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Queued Up:

Characteristics of Power Plants Seeking Transmission Interconnection As of the End of 2021

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ESIG Special Topics Webinar:
Generation Interconnection Criteria
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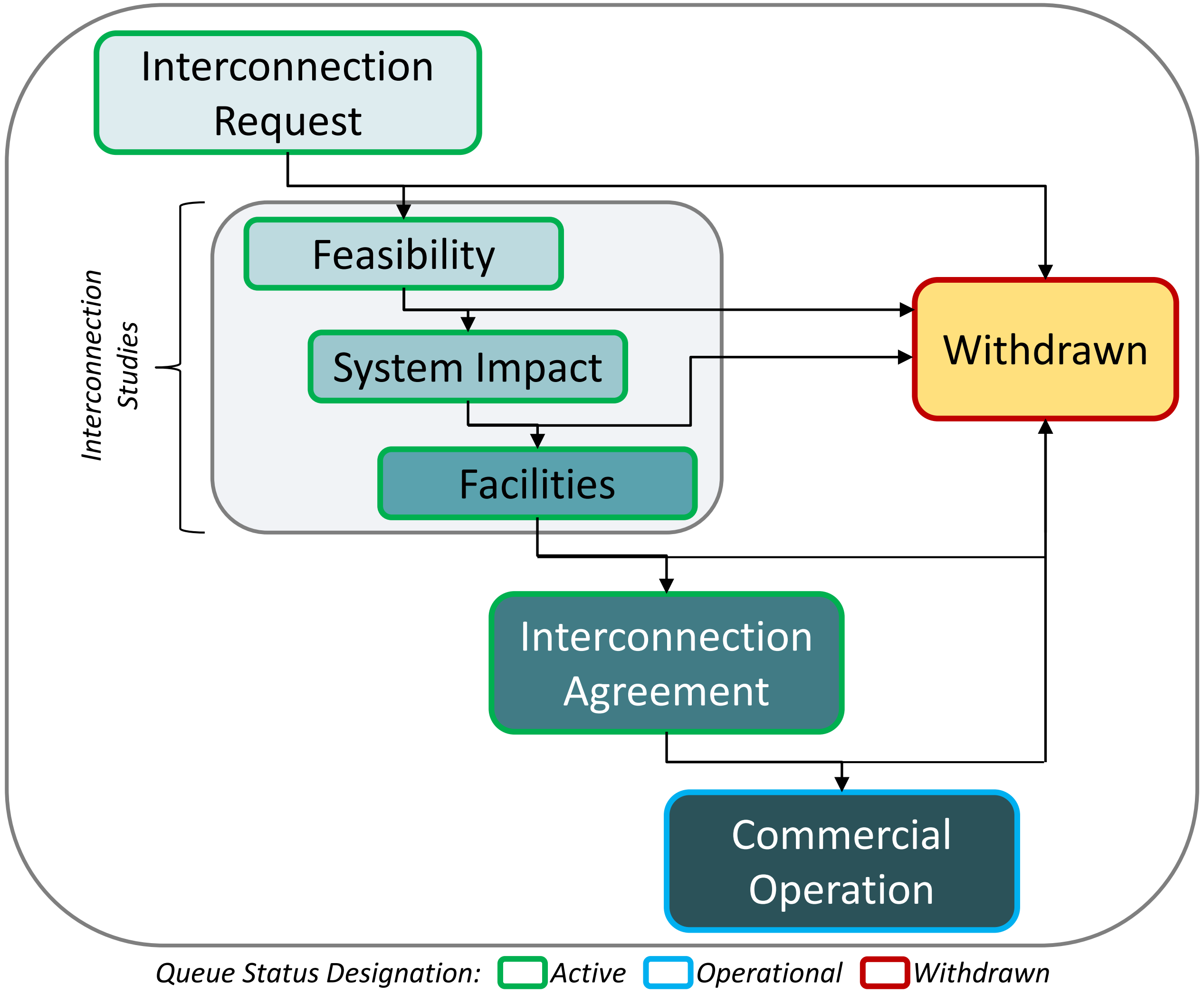
Typical Interconnection Study Process and Timeline

- A project developer initiates a new ***interconnection request (IR)*** and thereby enters the ***queue***
- A series of ***interconnection studies*** establish what new transmission equipment or upgrades may be needed and assigns the costs of that equipment
- The studies culminate in an ***interconnection agreement (IA)***: a contract between the ISO or utility and the generation owner that stipulates operational terms and cost responsibilities
- Most proposed projects are ***withdrawn,*** which may occur at any point in the process
- After executing an IA, some projects are built and reach ***commercial operation***

Simplified Interconnection Study Process



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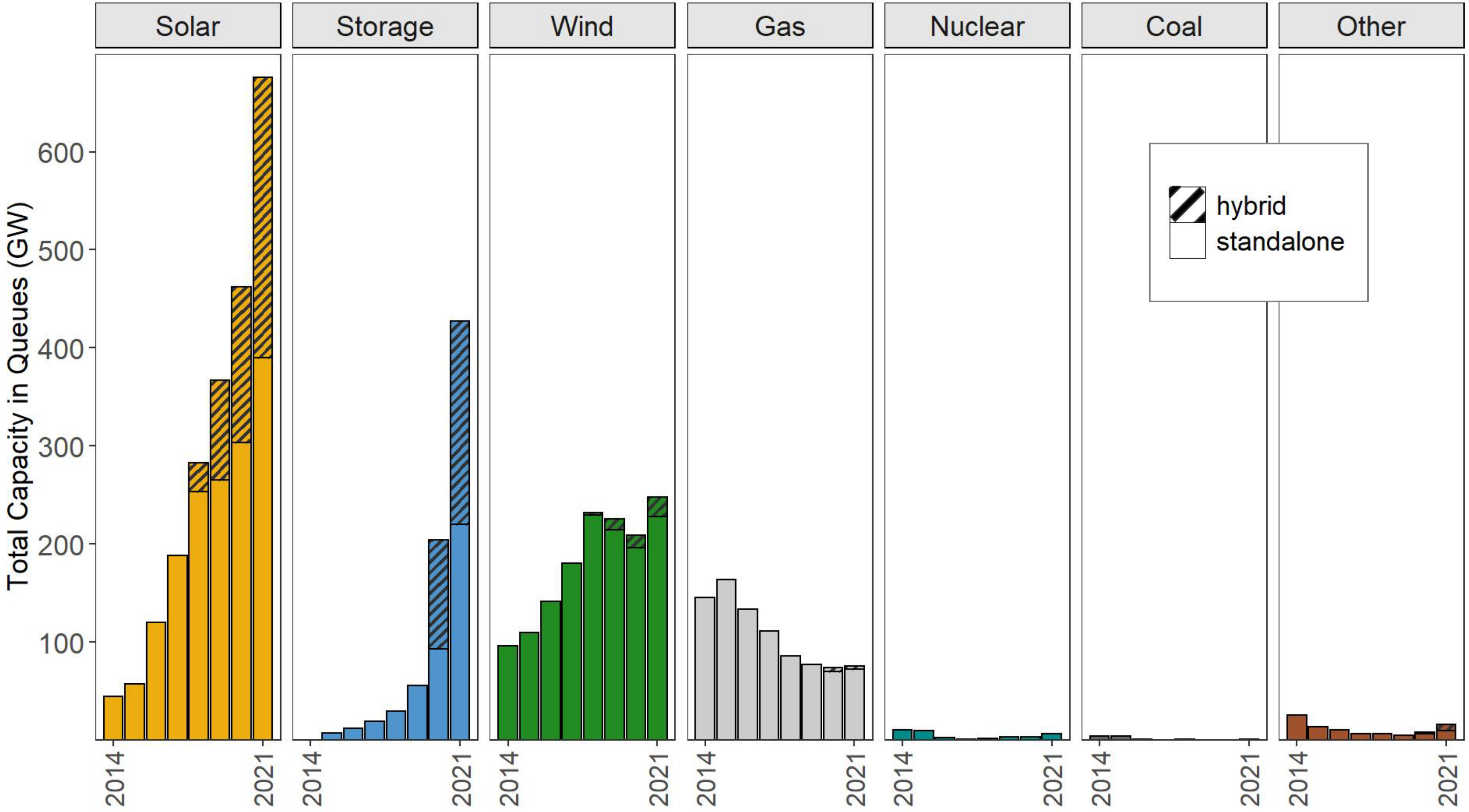
Interconnection queues indicate that commercial interest in Solar and Storage has grown, including via hybridization; Wind and Gas relatively stable in recent years



- "**Wind**" includes both onshore and offshore.
- "**Other**" includes
  - Hydropower
  - Geothermal
  - Biomass/biofuel
  - Landfill gas
  - Solar thermal
  - Oil/diesel
- "**Storage**" is primarily (98%) battery, but also includes pumped storage hydro, compressed air, gravity rail, and fuel cell projects.

**Hybrid storage capacity is estimated using storage:generator ratios from projects that provide separate capacity data*
Storage capacity in hybrids was not estimated for years prior to 2020.
Note: Not all of this capacity will be built

