6b – Power Cost Trade-offs of Carbon Reduction Levels Beyond the 50% Reduction Level in Florida

October 2020

Increased CO_2 Reduction Means Much More Solar in FL

Depending on CO_2 Reduction Level, Battery Costs Are the Wildcard

- FMPA/FL currently on a path to meeting 50 percent CO_2 reduction by ~2027 from 2005 levels in a very cost-effective manner
- High level analysis to understand the relative electric price impacts using currently known technologies and expected cost improvements to meet higher levels of CO_2 reduction by 2035
- Recognizes FL has limited transmission import capability (5%) due to geography, so generation likely to come from within state
- The Southeast US has very limited renewable resources with no new hydro available and limited wind resources
- For FL, more CO_2 reductions means more local solar and batteries and less low cost gas generation
- Assumes 4 hour battery back-up systems with multiple sets needs to cover 24 hour or longer period

Accelerated CO_2 Reduction Would Raise Costs

Range of Cost Increase Depends on Amount of CO_2 Reductions

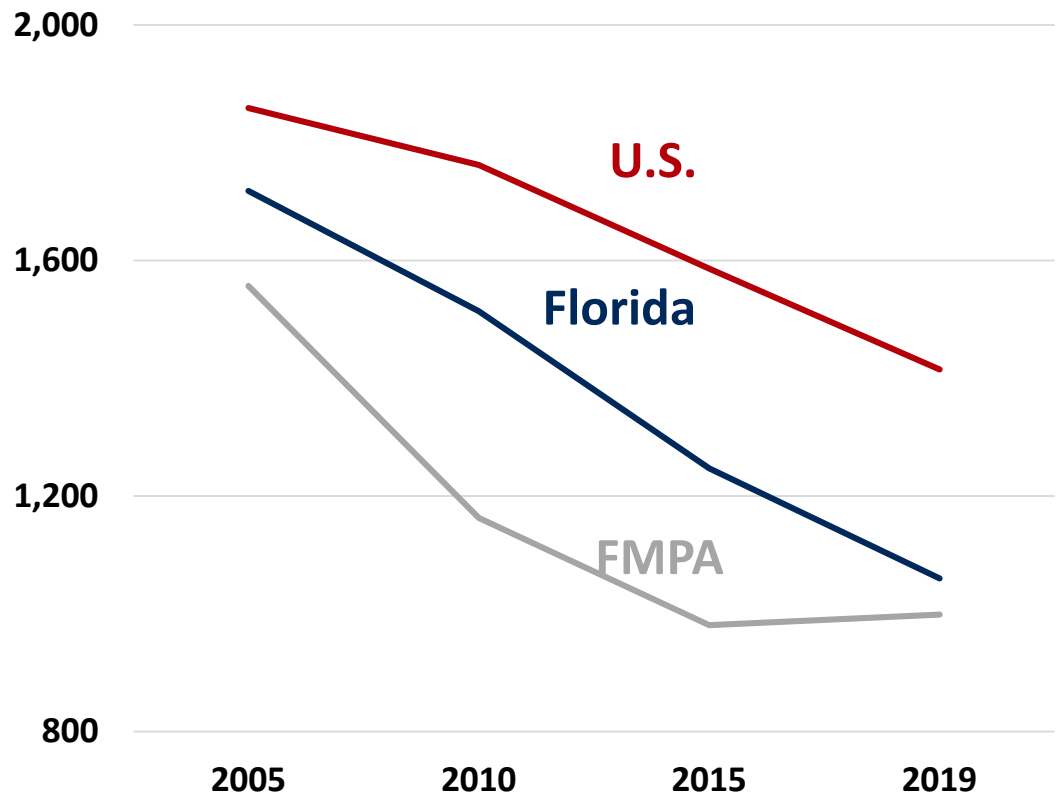
- Wholesale power costs expected to increase at ~inflationary levels through 2027 while achieving 50% CO_2 reduction from 2005 levels
- Wholesale power costs could increase between ~20% - 250% above projected costs by 2035 as CO_2 reduction moves from ~70% to 100% levels
- A 70% CO_2 reduction achievable with relatively small (20%) cost increases using natural gas generation for reliability and peaking; solar capacity increased to 55 GW plus some additional batteries (5 GW)
- A ~97% CO_2 reduction has a significant cost increase (75%) with solar/battery mix plus natural gas for emergency use, increasing solar capacity to 115 GW with 86 GW of new storage
- A 100% decline in CO_2 has a dramatic cost impact (250%) with a 4-day storage reserve to cover consecutive cloudy days, increasing solar capacity to 150 GW (83X current solar) with over 650 GW of new batteries
- Investment required in transmission/substation reconfiguration for ~60-800 GW of new generation depending on the amount of new capacity added
- Real issue for policymakers is how much more cost can be placed on customers to achieve CO2 reduction goals?

