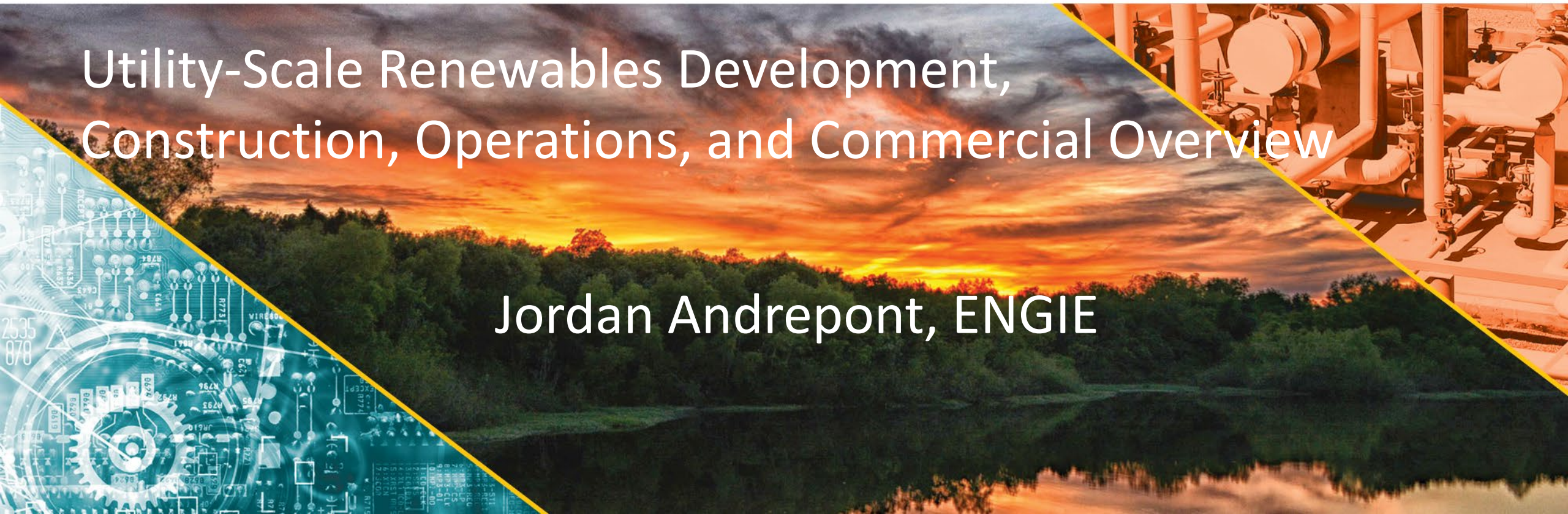




**September 29-30, 2022**  
Houston Marriott Sugar Land

Utility-Scale Renewables Development,  
Construction, Operations, and Commercial Overview

Jordan Andrepont, ENGIE





## Background

- Wind, Solar, and Storage Overview
- Technical Considerations
- Commercial Offtake
- Questions