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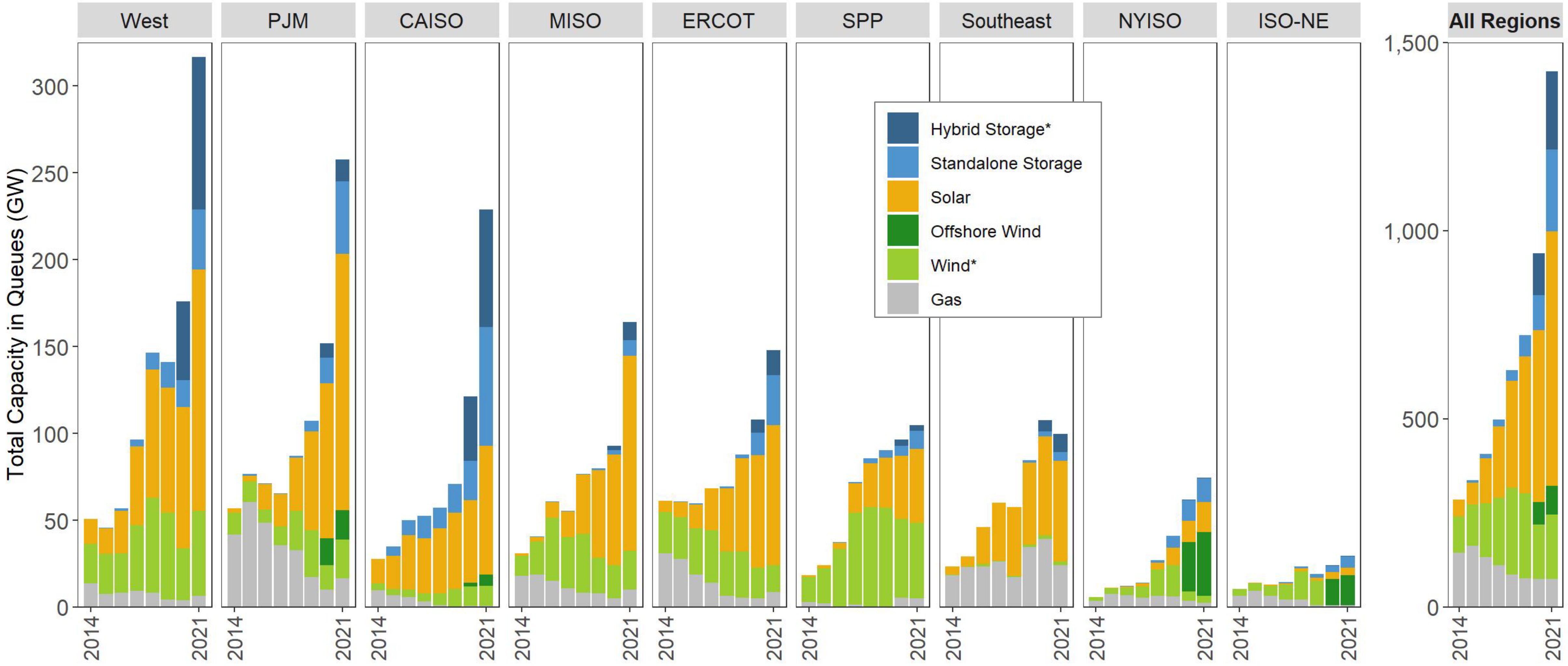
Solar and Storage booming in most regions, especially the West, PJM, and CAISO. Wind growing in the West and offshore, with slight declines in ERCOT, SPP, MISO.

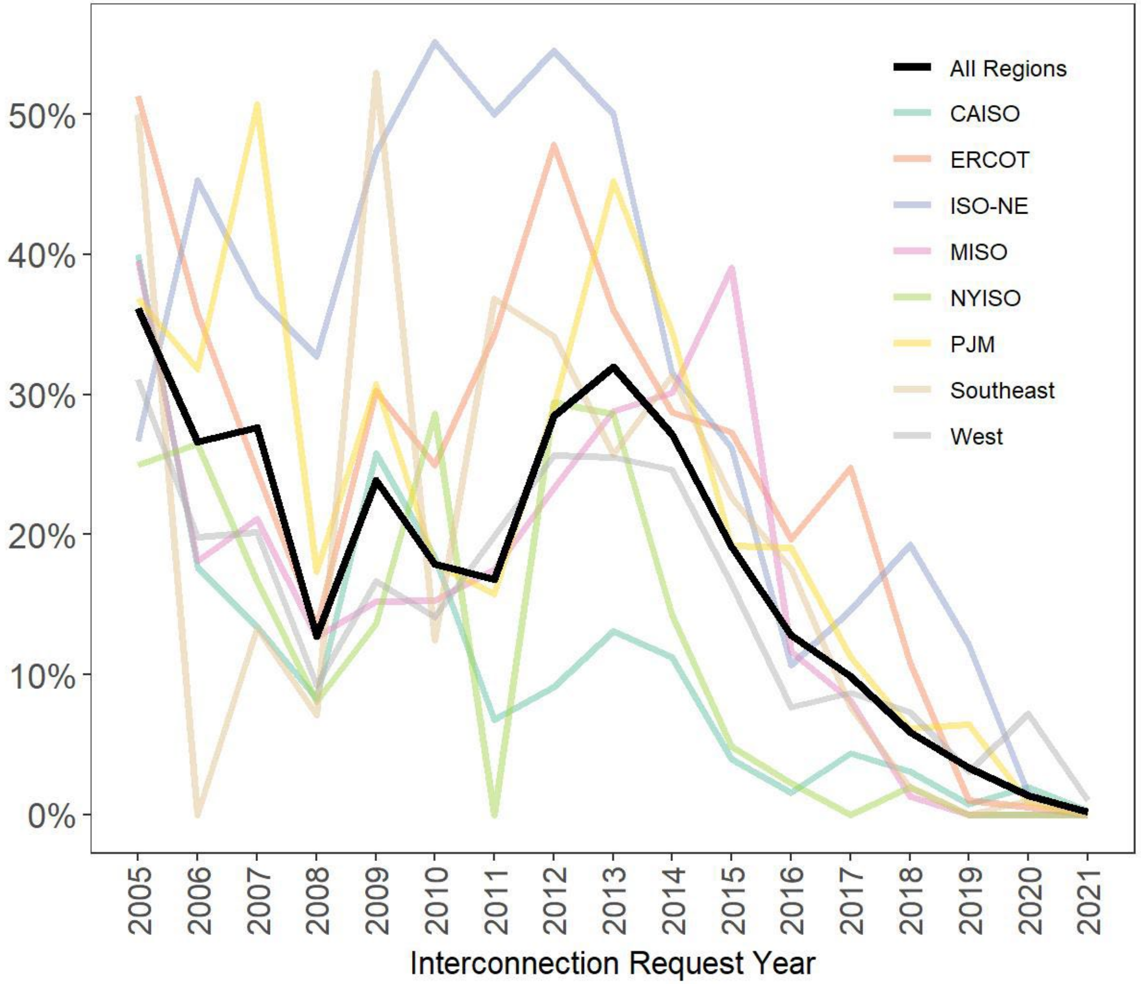


*Hybrid storage capacity is estimated for some projects, and that value is only included starting in 2020. Wind capacity includes onshore and offshore for all years, but offshore is only broken out starting in 2020.

Notes: (1) Hybrid generation capacity is included in all applicable generator categories. (2) Not all of this capacity will be built.

There is considerable variation in completion rates across ISOs and regions; wind (20%) and solar (16%) have lower completion rates from 2000-2016 than other types

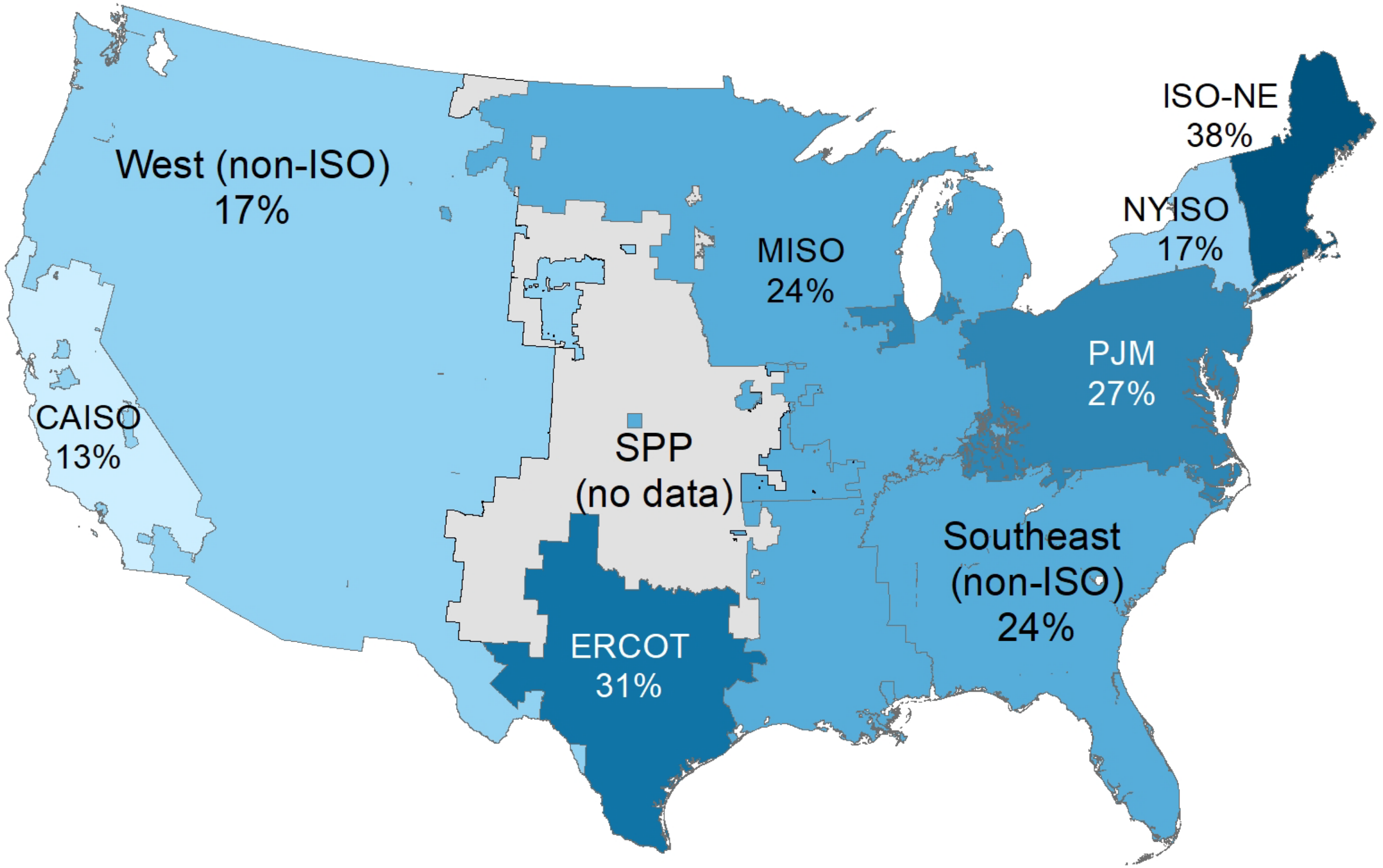
Completion percentage by region:



Completion percentage by generator type:

Note: Completion rate is calculated by number of projects, not capacity-weighted. Includes data from six ISOs and 25 utilities.