FMPA MUNICIPAL POWER

FL CO_2 Declined ~40% Over Last 15 Years, Prices Up 25%

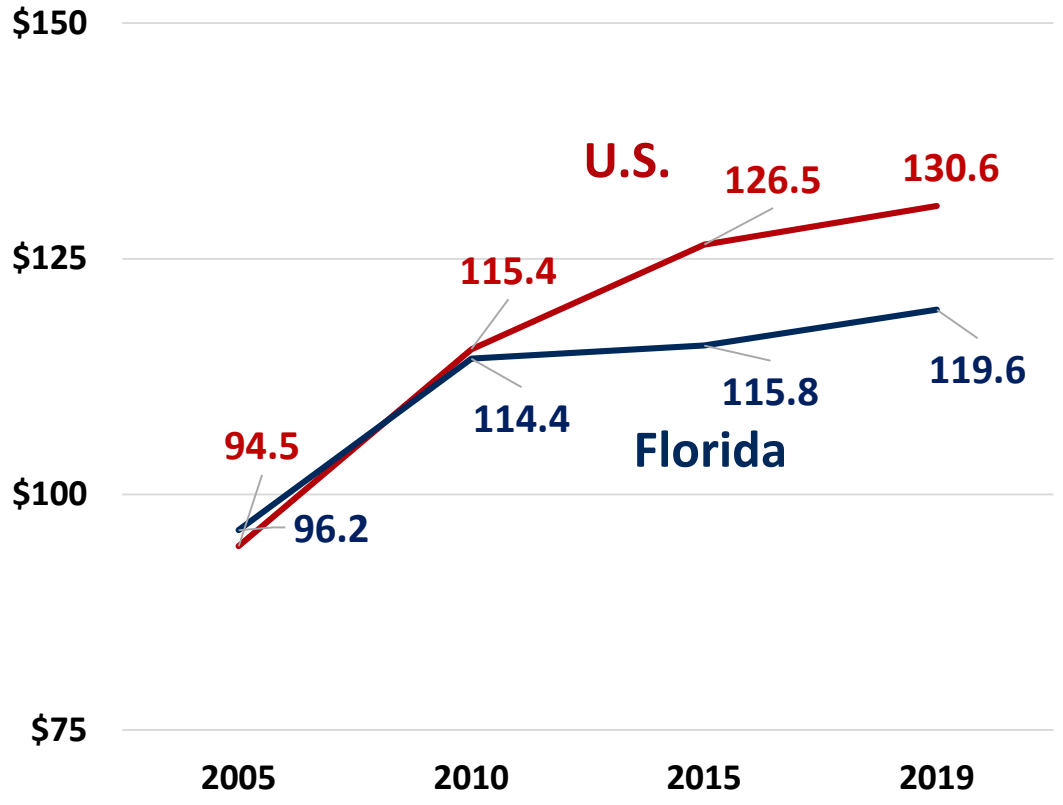
FL CO_2 Levels Well Below US Even as US Power Prices Rise 38%

CO_2 Emissions (lbs./MWh)



SOURCE: EPA's Acid Rain Program database

Residential Rate ($/MWh)

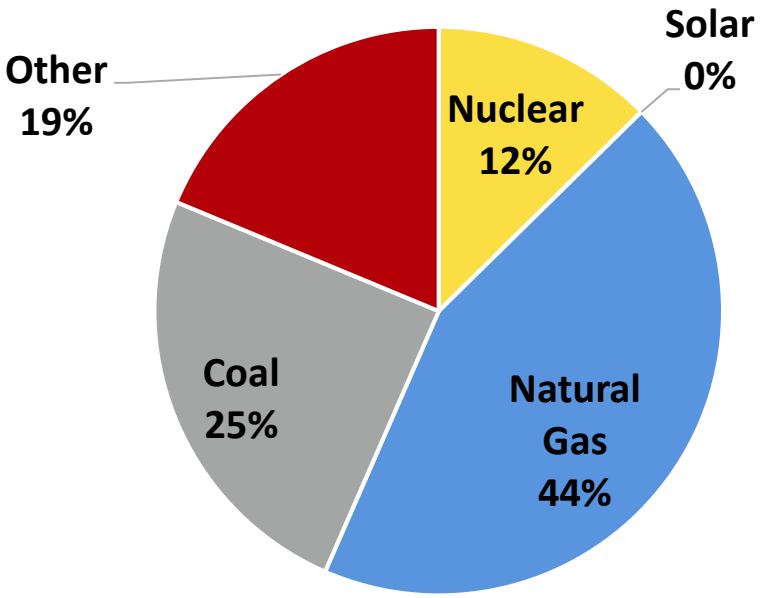


SOURCE: EIA

FL Energy Sources Already Shifting Towards Less CO_2

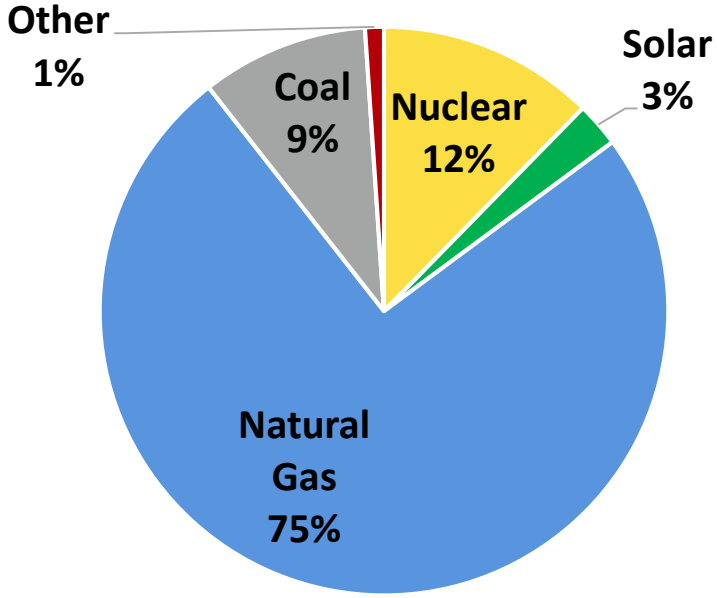
Coal/Oil Replaced by Natural Gas Leads to 40% Decline from 2005

2005*



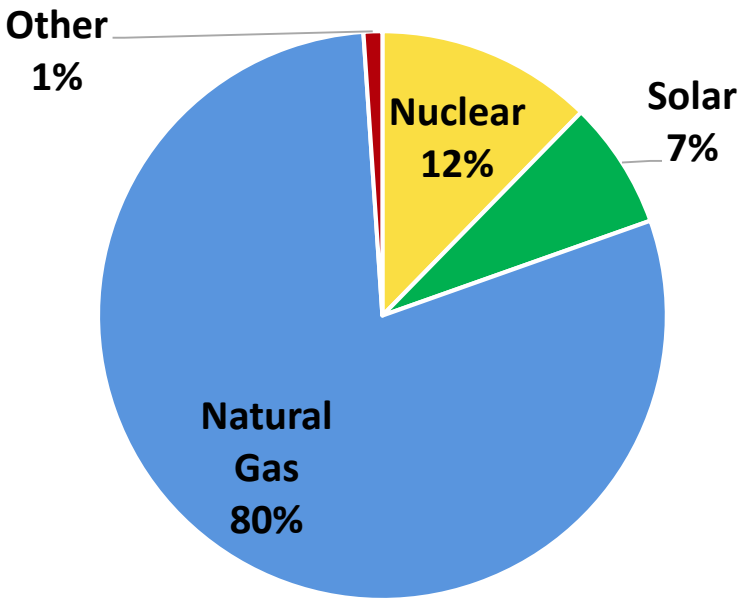
226,544 GWh

Today



238,535 GWh

2027 (Estimated)