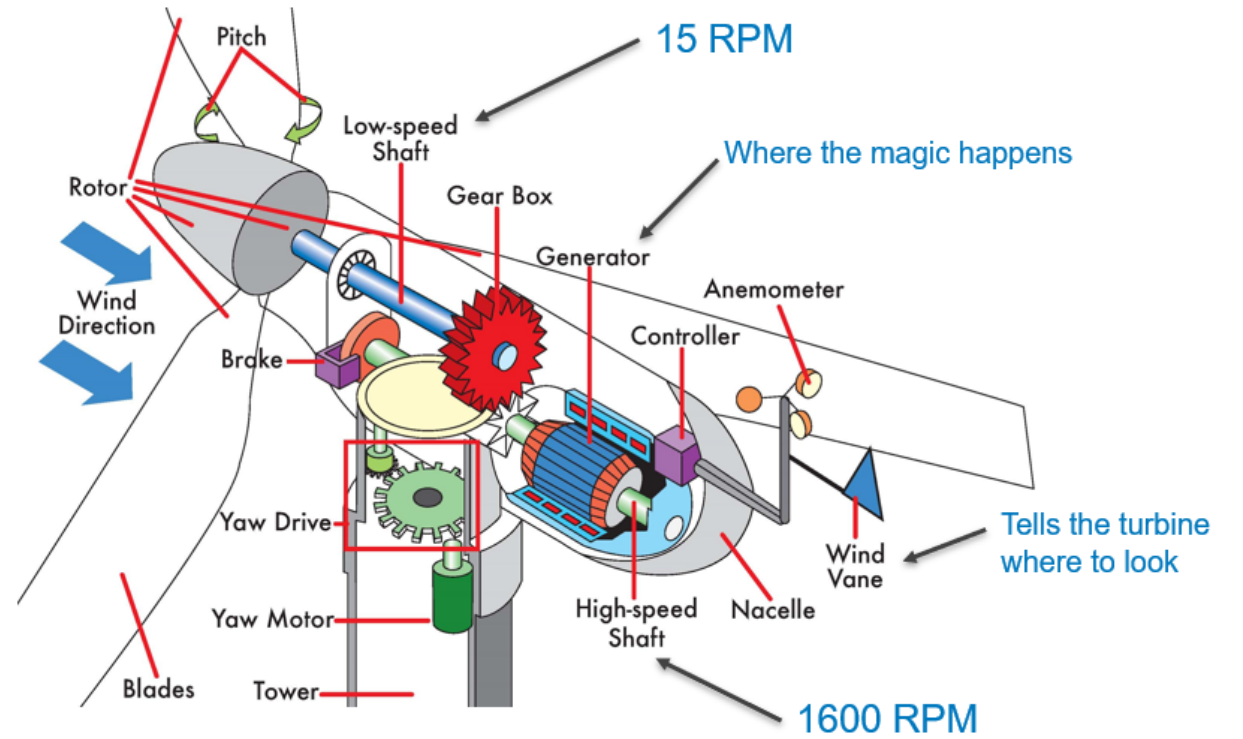
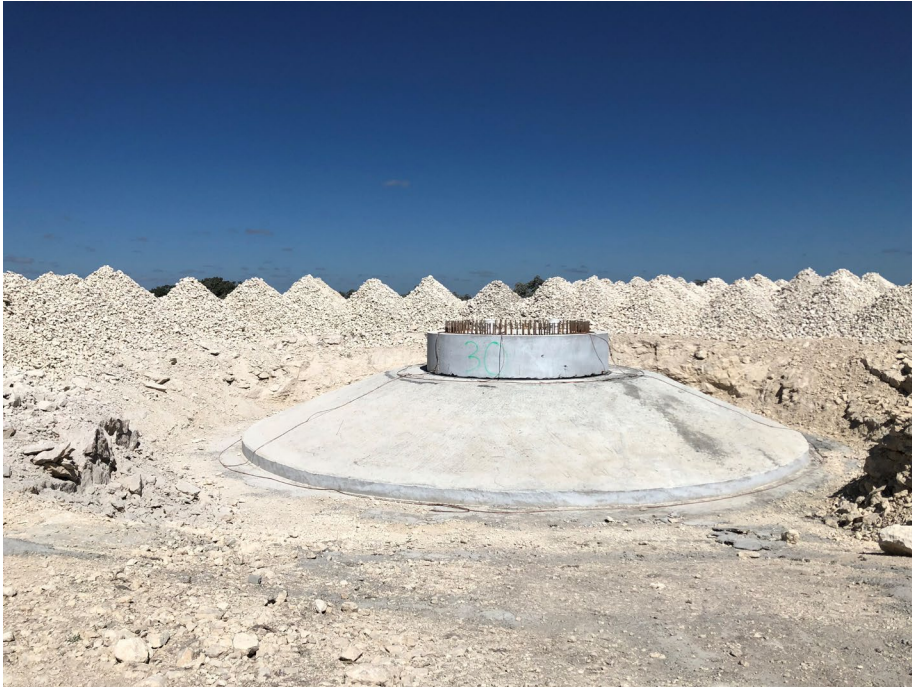


## Wind

- Development
  - Site Control
  - Resource Assessment
- Construction
  - Safety
  - Installation
  - Commissioning
  - Environmental
- Operations
  - Maintenance
  - Compliance