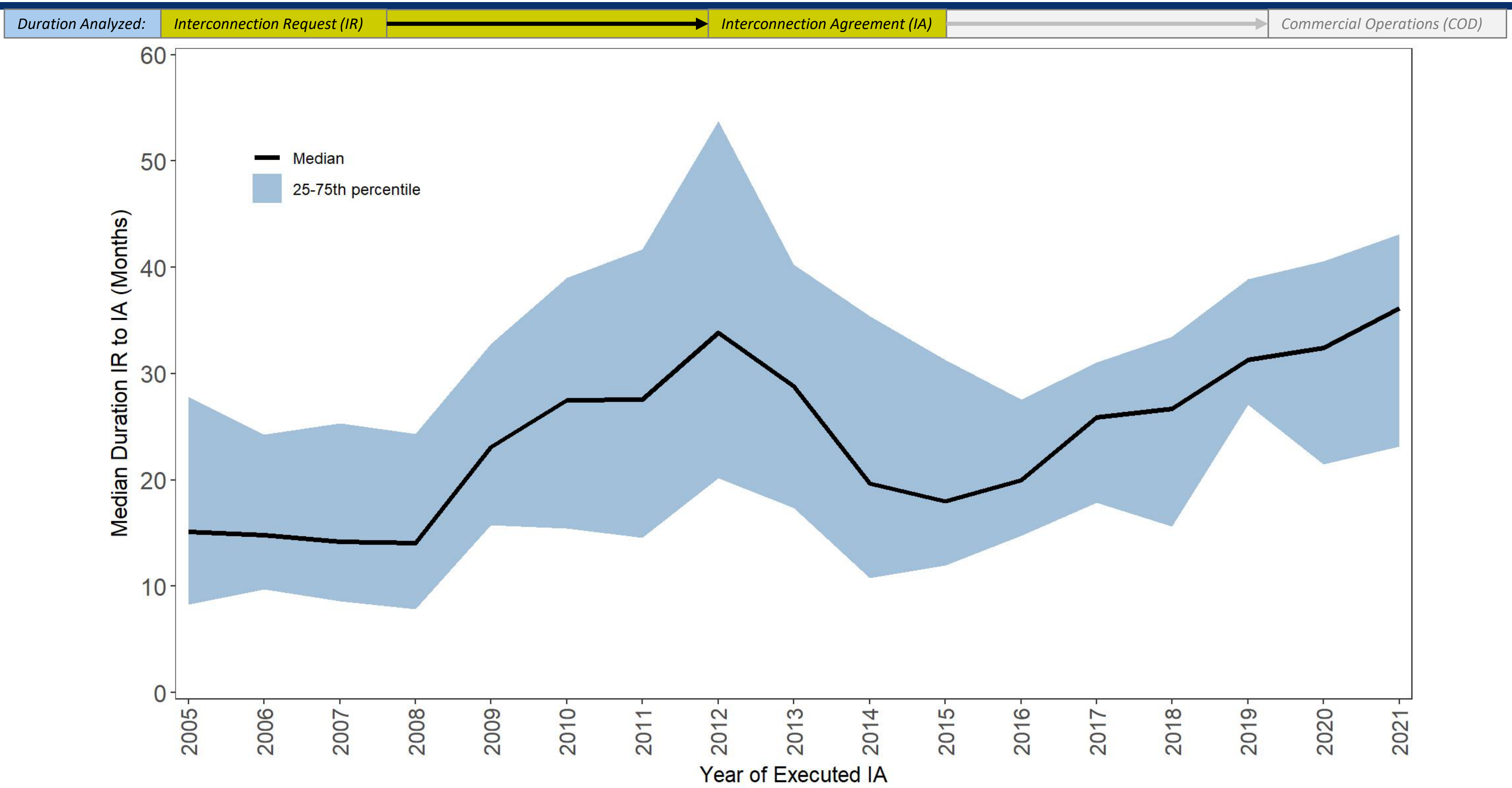
The share of projects that entered the queues from 2000-2016 and have reached COD is relatively low across regions: Only ISO-NE and ERCOT exceed 30% completion



- The share of queued projects that reach COD is relatively low
- For interconnection requests from 2000-2016, ISO-NE (38%) and ERCOT (31%) had the highest project completion percentages, with CAISO (13%) and NYISO (17%), and the non-ISO West (17%) lower on average
- These rates are variable by year, and trends may be shifting as queue volumes and reforms evolve
- The difference between regions, temporal trends, and the implications of these low rates on electric-sector decarbonization, are important areas for future research

Note: Completion rate is calculated by number of projects, not capacity-weighted. Includes data from six ISOs and 25 utilities.

After falling from a 2012 peak, the typical duration from interconnection request to interconnection agreement has increased sharply since 2015, exceeding 3 years in 2021

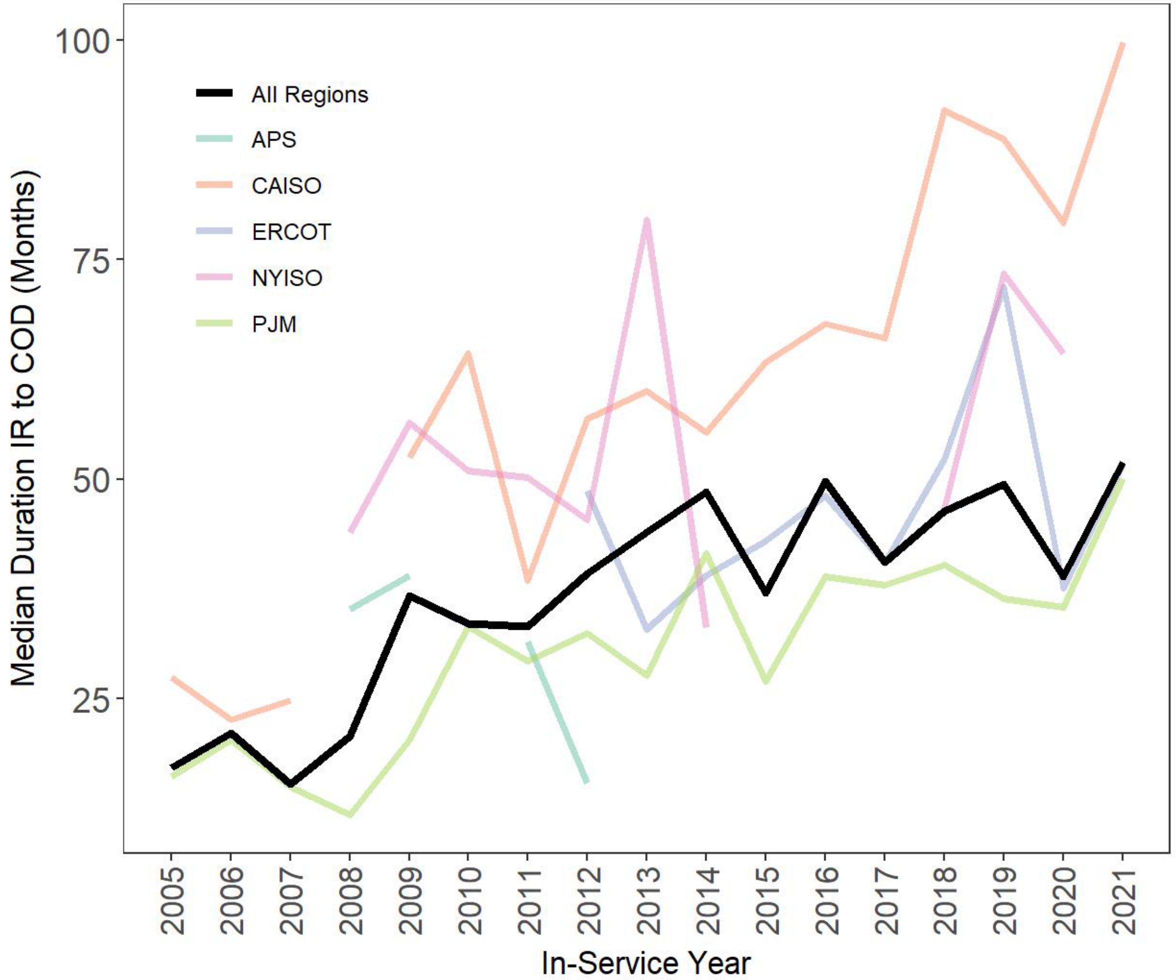


Notes: (1) Sample includes 2,717 projects from 5 ISO/RTOs and 4 Western utilities with executed interconnection agreements since 2005. (2) Not all data used in this analysis are publicly available.

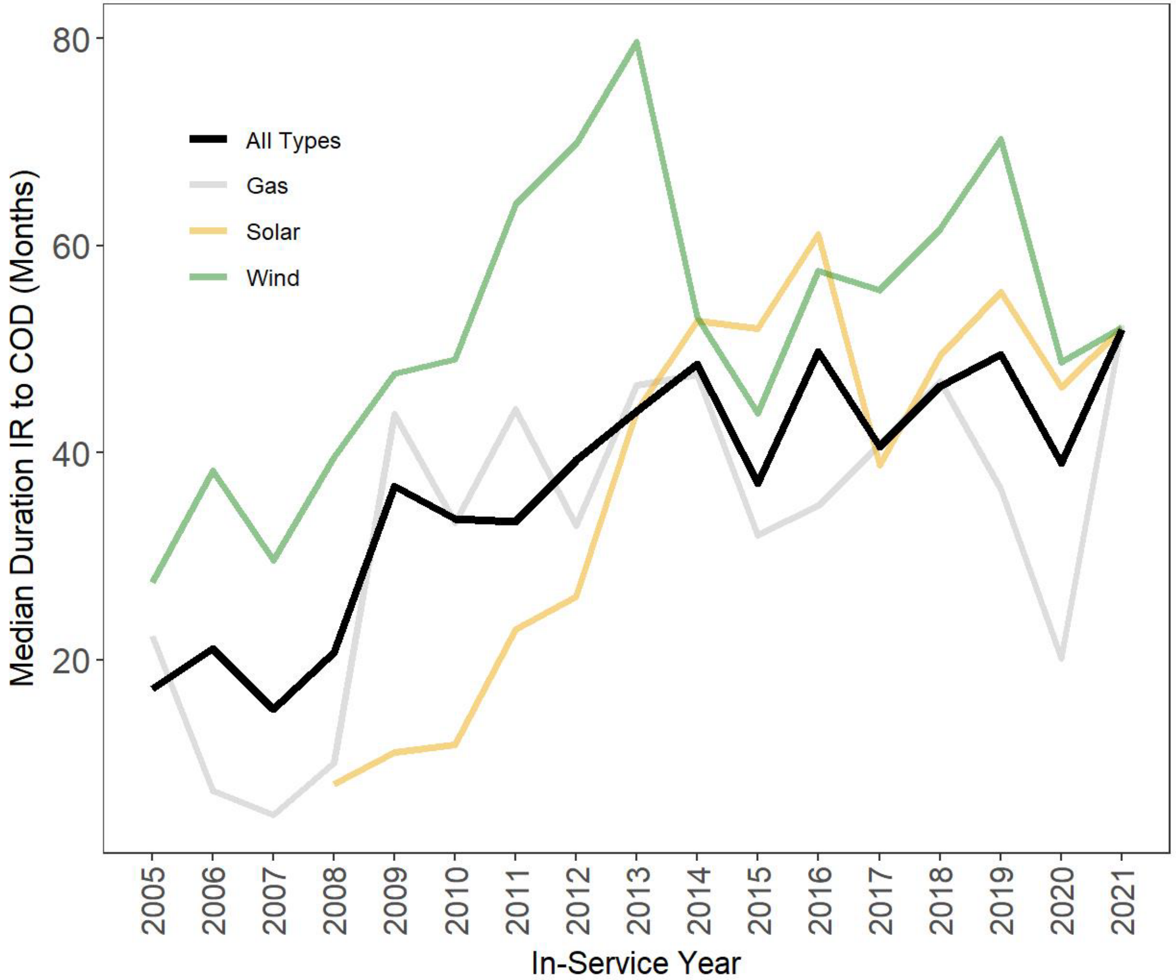
The typical time from interconnection request (IR) date to commercial operations date (COD) is increasing for some regions and generator types and now exceeds 4 years overall

