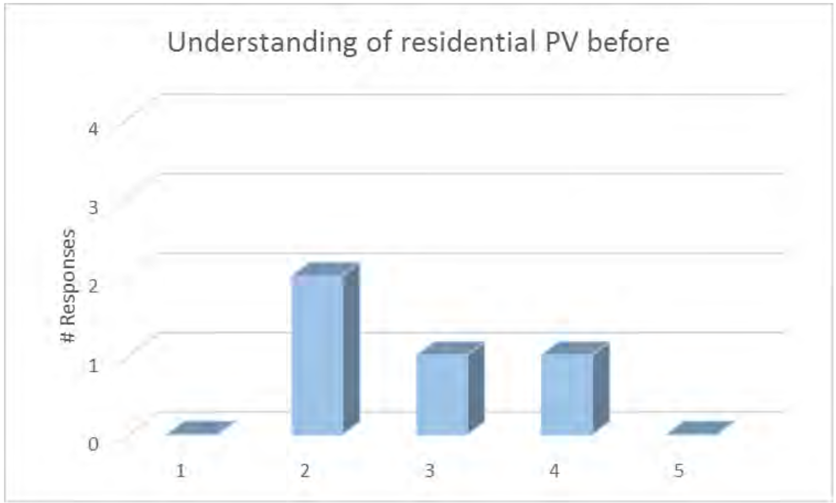
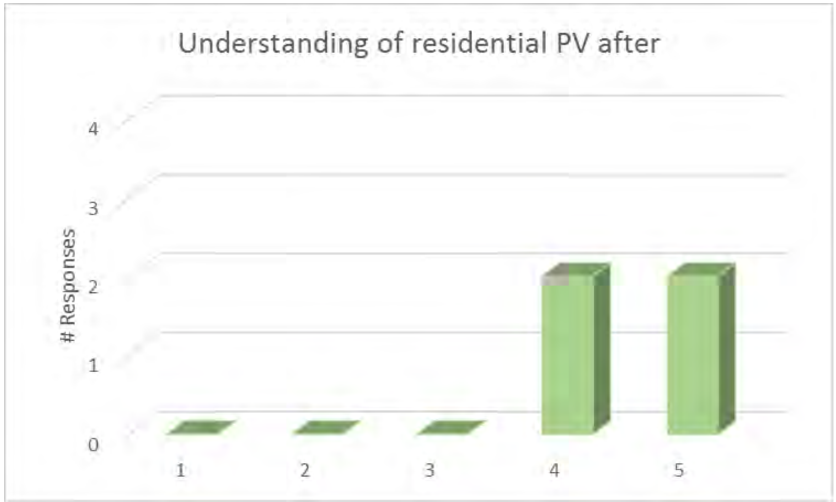
Residential PV Survey Feedback

Respondents confirmed that their understanding of residential PV increased





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Residential Solar Experience- Insights

- Economic merit is heavily case dependent
  - Some factors can combine to swing decisions
    - High energy consumption
    - Lack of natural gas, or numerous electric appliances
    - State/Local incentives (tax credit, net metering at retail rates)
  - Balance of system costs may be lower for stand-alone
  - Caveat: Not all factors are reflected here
- Tax credit was among top drivers
- ***100%*** self-sufficiency is not generally a primary objective but more control may be
- Experiences have increased awareness, informed behavior
- Biggest surprises…
- Best advice…

Source: R. Simmons, Georgia Tech
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Acknowledgements

- The Model Solar Ordinance University Team
- Residential Solar Survey Participants
- UGA Extension

Thank you

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