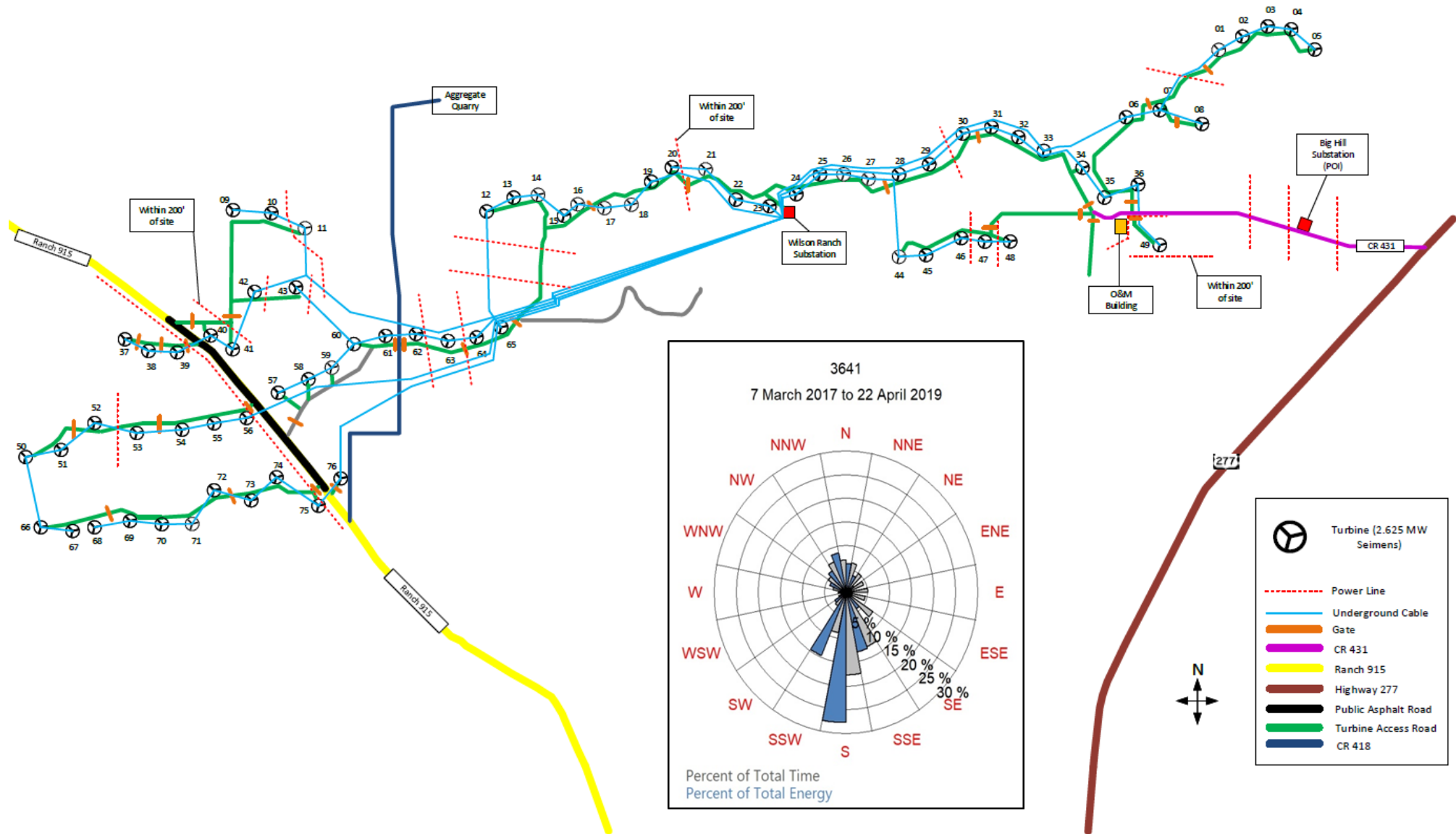


## Wind





# Wind



## Solar

- Development
  - Site Control
  - Resource Assessment
- Technology
  - Monofacial/Bifacial
- Construction
  - Safety
  - Installation
  - Commissioning
  - Environmental
- Operations
  - Maintenance
  - Compliance





## Solar

### Shading

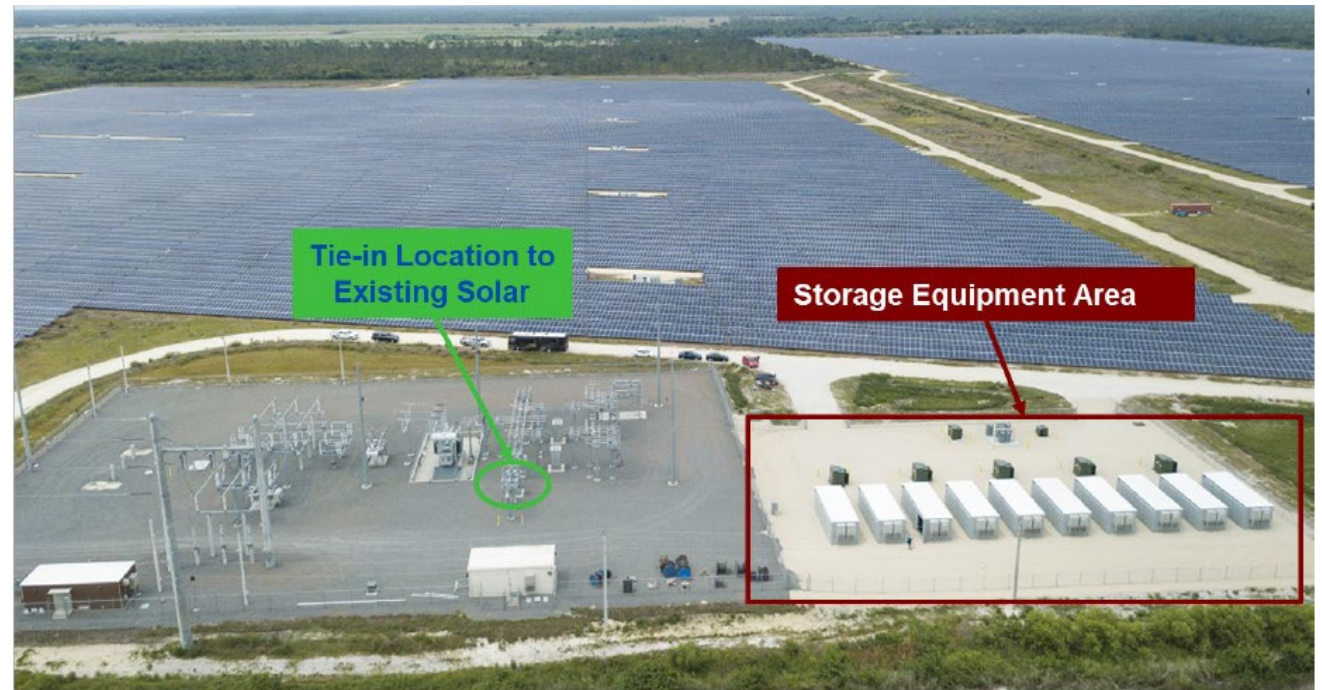
- Landscape/terrain
- Panel shadows
- Drainage
  - Basins
  - Grading
- Tracking System