Duration Analyzed:	*Interconnection Request (IR)* →	*Interconnection Agreement (IA)* →	*Commercial Operations (COD)*

Median Duration from Interconnection Request to Commercial Operations, by Region



Median Duration from Interconnection Request to Commercial Operations, by Generator Type



Notes: (1) In-service date was only available for 1,570 operational projects from 4 ISOs and one utility. (2) Duration is calculated as the number of months from the queue entry date to the in-service date.

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More Information:

Visit https://emp.lbl.gov/queues to download the data used for this analysis and to access an interactive data visualization tool

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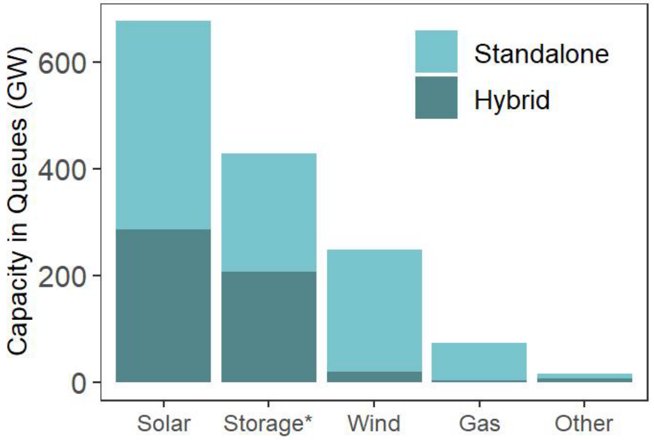
Appendix

High-Level Findings

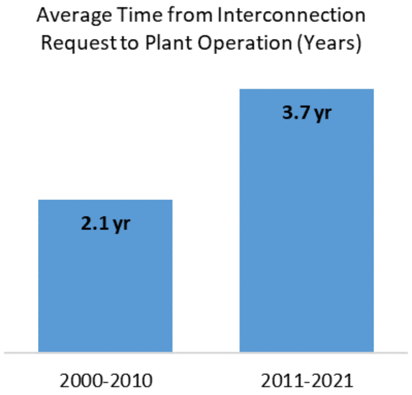
Developer interest in solar, storage, and wind is strong

- Over 1 TW (1000 GW) of generator capacity and 420 GW of storage currently seeking interconnection
- Most (~930 GW) proposed generation is zero-carbon
- Hybrids now comprise a large – and increasing – share of proposed projects



Completion rates are generally low; wait times may be increasing

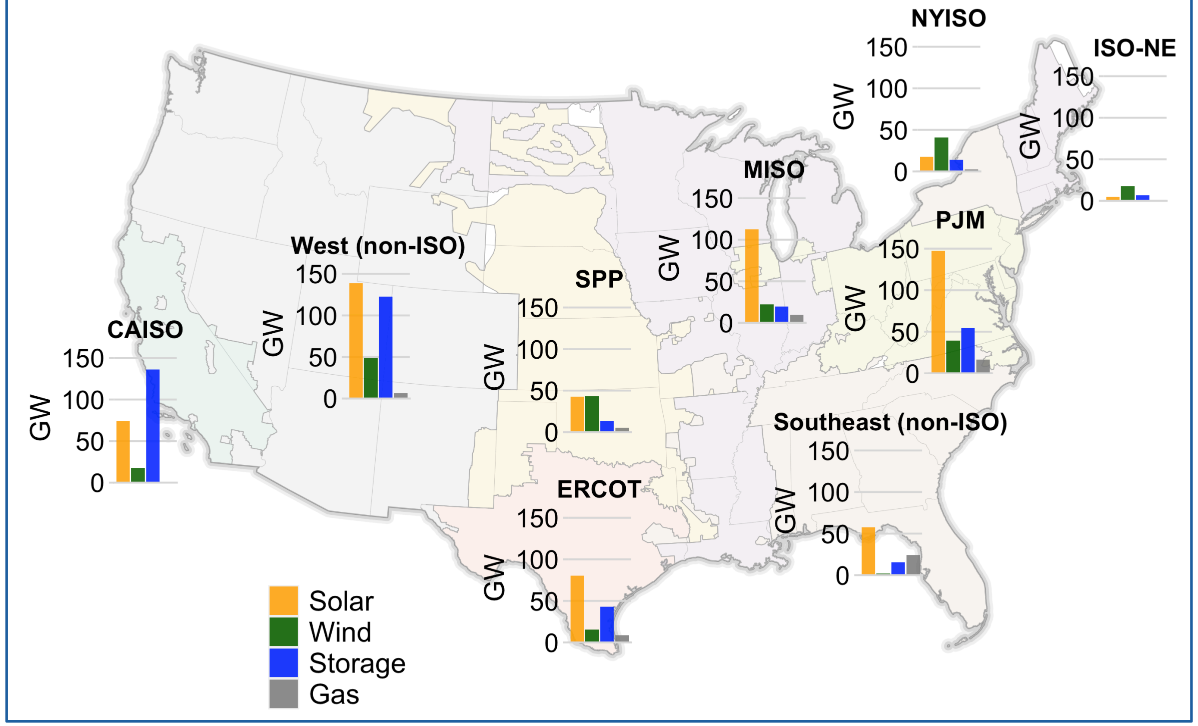
- Only ~23% of projects that requested interconnection from 2000-2016 have reached commercial operations; 72% have withdrawn



- Completion rates are even lower for wind (20%) and solar (16%)
- For five regions[1] where data were available, the time projects spent in queues before being built increased from ~2.1 years for projects built in 2000-2010 up to ~3.7 years for those built in 2011-2021

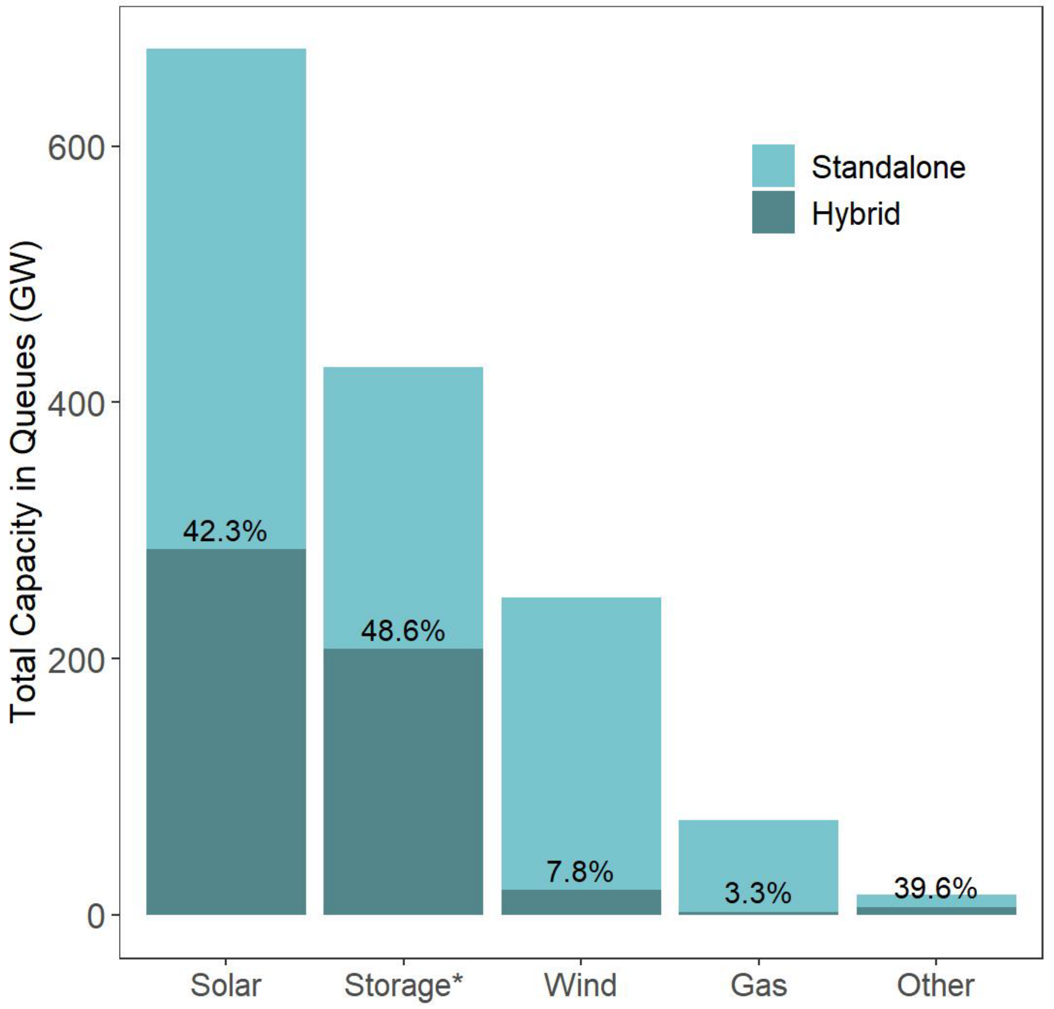
Proposed capacity is widely distributed across the U.S.

