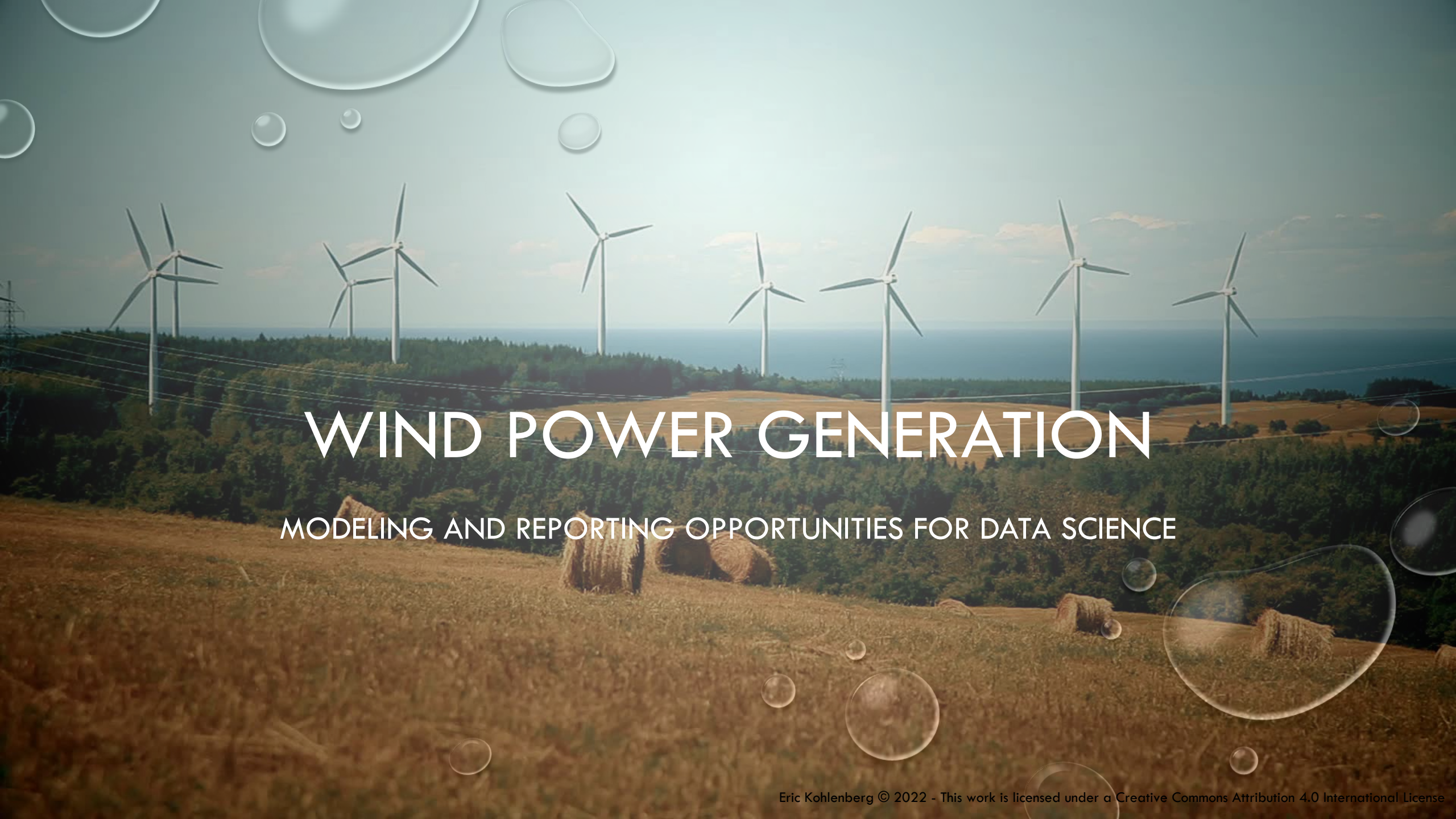


WIND POWER GENERATION

MODELING AND REPORTING OPPORTUNITIES FOR DATA SCIENCE

CONTENTS

- COMMODITY TRADING BACKGROUND
- POWER MARKETS
- POWER DATA STRUCTURE
- VALUATION AND REPORTING
- WIND GENERATION CHALLENGES
- SUMMARIZE OPPORTUNITIES FOR DATA SCIENCE

COMMODITY TRADING BACKGROUND

COMMODITIES

- COMMODITIES ARE BASIC GOODS IN COMMERCE THAT CAN BE INTERCHANGED WITH GOODS OF THE SAME TYPE OR VALUE
- COMMODITY CATEGORIES ARE METAL, ENERGY, MEAT, AND AGRICULTURE
- THE POWER MARKET IS A SUBSET OF THE BROADER ENERGY MARKET