## Storage

- Battery Technologies
  - Lithium Ion
- Standalone versus colocation
  - Shared substation helps with design/construction costs
  - Added complexity
- Commercial Opportunities
  - Energy Arbitrage
  - Support renewable PPAs
  - Ancillary Services
- Plant Controls
  - Active power control
  - Voltage regulation





## Power Collection and Transmission

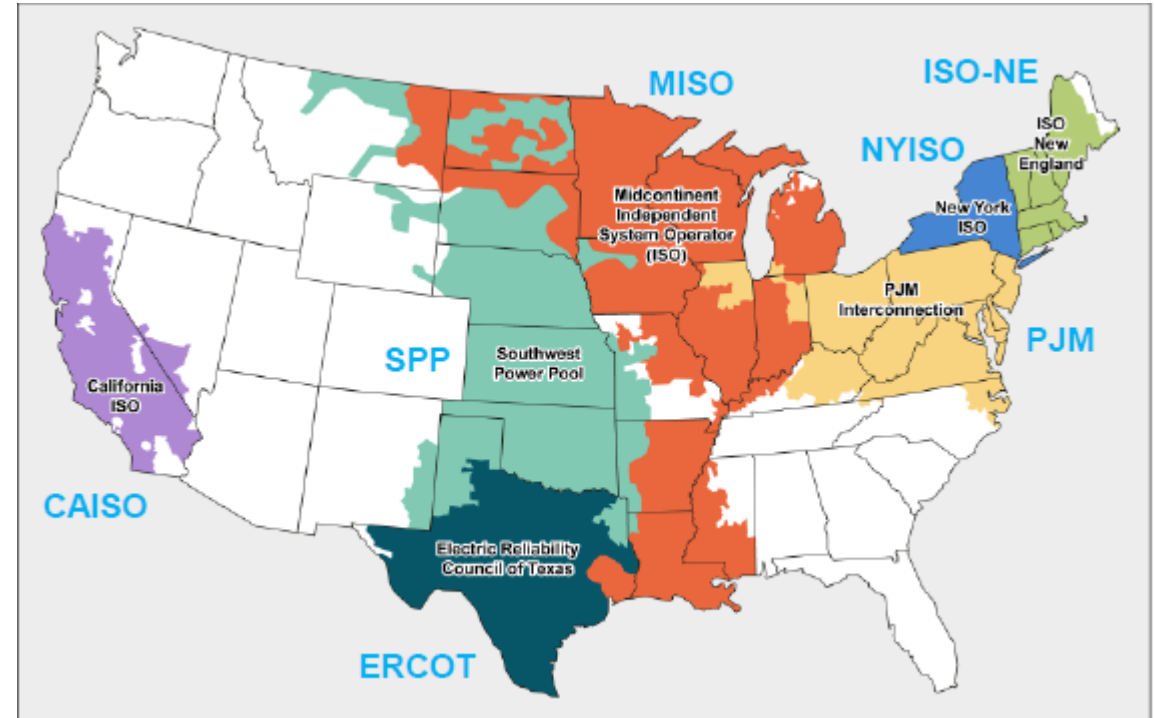
- Collection System
- Substation (voltage transformation)
- Transmission
- Coordination with utilities and Independent System Operators (ISO)