- Substantial proposed solar capacity exists in most regions of the U.S.
- Wind capacity is highest in the non-ISO West and SPP, with increasing share of East Coast offshore projects
- Storage is primarily in CAISO and the West, but also strong in PJM
- Proposed gas is primarily in the Southeast and PJM



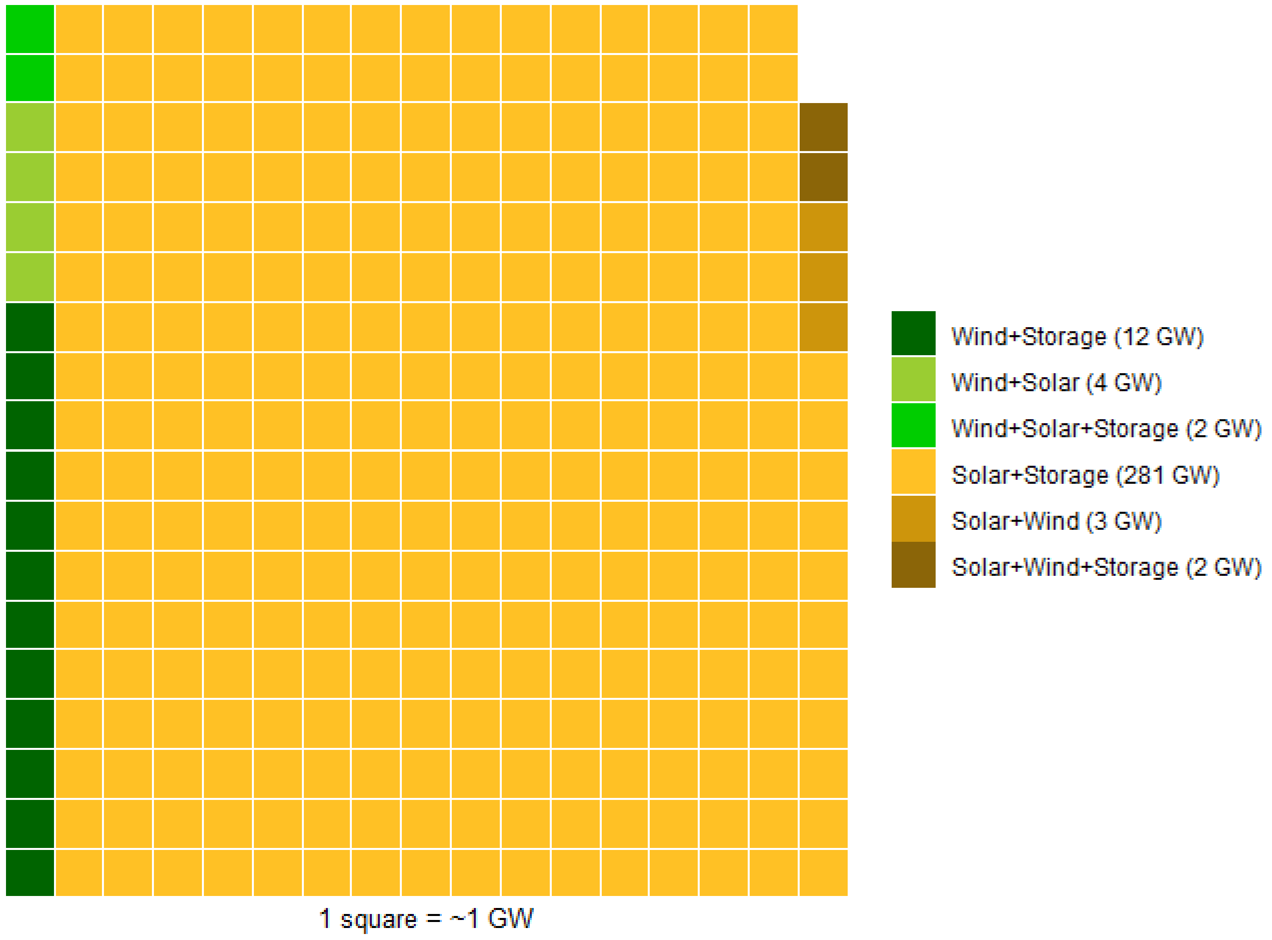
1. In-service date was only available for 1,570 operational projects from 4 ISO/RTOs (CAISO, ERCOT, NYISO, PJM) and one utility (APS).

Interest in hybrid plants has increased: 42% of solar (285 GW) proposed as hybrids, 8% of wind (17 GW) proposed as hybrids (up from 34% and 6% in 2020, respectively)



**Hybrid storage capacity is estimated using storage:generator ratios from projects that provide separate capacity data*

Solar+Storage (281 GW) is by far the largest hybrid configuration

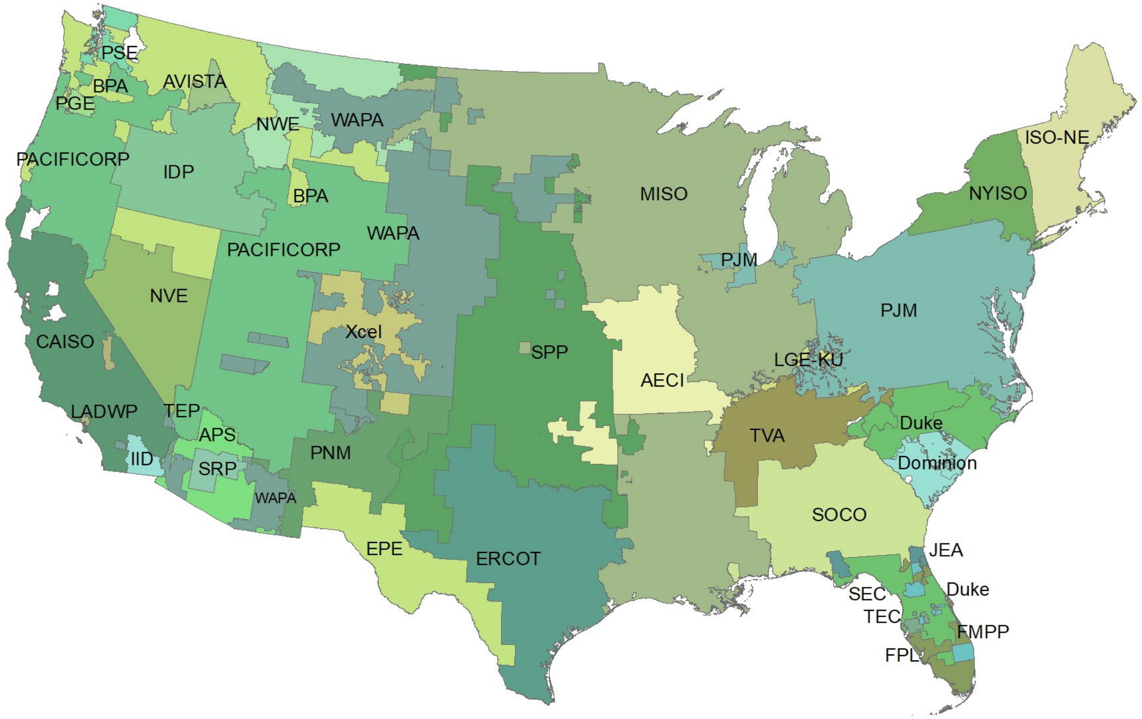


*Only the **generator** capacity is illustrated here (not storage); for hybrid configurations with multiple generator types, each color represents **only the first generator** type.*

Notes: (1) Some hybrids shown may represent battery capacity added to existing generation; only the net increase in capacity is shown; (2) Hybrid plants involving multiple generator types (e.g., wind+PV+storage, wind+PV) show up in all generator categories, presuming the capacity is known for each type.

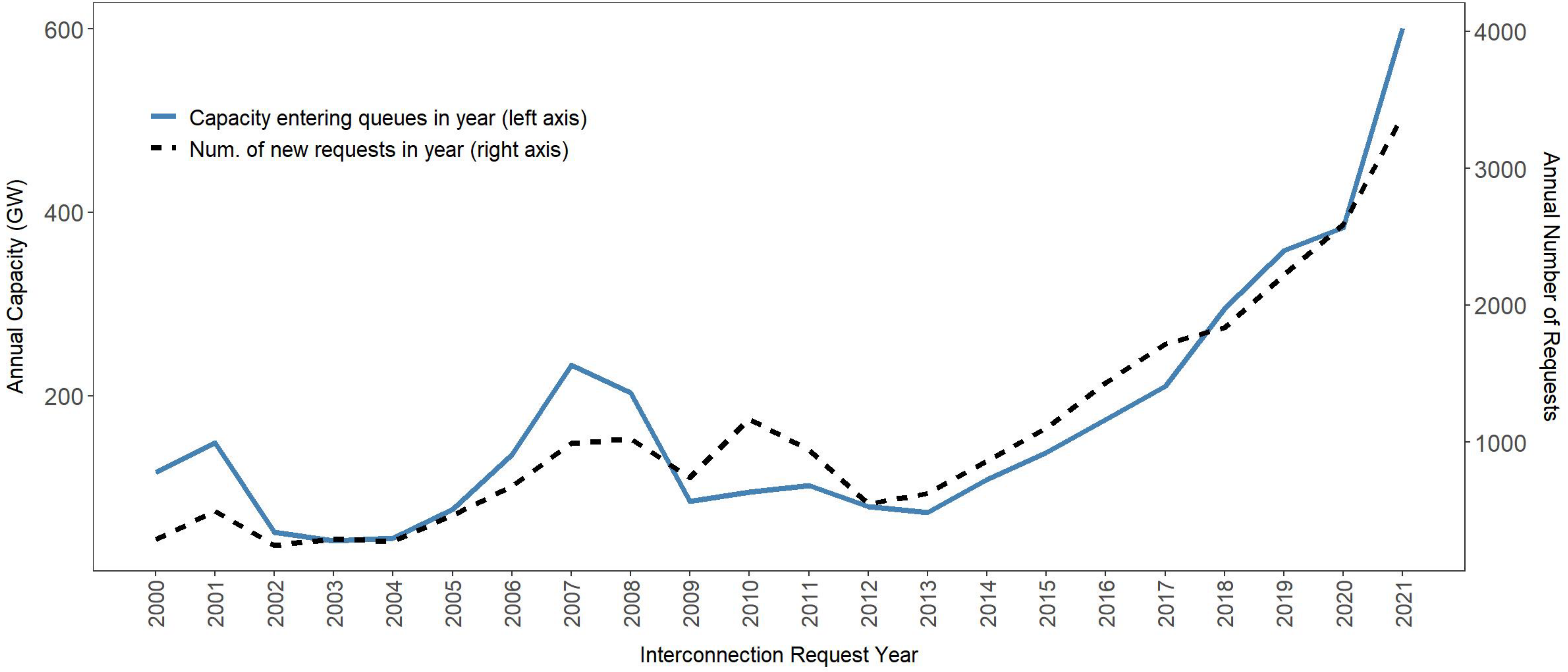
Methods and Data Sources

- Data collected from interconnection queues for 7 ISOs / RTOs and 35 utilities, which collectively represent >85% of U.S. electricity load
  - Projects that connect to the bulk power system: not behind-the-meter
  - Includes all projects in queues through the end of 2021
  - The full sample includes:
    - 8,133 “active” projects
    - 12,585 “withdrawn” projects
    - 3,439 “operational” projects
    - 229 “suspended” projects
- Hybrid / co-located projects were identified and categorized
  - Storage capacity in hybrids (separate from generator capacity) was estimated based on available data for some projects
- Note that being in an interconnection queue *does not guarantee* ultimate construction