COMMODITY TRADING PRIMER

- GOODS SUCH AS GRAIN AND LIVESTOCK WERE ORIGINALLY BOUGHT AND SOLD ON A ”SPOT” BASIS.
  - HOW MUCH DOES *N* BUSHELS COST
- SPOT MARKETS MAKE IT DIFFICULT TO MANAGE RISK
  - HOW BIG OF A CROP SHOULD BE PLANTED?
  - HOW MUCH MONEY WILL THE PRODUCER MAKE NEXT SEASON?
- COMMODITY MARKETS INTRODUCE THE CONCEPT OF ”FUTURES”
  - “I WILL PAY *X* DOLLARS PER BUSHEL FOR *Y* BUSHELS IN *Z* MONTHS
- FUTURES ENABLES BOTH THE BUYER AND SELLER TO MANAGE THEIR RISK BY KNOWING THEIR OBLIGATIONS IN ADVANCE

KEY CONCEPTS

- ECONOMICS ARE BASED PRODUCT, QUANTITY, TIME, AND PRICE
- POWER UTILIZES A "FLOW" DELIVERY PATTERN. QUANTITY IS PURCHASED TO BE DELIVERED CONTINUOUSLY OVER A TIME PERIOD
- FOR A GIVEN COMMODITY TRADE, DELIVERY PERIODS IN THE PAST ARE CONSIDERED SETTLED OR REALIZED
- DELIVERY PERIODS IN THE FUTURE ARE CONSIDERED UNREALIZED
- HEDGING STRATEGIES ATTEMPT TO MANAGE RISK EXPOSURE IN THE UNREALIZED TIMEFRAME

COMMODITY TRADER TYPES

- PRODUCERS AND CONSUMERS
  - PRODUCERS AND CONSUMERS TRADE THE ACTUAL COMMODITY WITH THE INTENT OF DELIVERING AND USING THE COMMODITY
- MARKETERS
  - THE POWER INDUSTRY IN TEXAS INCLUDES MARKETERS WHO ACT AS MIDDLEMEN TO PURCHASE WHOLESALE POWER FROM PRODUCERS AND SELL TO CONSUMERS
- SPECULATORS
  - SPECULATORS TRADE BASED ON THE VOLATILITY WITHIN A MARKET BUT NEVER INTEND TO ACTUALLY PRODUCE OR TAKE DELIVERY OF A COMMODITY
- EACH TRADER TYPE USES A VARIETY OF PHYSICAL AND FINANCIAL HEDGES TO MITIGATE RISK

MARKETER TRADING STRATEGIES

- MARKETERS ACT AS BROKERS BETWEEN PRODUCERS AND CONSUMERS
- WHOLESALE POWER PURCHASES FROM PRODUCERS
- RETAIL POWER SALES TO CONSUMERS
- FUEL HEDGES TO MANAGE FUEL RISK
- WEATHER HEDGES TO MANAGE PRODUCTION AND DEMAND RISK

POWER MARKETING

RETAIL POWER RATES ARE COMPOSED OF THREE MAIN COMPONENTS:

- GENERATION – THE COST TO PURCHASE ELECTRICITY FROM A PRODUCER
- TRANSMISSION – THE COST TO MOVE THE ELECTRICITY TO THE REGIONAL NODE FROM WHICH THE POWER WILL BE DISTRIBUTED
- DISTRIBUTION – THE "LAST MILE" COSTS TO THE LOCAL PHYSICAL PROVIDER

DEREGULATION

- ONCE UPON A TIME, POWER WAS PROVIDED BY FULLY INTEGRATED UTILITIES
- THE UTILITIES WERE REGULATED BY THE FEDERAL ENERGY REGULATORY COMMISSION (FERC) AND THE NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION (NERC)
- IN THE EARLY 1990'S, THE FEDERAL GOVERNMENT ALONGSIDE SEVERAL STATES BEGAN A PROCESS OF RESTRUCTURING THE INDUSTRY TO ENCOURAGE COMPETITION IN THE WHOLESALE MARKET

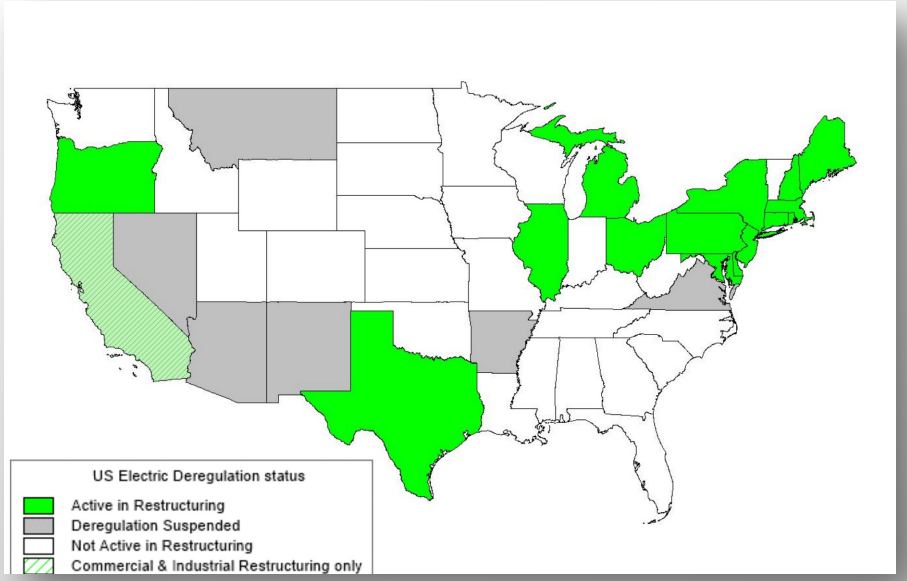


Image Source: netl.doe.gov

DEREGULATED MARKETS

- GENERATION IS DRIVEN BY THE MARKET
- TRANSMISSION COSTS ARE REGULATED BY FERC
- DISTRIBUTION COSTS ARE DRIVEN BY LOCAL PUBLIC UTILITIES COMMISSIONS (PUCS)