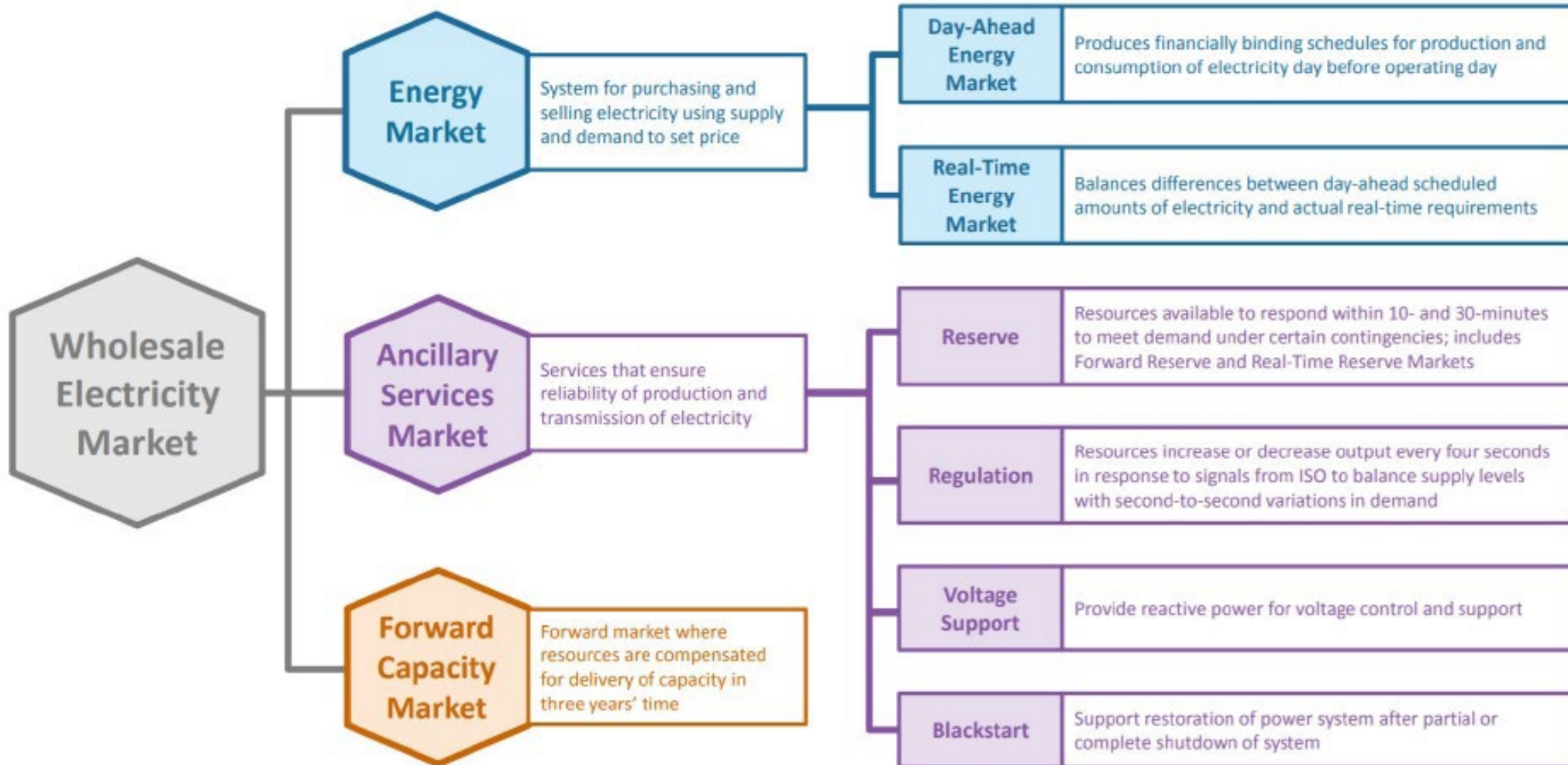
## Commercial Offtake

- ISOs
  - ERCOT, PJM, MISO, SPP, CAISO, etc.
- Regulated vs. deregulated
- Wholesale versus retail
  - Wholesale – between generators and utilities and energy traders
  - Retail – electricity sales to customers
- Interconnection
  - Studies
  - Upgrades