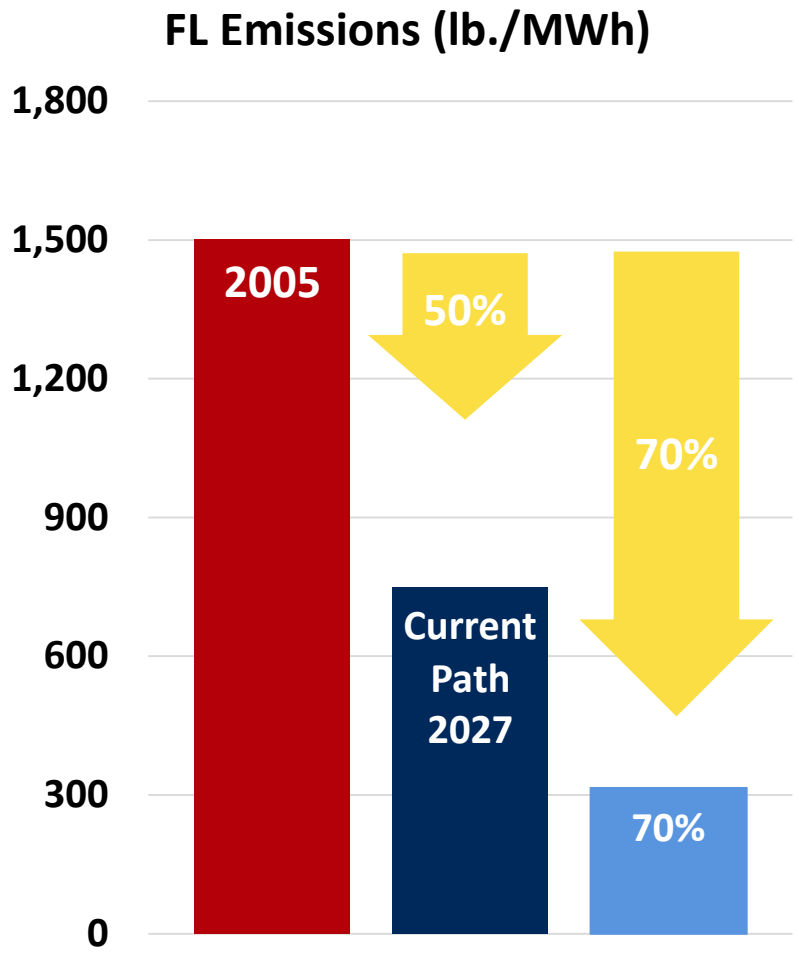
238,535 GWh

*Other includes residual and distillate fuel oil.

70% CO_2 Reduction – Balancing Solar with Natural Gas

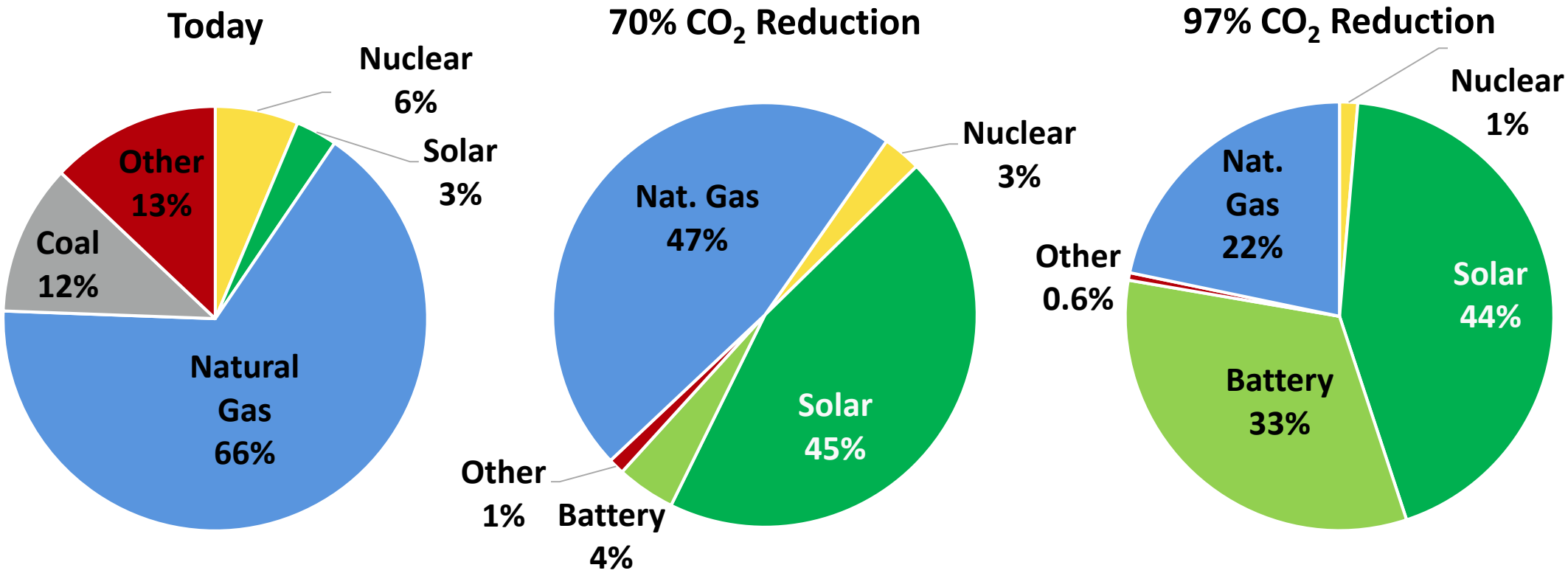
Solar for Energy and Thermal Generation for Capacity & Energy

- Adding solar curbs gas generation during high sun hours of day
- Keeping low cost, clean gas fleet has several significant benefits
  - Lower cost than adding batteries
  - Provides needed reliability and grid stabilization
- As coal and oil retires, additional gas units will be needed to meet required capacity