Coverage area of entities for which data was collected
Data source: Homeland Infrastructure Foundation-Level Data (HIFLD)
A full list of included balancing areas can be found in the Appendix
Note that service areas can overlap
No data collected for Hawaii or Alaska

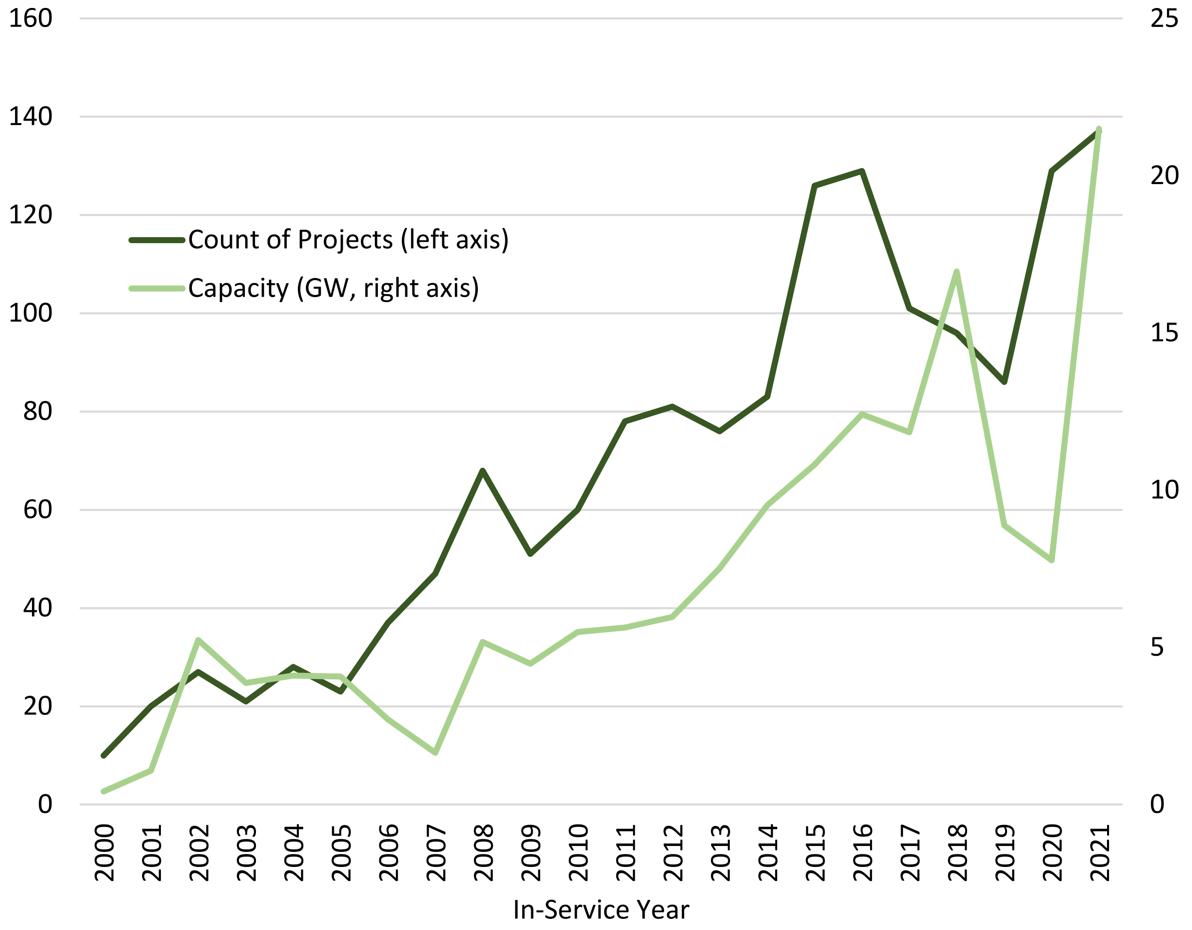
There has been a substantial increase in annual interconnection requests (both in terms of number and capacity) since 2013; over 600 GW added in 2021 alone



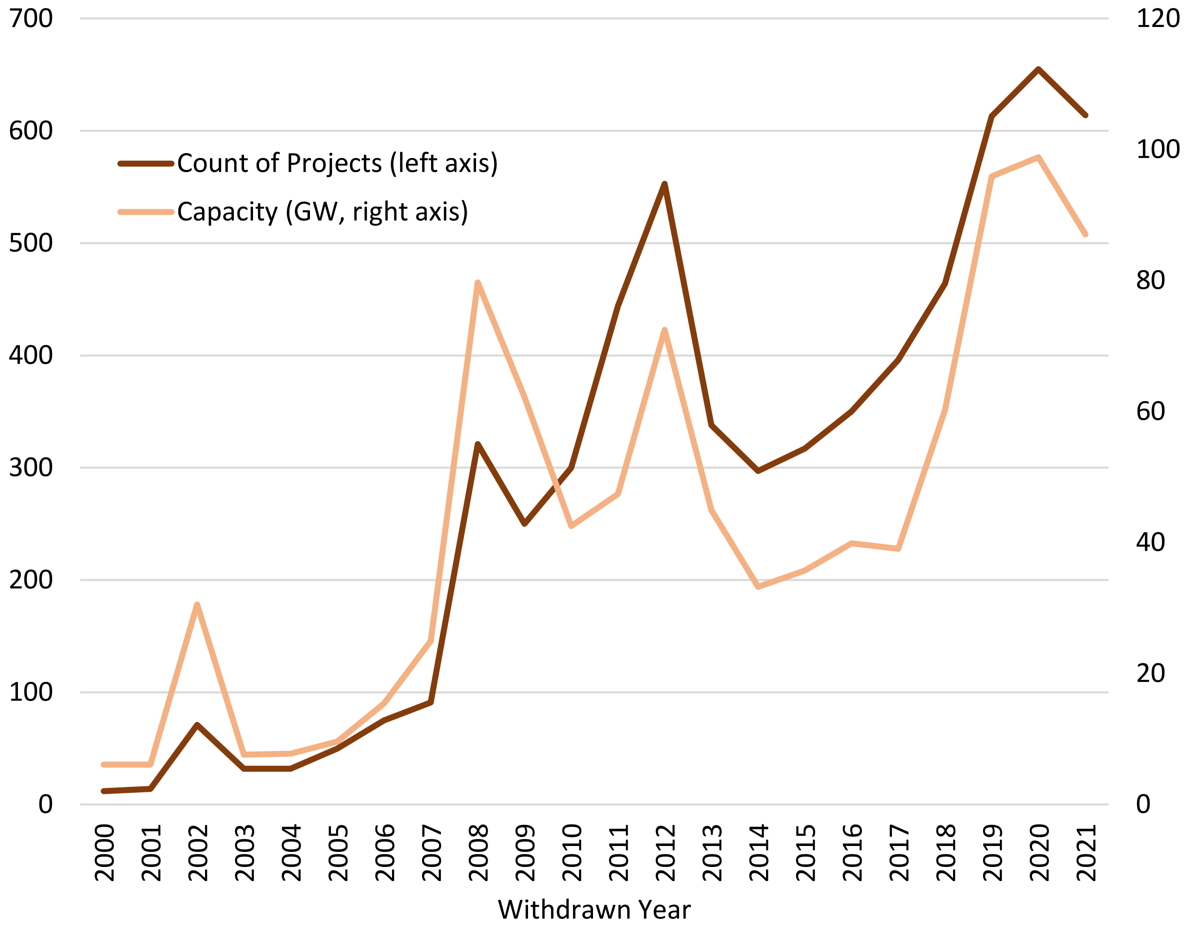
Notes: (1) This total annual volume includes projects with a queue status of "active", "suspended", "withdrawn", or "operational".
(2) All values – especially for earlier years – should be considered approximate.

Volume (number and capacity) of operational and withdrawn projects are increasing year-over-year

Volume of Operational Projects by In-Service Year



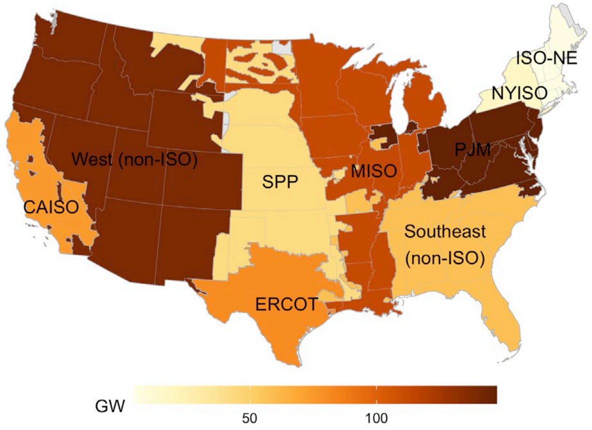
Volume of Withdrawn Projects by Withdrawn Year



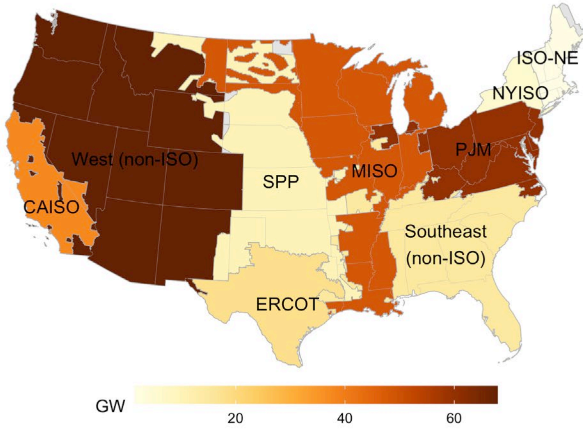
Note: In-service year only available for 44% of the "operational" project sample; withdrawn year only available for 50% of the "withdrawn" project sample. These figures therefore only include a subset of total data.