## Commercial Offtake

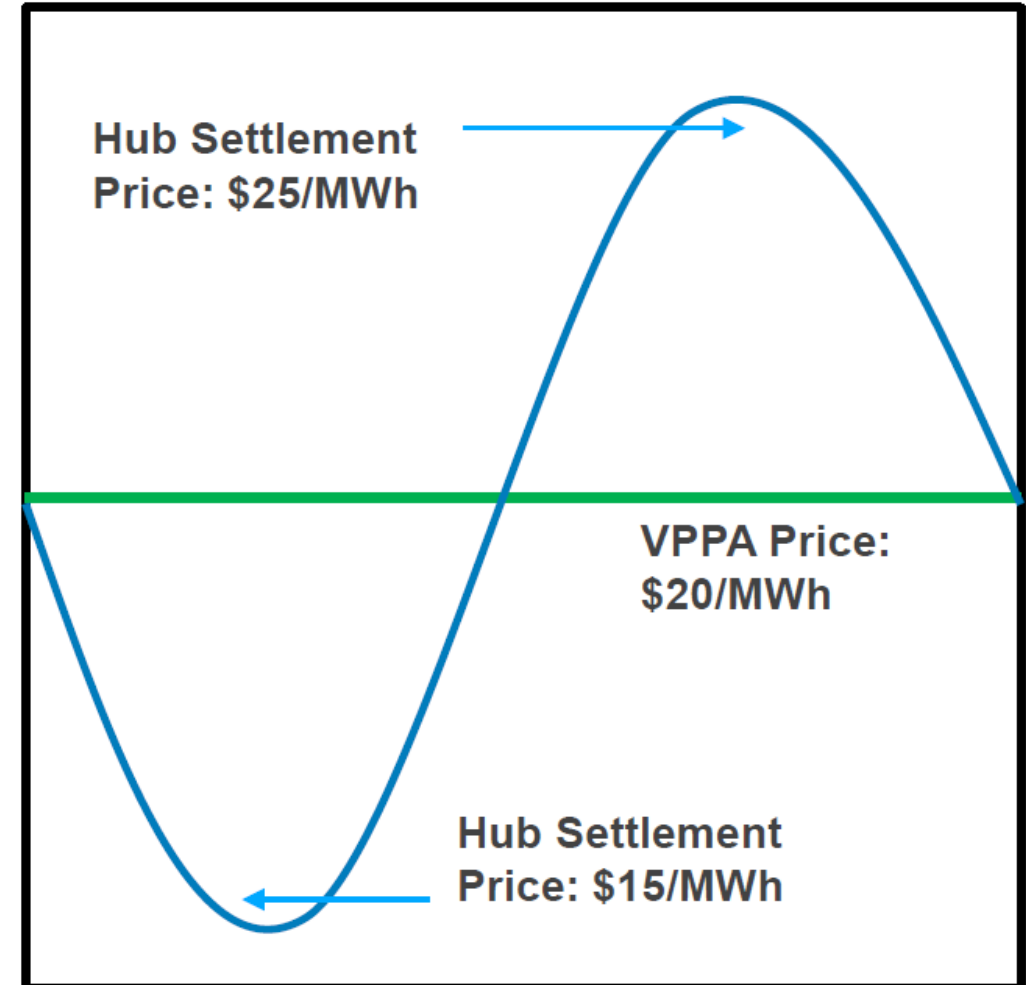




## Commercial Offtake

### Power Purchase Agreements

- Physical Busbar
  - Usually w/ Utilities
  - Delivered at local busbar and settles there
- Virtual PPA
  - Generated at busbar but settles at an ISO “hub”
- Sleeved PPA
  - 3 way 2 part contract
  - Generator in contract with utility, and utility is in contract with corporate customer





## Commercial Offtake

### Structured Offtake

- Based on a fixed shape that comes from the resource assessment and some probabilistic model for expected generation

### Proxy Revenue Swap

- Settles based on the expected generation for a given wind speed or irradiance
- Utilizes site measured meteorological data