Significant CO_2 Reduction via Solar Capacity Adds by '35

Natural Gas Back-up Remain with Various Levels of Batteries Increases



57,194 MW

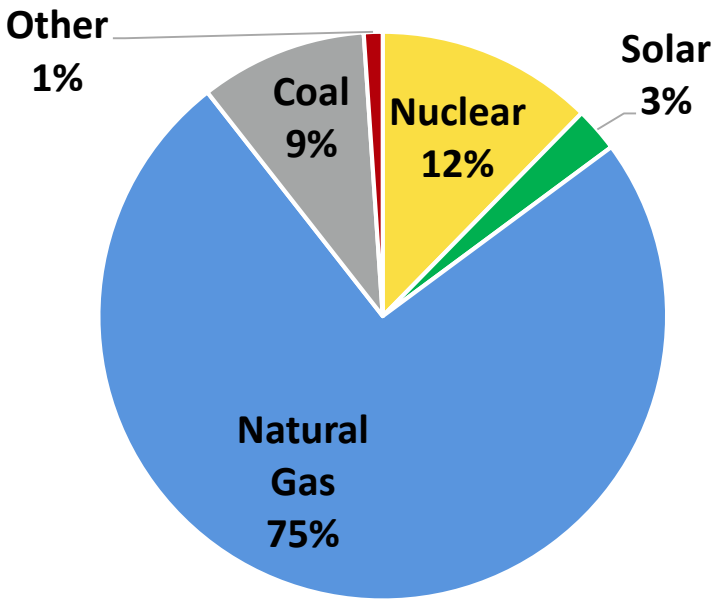
123,247 MW

265,112 MW

Solar Predominant Source for Additional CO_2 Reduction

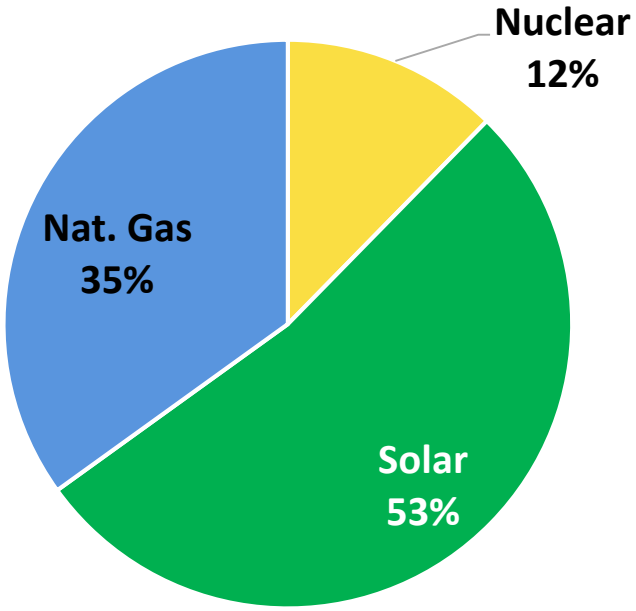
Gas Energy Share Reduced, Nuclear Energy Stable