Regional trends: Proposed solar is widespread, with less in SPP and Northeast; Most wind in the West and SPP with new offshore in NY; Most storage in CAISO, West, and PJM; Gas is largely in the Southeast

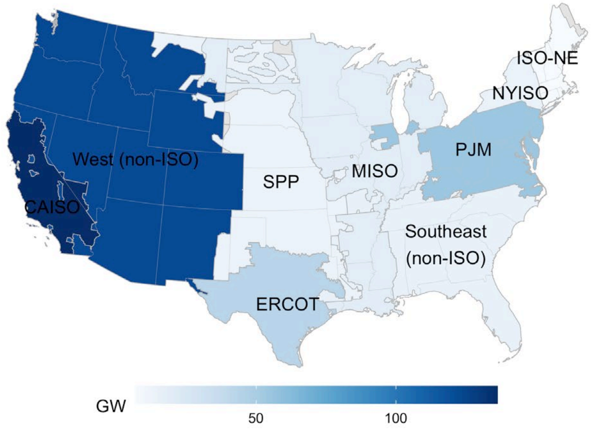
Total Solar Capacity in
Interconnection Queues at the end of 2021



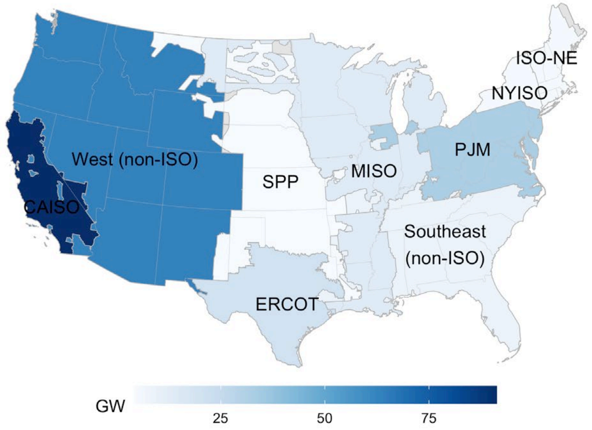
New Solar Capacity Added to
Interconnection Queues in 2021



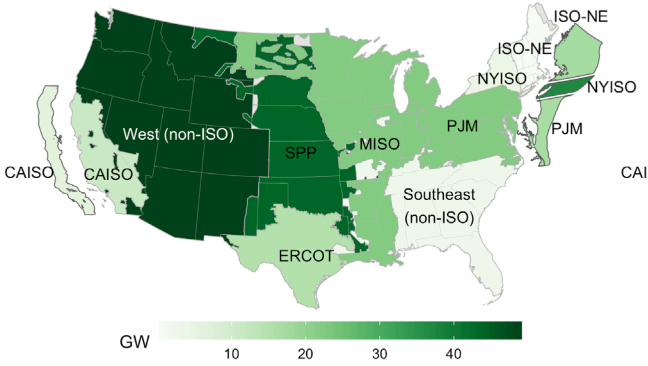
Total Storage Capacity in
Interconnection Queues at the end of 2021



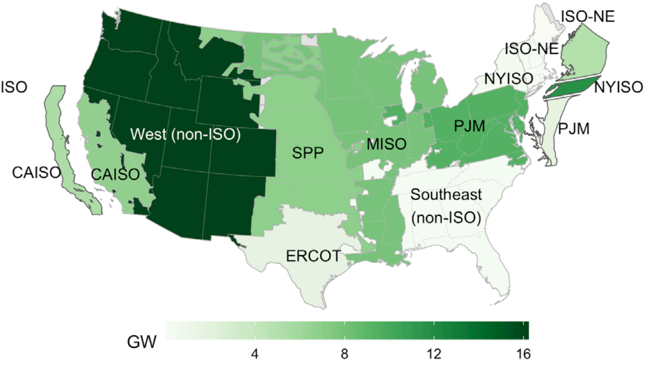
New Storage Capacity Added to
Interconnection Queues in 2021



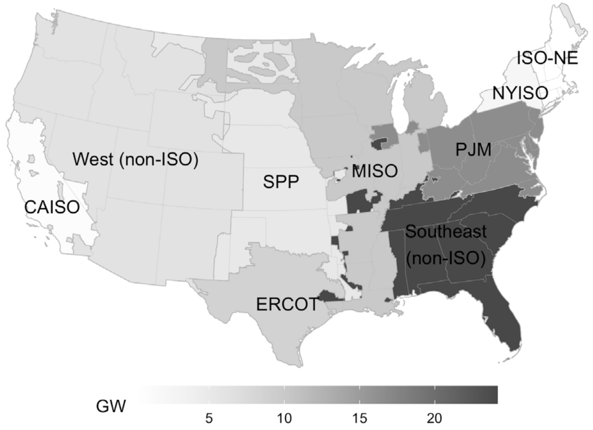
Total Wind Capacity in
Interconnection Queues at the end of 2021



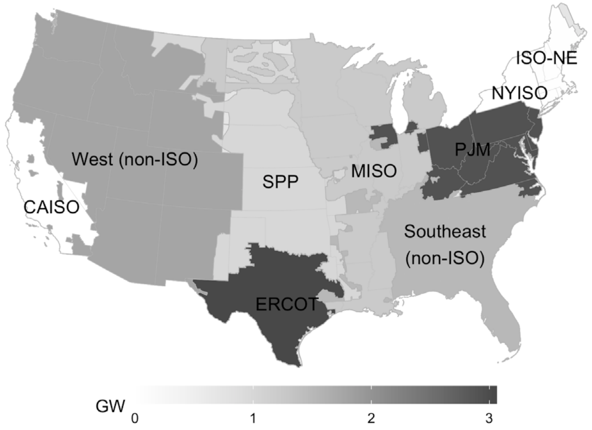
New Wind Capacity Added to
Interconnection Queues in 2021



Total Gas Capacity in
Interconnection Queues at the end of 2021



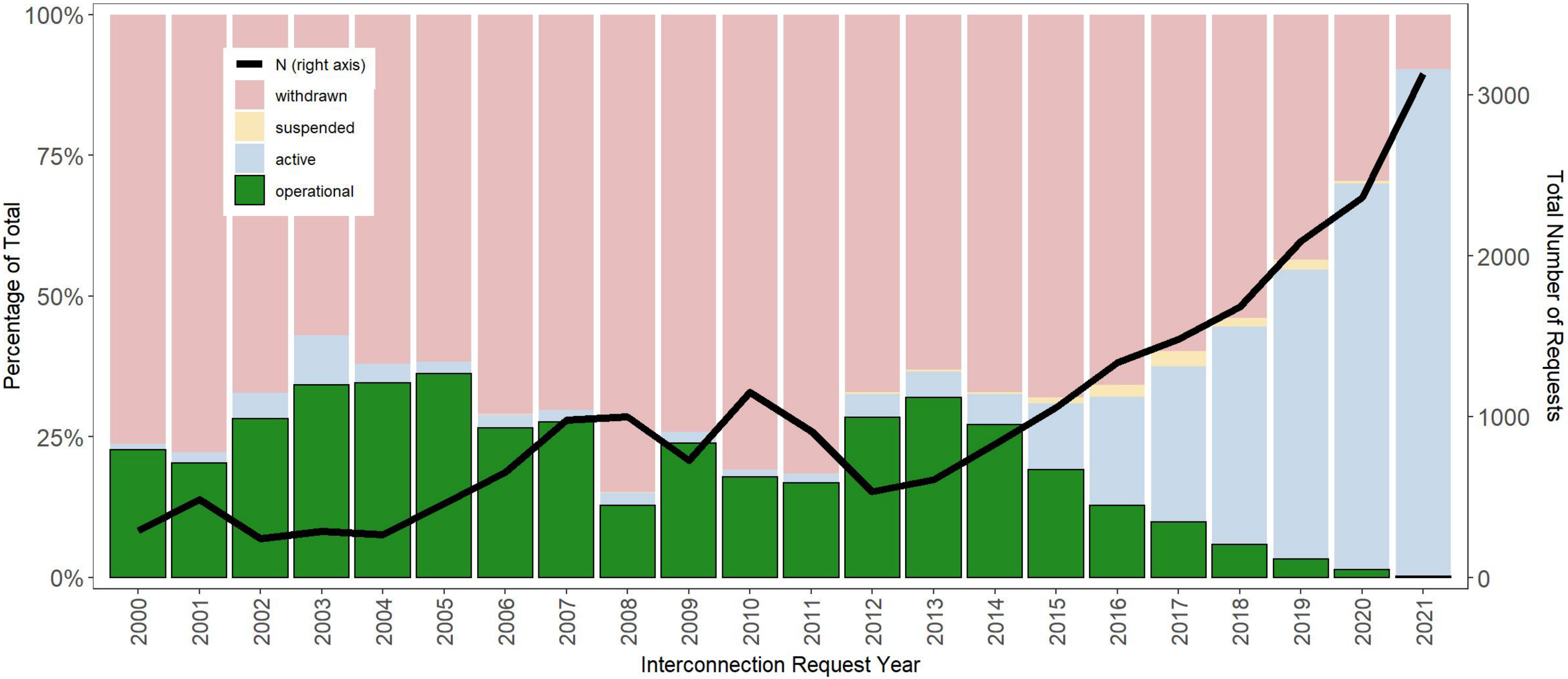
New Gas Capacity Added to
Interconnection Queues in 2021



Note: Queue capacity mapped by county can be found in appendix slides.