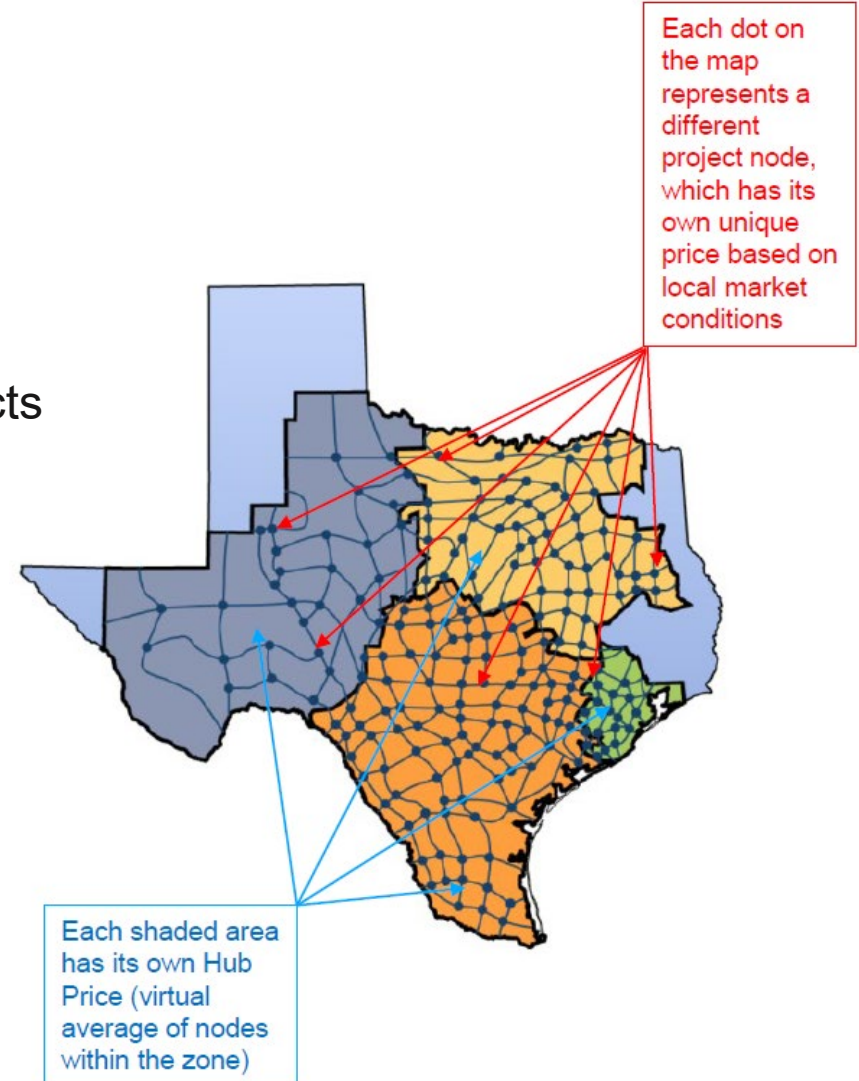


## Commercial Offtake

### Basis

- Difference between hub price and nodal price
- Can be positive or negative depending on realtime pricing
- Impacted heavily by congestion on the grid combined with projects obligation to generate

PPA (Fixed) Price	\$22
Hub (Floating) Price	-\$24
<b>PPA Settlement</b>	<b>-\$2</b>
Nodal (Generation) Price	\$20
<b>Net Realized Price</b>	<b>\$18</b>
<b>Basis</b>	<b>-\$4</b>



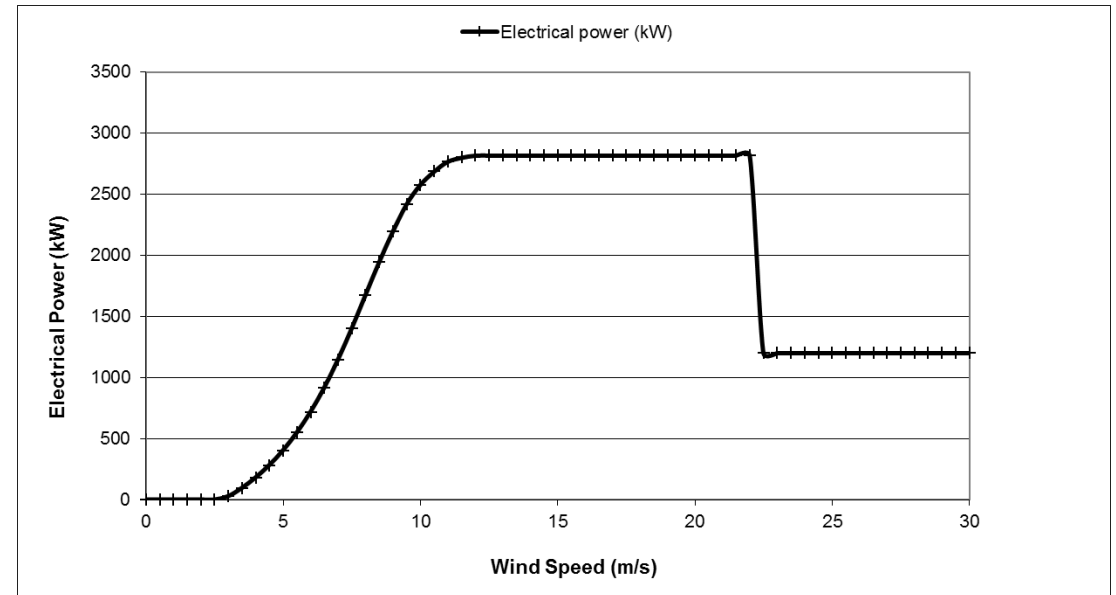


# Questions?



## Extra information

- How much energy will a project generate each year over its life? Generation = Revenue
- Measuring wind speed, direction, shear, frequency, and distribution over time help to establish the baseline
  - Meteorological Towers are installed to monitor these elements
  - 1+ year of data required for reliable estimates
- Turbine layouts are developed with the above information
- Using turbine power curve to calculate theoretical potential generation
- Actual generation / Potential generation = Net Capacity Factor (NCF)





## Extra information

### Relay Protection and Control

- Protects substation and transmission equipment from electrical faults
- Can operate equipment to safely isolate devices for maintenance/repairs





## Extra information

Busbar PPA (Financial settlement at node)

- **ISO Revenue** = Nodal price \* MW Gen'd
- **Swap Settlement** = (contract price – nodal price RT) \* MW
- **Total Revenue** = ISO revenue – swap settlement

HE	Nodal Price, RT	Contract Price	MW Gen'd	ISO Revenue	Swap Settlement	Total Rev
12	\$25	\$20	50	\$1,250	-\$250	\$1,000
13	\$15	\$20	50	\$750	\$250	\$1,000
14	\$30	\$20	50	\$1,500	-\$500	\$1,000
15	\$20	\$20	40	\$800	\$0	\$800
16	\$25	\$20	40	\$1,000	-\$200	\$800
17	\$30	\$20	40	\$1,200	-\$400	\$800