Today



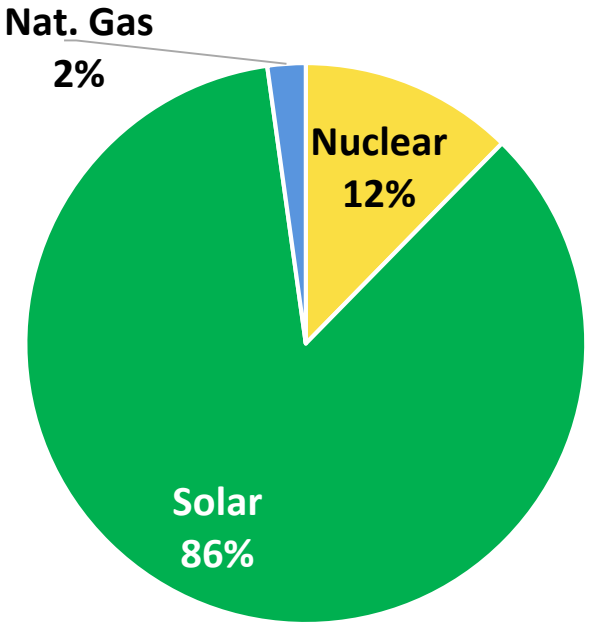
238,535 GWh

70% CO_2 Reduction



238,535 GWh

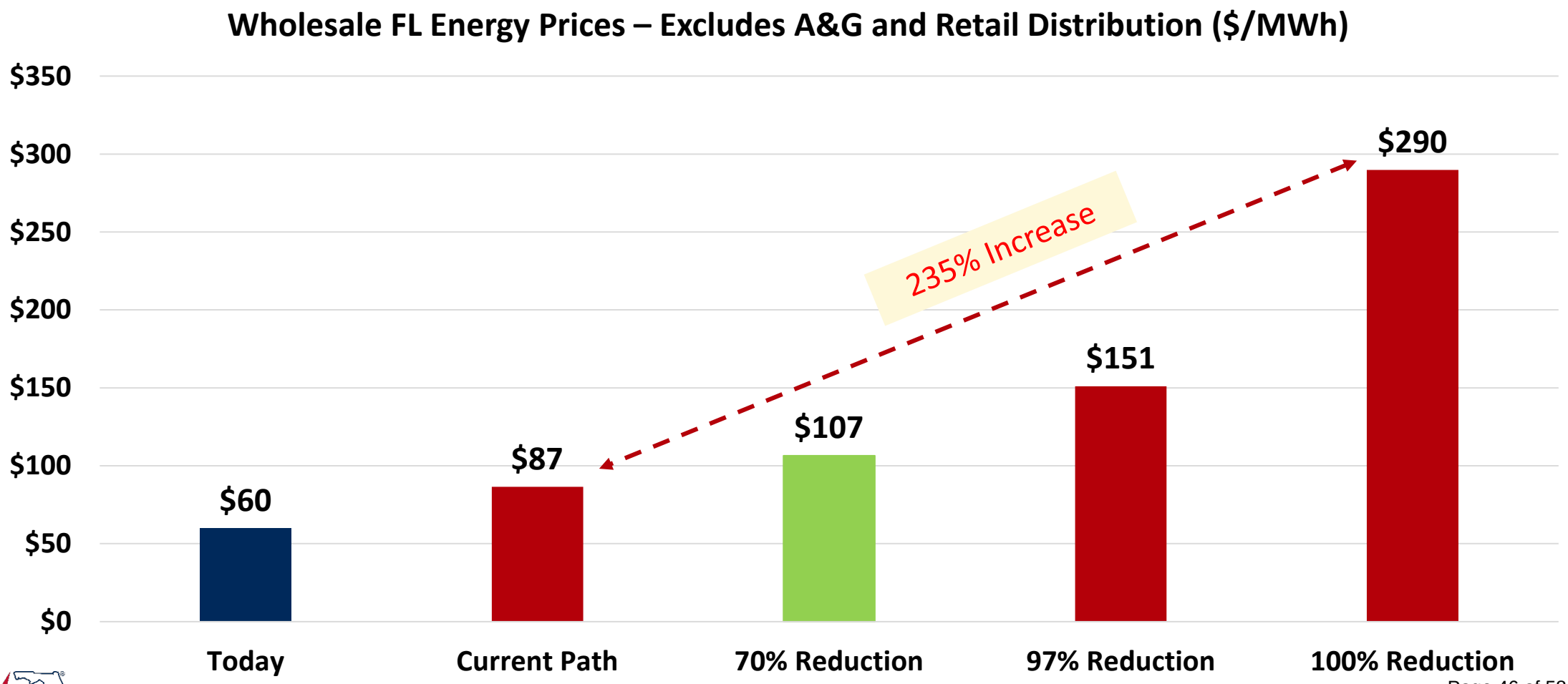
97% CO_2 Reduction



238,535 GWh

Prices Increase Materially by 2035 at High End of CO_2 Reduction

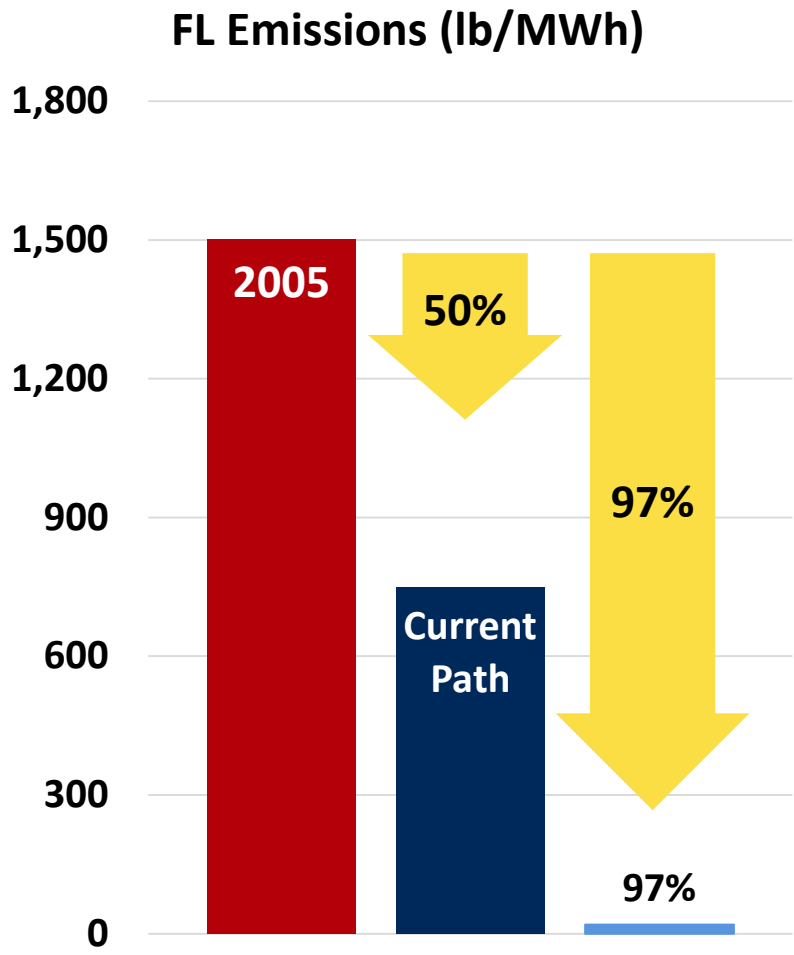
Dramatic Increase In Batteries Beyond Current Capacity Drives Costs



97% CO_2 Reduction - Solar with Batteries & Natural Gas

Battery Mix Further Reduces CO_2, But Still At Very High Cost

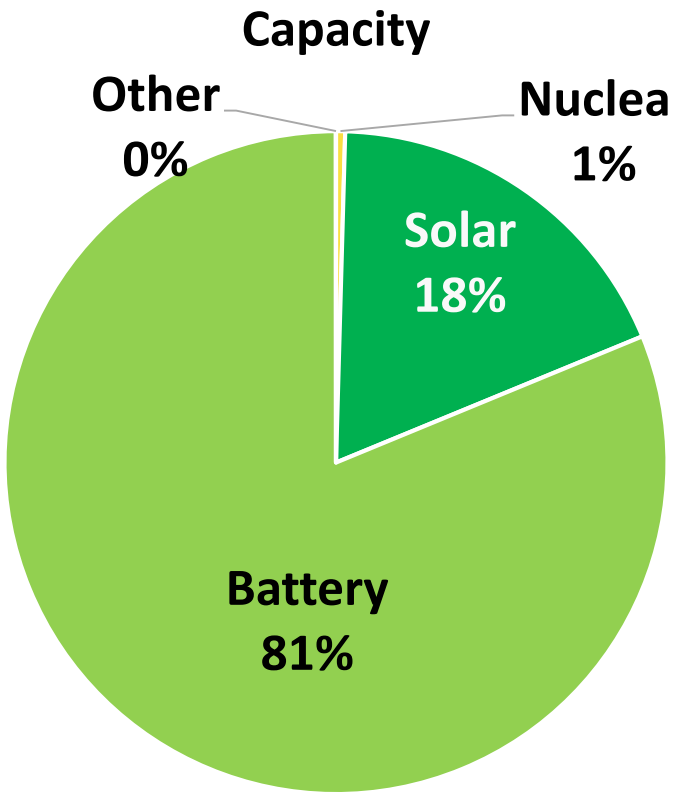
- Solar and Batteries are 4X current FL System
  - Solar energy sufficient to serve load and charge battery
  - Batteries sufficient to serve load during non daylight hours
  - Gas generation serves load and charges batteries when solar energy is insufficient to meet all load ~ 50% of days
- Gas fleet maintained for peaking/reliability
  - Prevents reliability and stability problems when intermittent resource not available
  - Keeping gas peaking units lower cost than more batteries