Less than 23% of all projects proposed from 2000-2016 have reached commercial operations – 72% have withdrawn from queues

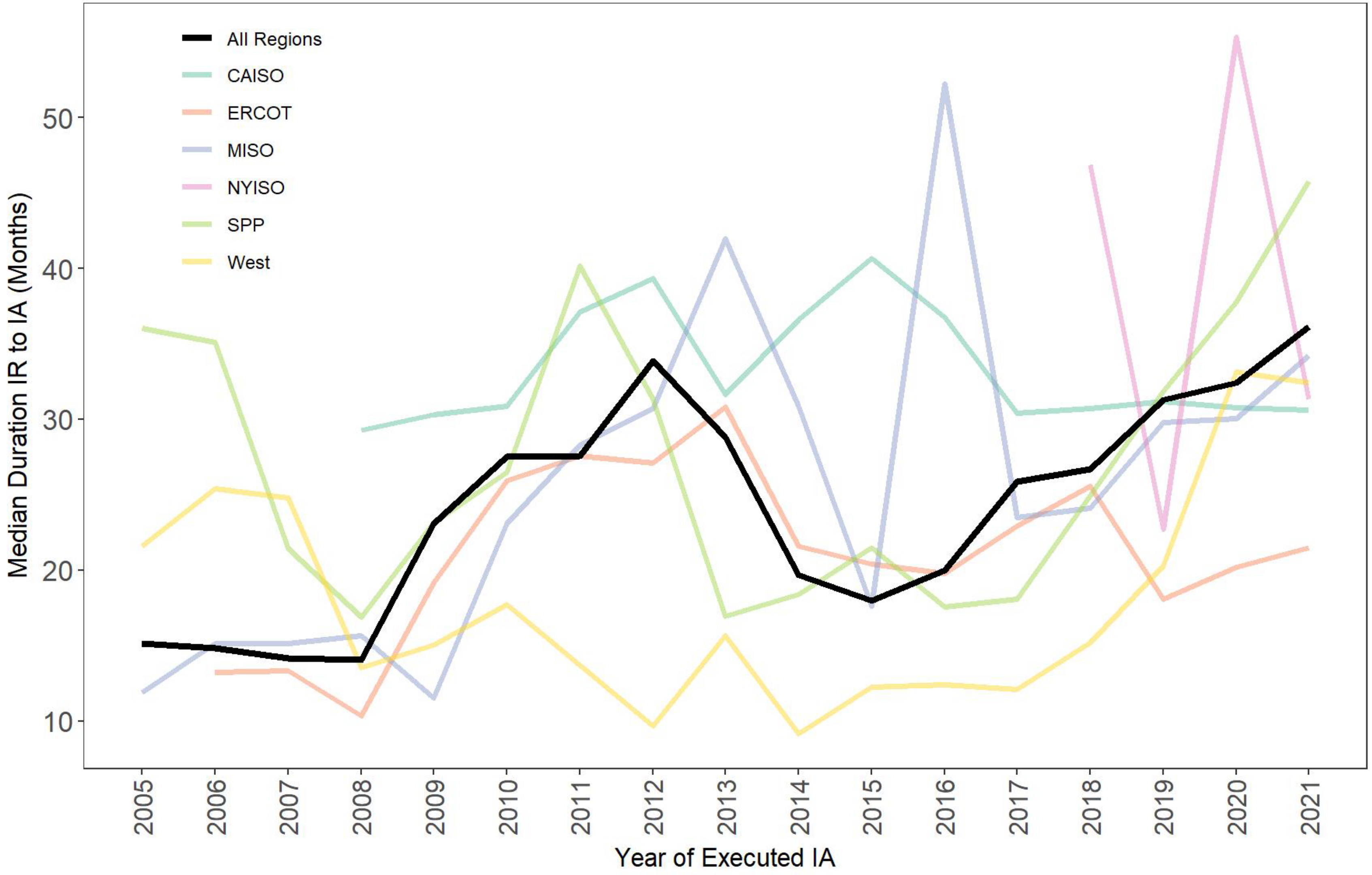
The completion rate may have increased temporarily after 2010-2012 queue reforms[1] but appears to be declining for projects proposed since 2013. Trends for projects proposed in 2017 and after cannot yet be determined.



1. Americans for a Clean Energy Grid. *Disconnected: The Need for a New Generator Interconnection Policy.* January, 2021.
Notes: (1) Completion rate is calculated by number of projects, not capacity-weighted. (2) Limited to data from 6 ISO/RTOs and 25 utilities.

Recent Increases in IR to IA Durations Are Evident in Some Regions (MISO, SPP, non-ISO West), But Others (CAISO, ERCOT) Have Been Steady Over Time

Duration Analyzed: *Interconnection Request (IR)* → *Interconnection Agreement (IA)* → *Commercial Operations (COD)*



Sample Size (Number of Projects)

IA Year	CAISO	ERCOT	MISO	NYISO	SPP	West
2005		10	68		4	6
2006		24	65		7	5
2007	5	30	63		9	10
2008	9	15	83		6	26
2009	7	14	91		6	13
2010	17	5	109		10	20
2011	24	10	152	4	25	19
2012	16	19	162		14	10
2013	25	37	70	4	19	17
2014	27	30	41		14	29
2015	14	39	29		20	44
2016	11	24	37		18	24
2017	20	17	30	4	6	16
2018	27	66	37	5	20	27
2019	14	46	68	14	25	51
2020	22	76	55	23	25	31
2021	23	66	61	36	11	30

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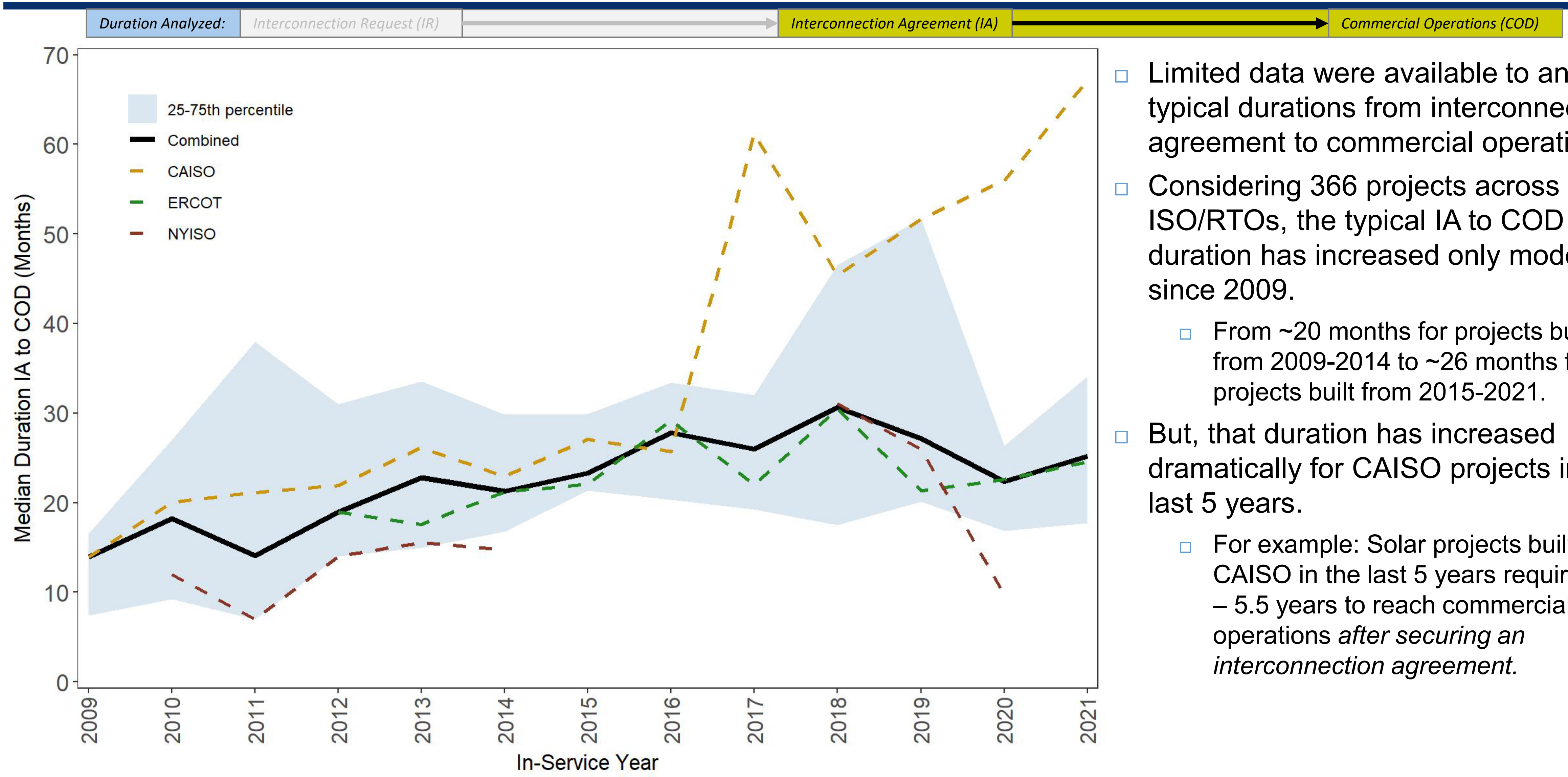
Notes: (1) Data are only shown where sample size is >2 for each region and year. (2) Not all data used in this analysis are publicly available.

Typical Duration from IA to Commercial Operations Date (COD) has Increased Modestly, Except in CAISO Where Recently Built Projects Took ~5 Years



- Limited data were available to analyze typical durations from interconnection agreement to commercial operations
- Considering 366 projects across 3 ISO/RTOs, the typical IA to COD duration has increased only modestly since 2009.
  - From ~20 months for projects built from 2009-2014 to ~26 months for projects built from 2015-2021.
- But, that duration has increased dramatically for CAISO projects in the last 5 years.
  - For example: Solar projects built in CAISO in the last 5 years required 3.5 – 5.5 years to reach commercial operations *after securing an interconnection agreement.*

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Notes: (1) Data were only available for 366 projects across the 3 ISO/RTOs shown. (2) Not all data used in this analysis are publicly available.

Balancing Areas Included In Data:

ISO/RTOs	Other (non-ISO) Transmission Operators				
PJM	Southern Company	Associated Electric Coop.	LG&E & KU Energy	Portland General Electric	Public Service Co. of NM
MISO	Tennessee Valley Authority	PSCO	Salt River Projects	Idaho Power	Avista
ERCOT	Duke/Progress	Santee Cooper	NV Energy	Florida Municipal Power Pool	El Paso Electric
SPP	WAPA	Georgia Transmission Corp.	Navajo-Crystal	Tri-State G&T	Imperial Irrigation District
NYISO	Florida Power & Light	Arizona Public Service	Dominion	Jacksonville Electric Authority	Platte River Power Authority
CAISO	Bonneville Power Admin.	LADWP	Puget Sound Energy	Tucson Electric Power	Black Hills Colorado
ISO-NE	PacifiCorp	Seminole Electric Coop.	Tampa Electric Co.	NorthWestern	Cheyenne Light Fuel & Power