*HE – Hour Ending*

*Nodal Price RT – Price at project*

*MW Gen'd – Generation*



## Extra information

Hub Settlement (Financial settlement at hub)

- **ISO Revenue** = Nodal price \* MW Gen'd
- **Swap Settlement** = (contract price – hub price) \* MW
- **Total Revenue** = ISO revenue – swap settlement

HE	Nodal Price, RT	Hub Price, RT	Contract Price	MW Gen'd	ISO Revenue	Swap Settlement	Total Rev
13	-\$20	\$50	\$20	50	-\$1,000	-\$1,500	-\$2,500
14	\$20	\$85	\$20	50	\$1,000	-\$3,250	-\$2,250
15	\$40	\$35	\$20	50	\$2,000	-\$750	\$1,250



## Extra information

Hub Financial Settle Day Ahead (DA)

- **ISO Revenue** = Nodal price \* MW Gen'd
- **Swap Settlement** = (contract price – hub DA price) \* MW Gen'd
- **DA Sales** = (Nodal DA – Nodal RT) \* MW sold DA
- **Revenue** = ISO rev + Swap Settlement + DA sales
- **DART Risk** = (Hub RT – Hub DA) \* MW Gen'd
- **Basis Impact** = (Nodal RT – Hub RT) \* MW Gen'd

HE	Nodal Price, RT	Nodal, DA	Hub Price, RT	Hub, DA	Contract Price	MW, Sold DA	MW Gen'd	ISO Revenue	Swap Settlement	DA Sales	Total Rev	DART Impact	Basis Impact
13	\$30	\$35	\$30	\$35	\$20	44	50	\$1,500	-\$750	\$220	\$970	-\$250	0
14	\$20	\$25	\$15	\$15	\$20	44	50	\$1,000	\$250	\$220	\$1,470	0	250
15	\$40	\$45	\$40	\$45	\$20	44	50	\$2,000	-\$1,250	\$220	\$970	-250	0





## Extra information

Hub Physical Settle Day Ahead (DA) *(similar to financial DA just different calculations)*

- **ISO Revenue** = Nodal price \* MW Gen'd
- **ISO Scheduled** = -(hub DA \* MW Gen'd)
- **PPA Revenue** = contract price \* MW Gen'd
- **DA Sales** = (Nodal DA – Nodal RT) \* MW sold DA
- **Revenue** = ISO rev + ISO scheduled + PPA revenue + DA sales
- **DART Risk** = (Hub RT – Hub DA) \* MW Gen'd
- **Basis Impact** = (Nodal RT – Hub RT) \* MW Gen'd

HE	Nodal Price, RT	Nodal, DA	Hub Price, RT	Hub, DA	Contract Price	MW, Sold DA	MW Gen'd	ISO Gen	ISO Scheduled	PPA Revenue	DA Sales	Total Rev	DART Impact	Basis Impact
13	\$30	\$35	\$30	\$35	\$20	44	50	\$1,500	-\$1,750	\$1,000	\$220	\$970	-250	0
14	\$20	\$25	\$20	\$25	\$20	44	45	\$900	-1125	\$900	\$220	\$895	-225	0
15	\$40	\$45	\$40	\$45	\$20	42	40	\$1,600	-1800	\$800	\$210	\$810	-200	0



## Extra information

### Fixed Shape

- **ISO Revenue** = Nodal price \* MW Gen'd
- **Swap Settlement** = (contract price – hub price) \* Fixed Shape MW
- **Total Revenue** = ISO revenue – swap settlement
- **Basis Impact** = (hub price – nodal price) \* Fixed shape MW

HE	Nodal Price, RT	Hub Price, RT	Contract Price	Fixed Shape, MW	MW Gen'd	ISO Gen	Swap Settlement	Total Rev		Basis Impact
13	\$5	\$30	\$20	69	40	\$200	-\$690	-\$490		-\$1,725
14	\$20	\$20	\$20	68	50	\$1,000	\$0	\$1,000		\$0
15	\$4,000	\$4,000	\$20	67	50	\$200,000	-\$266,660	-\$66,660		\$0
16	\$4,000	\$4,000	\$20	64	100	\$400,000	-\$254,720	\$145,280		\$0
17	\$4,000	\$4,000	\$20	60	60	\$240,000	-\$238,800	\$1,200		\$0
18	\$1,000	\$4,000	\$20	58	90	\$90,000	-\$230,840	-\$140,840		-\$174,000
19	\$10	\$50	\$20	46	46	\$460	-\$1,380	-\$920		-\$1,840
20	\$30	\$30	\$20	29	29	\$870	-\$290	\$580		\$0