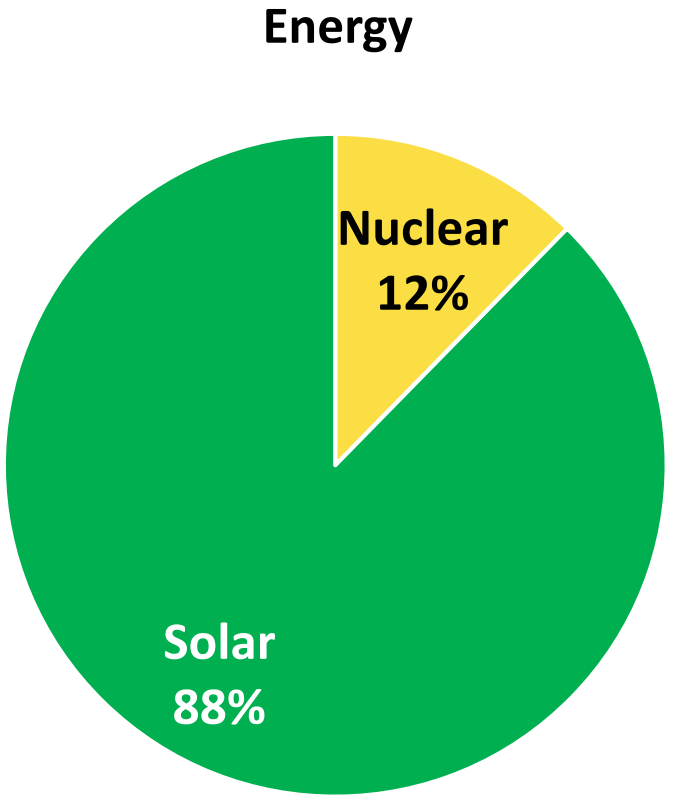
FMPA MUNICIPAL POWER

100% CO_2 Reduction Requires Extensive Overbuild

Excess Solar is Required With Batteries at 11X Current Capacity



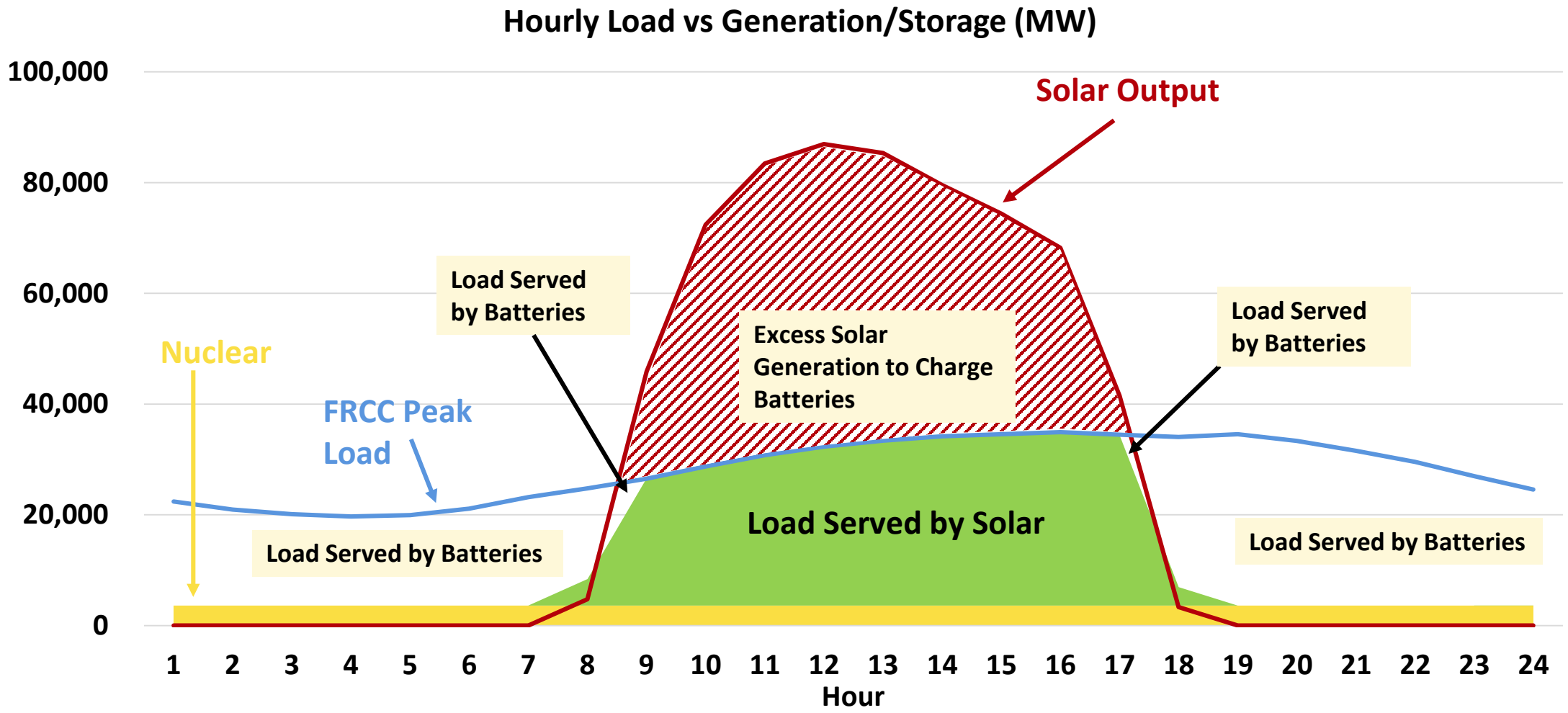
816,998 MW



238,535 GWh

Operational Challenges with Significant Solar

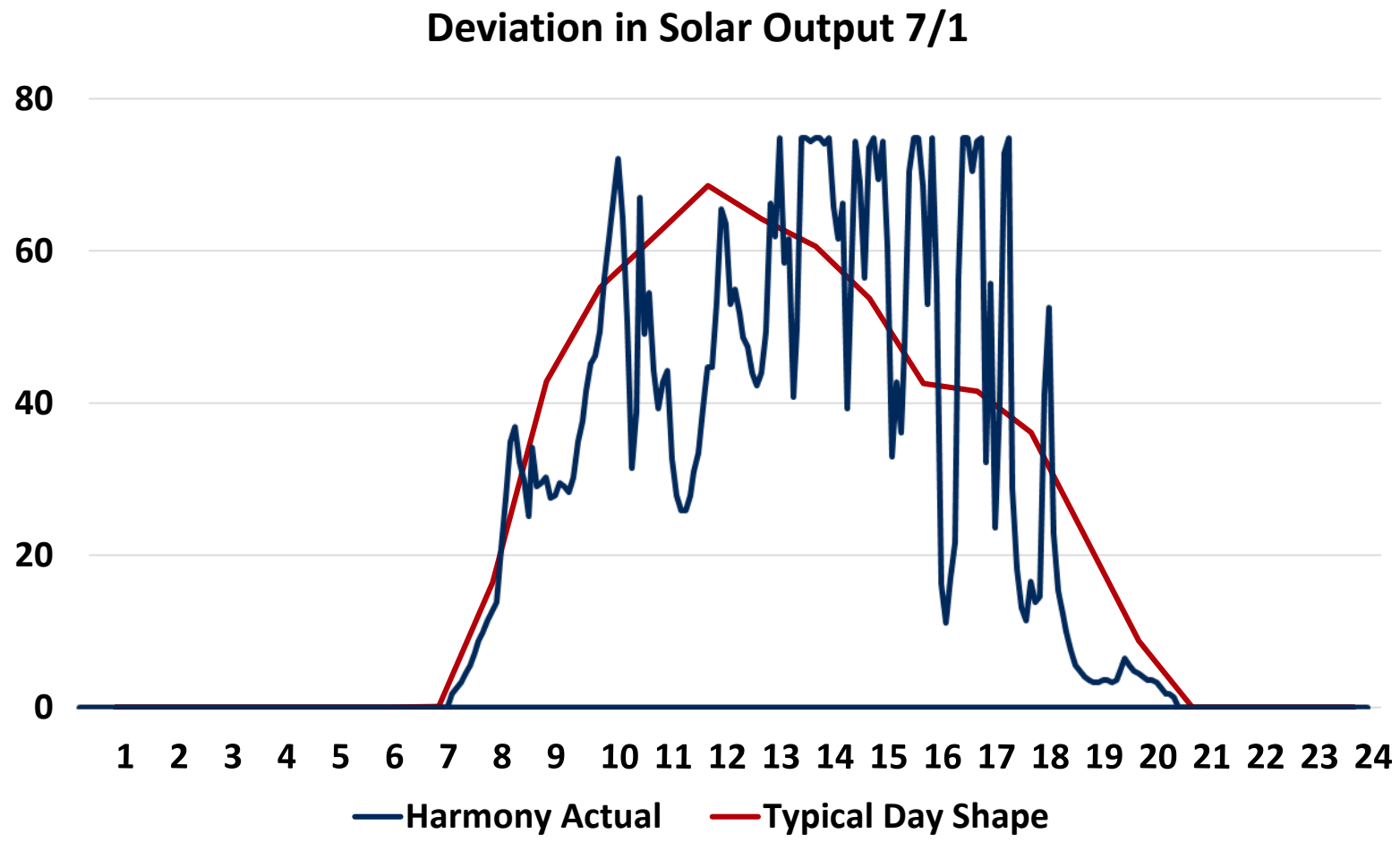
Lights Must Stay on Even as Solar Peak Different Time From Load Peak



Florida Solar Swings Significant Compared to SW

A Small Swing in Solar Output Can Drastically Affect Energy

- Florida cloud patterns much different than the SW US
- 5 min output may differ significantly from expected
- Solar output varies constantly requiring normalizing equipment and storage/on-line gas generation to supply load
- Many large generating sites will likely need to be converted to synchronous condensers
  - Reactive power for grid stability



FMPA MUNICIPAL POWER

Florida is Sunny ~68% of Time, Far Less Than AZ/CA

*Interior FL with Land Less Sunny - Orlando Averages 234 Sunny Days**

	Max Sunny Days	Average Sunny Days
Florida	**281**	**248**
Orlando	265*	234
California	281	263
Arizona	310	299
United States**	310	217

Orlando is roughly (on average):

- 11% less sunny than Los Angeles, CA
- 7% less sunny than San Diego, CA
- 25% less sunny than Phoenix, AZ

Location	Sunshine Ave % Possible	Clear Days	Partly Cloudy Days	Cloudy Days
FL Average*	68	95	145	126
Jacksonville, FL	64	94	127	144
Key West, FL	77	104	155	107
Miami, FL	70	74	175	115
Pensacola, FL	60	105	123	137
Tampa, FL	69	101	143	121
Orlando, FL	64*	89	147	130
AZ Average*	82	189	93	84
Phoenix, AZ	85	211	85	70
Tucson, AZ	85	193	91	81
CA Average*	72	169	91	105
Los Angeles, CA	72	186	106	73
San Diego, CA	69	146	117	102

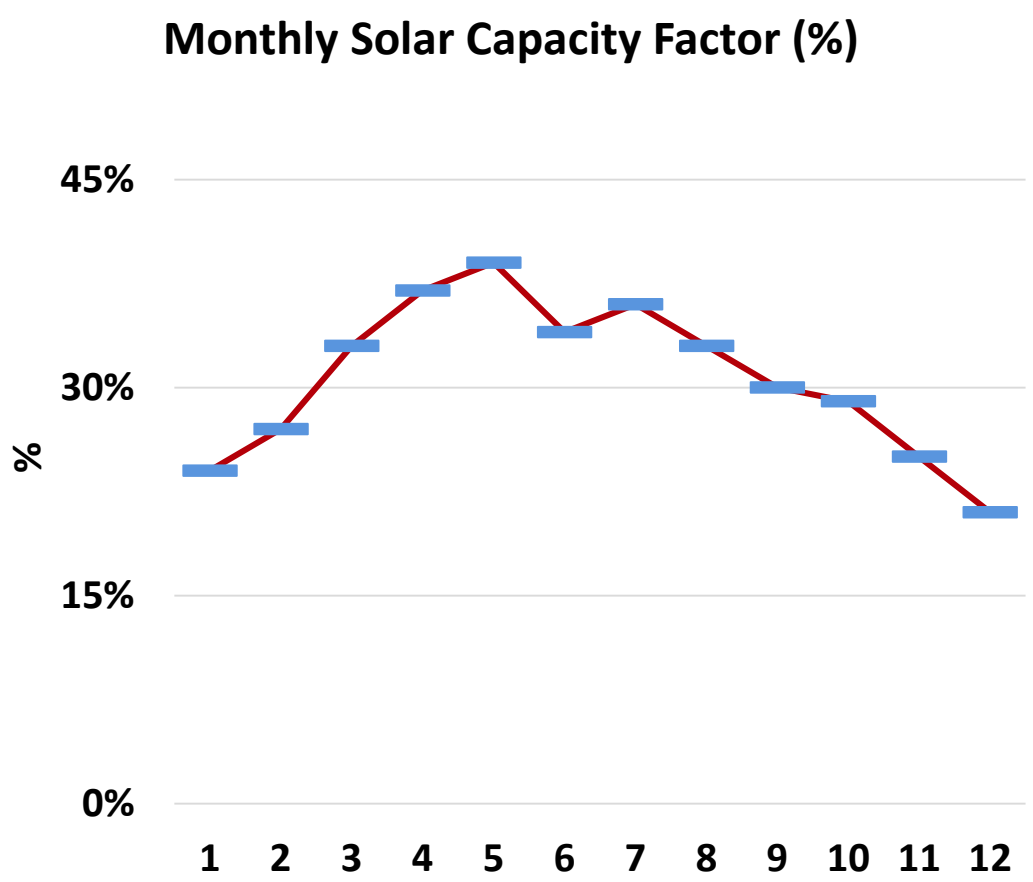
Source: NOAA Comparative Climate Data For the United States Through 2018

*Average of above source, http://bestplaces.net/climate/city/florida/orlando, and http://currentresults.com/weather/florida/annual-days-of-sunshine.php. Max sunny days for Orlando estimated based on FL level variance between average and max.

**Calculated from all weather stations in the source document.

Monthly Avg Solar Efficiency Variations Drive Needs

Solar Capacity Factor Drives Storage Required



- Solar has lower capacity in winter with fewer hours of high over-head sun
- Fall has lower capacity factor than spring due to less full sunny days in fall
- Highest capacity factor month is typically May which is not longest month, but is sunniest month
- August and September are challenging with high heat/humidity levels and short days/plenty of mid-day storms

FMPA MUNICIPAL POWER

Under Significant Reduction, Large Solar Land Needed

Tight Buildable Land May Limit Availability

- Suitable land
  - Close to existing transmission and infrastructure
  - No environmental restraints
- FL total land area = 34,647,040 acres[1]
  - Farm land 8,417,200 Acres (2016) (24% of FL)[2]
  - Solar land estimated to be required 1,294,800 Acres (4% of FL)
  - Battery footprint 53,120 Acres
- Cost per acre for suitable solar and battery varies and would likely increase as demand surges
  - Leases range from $250-$2,000 / acre in more rural areas
  - Model assumes $10,000 / acre costs financed over 20 years

Conversion	Units	Value
Solar Land Use (1 Axis, >20MW)[3]	Acres/MW-AC	8.3
Battery Land Use[4]	Acre/MWh	.02

Placing all solar in one condensed area implies a lot of compounded risk from single events.

1. https://dos.myflorida.com/florida-facts/quick-facts/
2. https://farmlandinfo.org/statistics/florida-statistics/
3. HDR June 2019 Energy-Storage-Technology-Assessment for Platte River Power Authority (for lithium ion)
4. NREL Land-Use Requirements for Solar Power Plants in the United States (2013)

FMPA MUNICIPAL POWER

Transmission Growth is Inevitable

Thermal Generation Keeps the Grid Stable

- The additional capacity of solar and batteries requires additional transmission lines for transport since new generation will likely be sited elsewhere (new locations)
- New substations will need to be built in great numbers to connect new solar and storage sites to the grid
- Grid stability requires many balancing elements to prevent black outs
  - Synchronous condensers support grid inertia and reactive power
  - Voltage regulators and frequency response solutions needed
- Assumption of $100M per 1 GW new solar or battery installation for transmission upgrades

Picture Source: https://ars.els-cdn.com/content/image/1-s2.0-S0378437114000466-gr1.jpg

Florida's CO_2 Reductions Continuing to 50% by 2027

Additional CO_2 Reductions Have Moderate to Significant Costs

- FMPA/FL currently on a path to meeting 50 percent CO_2 reduction by ~2027 from 2005 levels while FL costs stayed flat while US rose by __%
- In 2027, Florida will be 80% gas generation and 20% CO_2-free (nuclear and solar)
- Increases in CO2 reductions beyond 50% require varying levels of additional solar and batteries within FL
- Wholesale power costs could increase between ~20% - 250% above projected costs by 2035 as CO_2 reduction moves from ~70% to 100% levels
- Costs accelerate exponentially once reductions levels require significant battery installations of 2 – 10 times the current total generation capacity in FL
- Step function improvements in batteries could lead to lower power cost increases
- Investment required in transmission/substation reconfiguration for ~60-800 GW of new generation depending on the amount of new capacity added
- Real issue for policymakers is how much more cost can be placed on customers to achieve CO2 reduction goals?

FMPA MUNICIPAL POWER

AGENDA ITEM 7 – MEMBER COMMENTS

Policy Makers Liaisons Committee Meeting
October 14, 2020

AGENDA ITEM 8 – ANNOUNCEMENTS

a. Next Meeting (if schedule approved): Wednesday, January 20, 2021 at 1 p.m. at FMPA, 8553 Commodity Circle, Orlando, FL

Policy Makers Liaisons Committee Meeting
October 14, 2020

AGENDA ITEM 9 – ADJOURN

Policy Makers Liaisons Committee Meeting
October 14, 2020