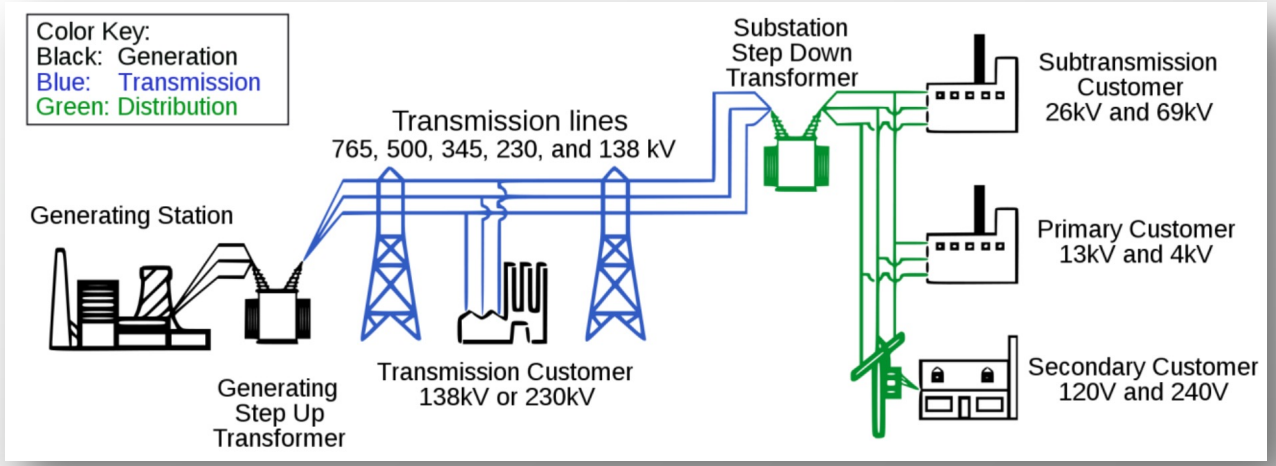
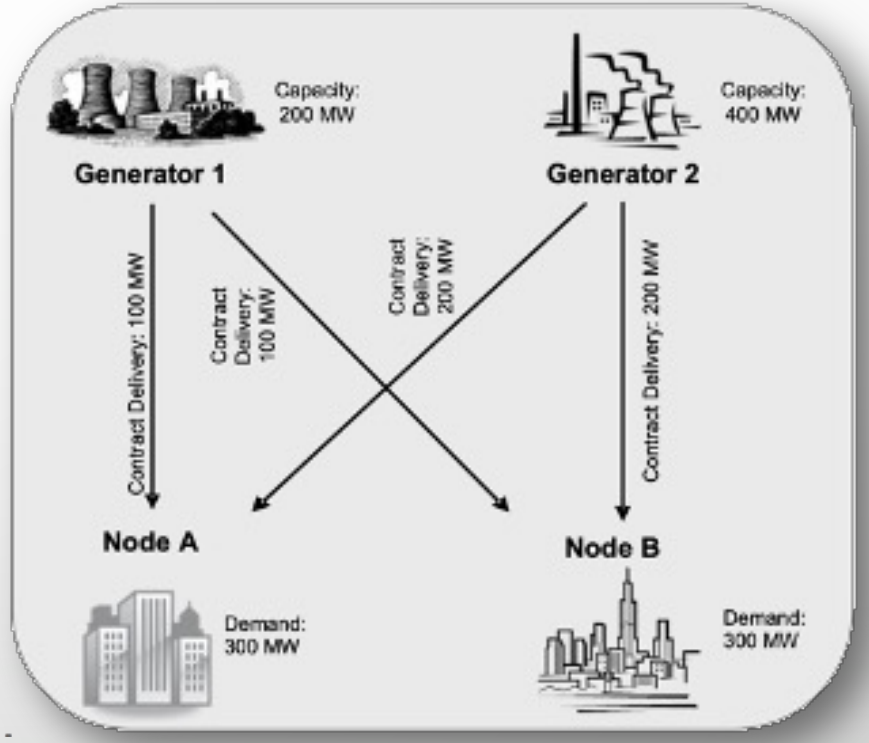


Image Source: netl.doe.gov

MARKET STRUCTURE

- POWER IS FUNGIBLE
- PRICED BY NODE
- NODAL PRICES ACCOUNT FOR TRANSMISSION COSTS
- CONSUMERS DO NOT HAVE A DIRECT TIE TO GENERATION SOURCES



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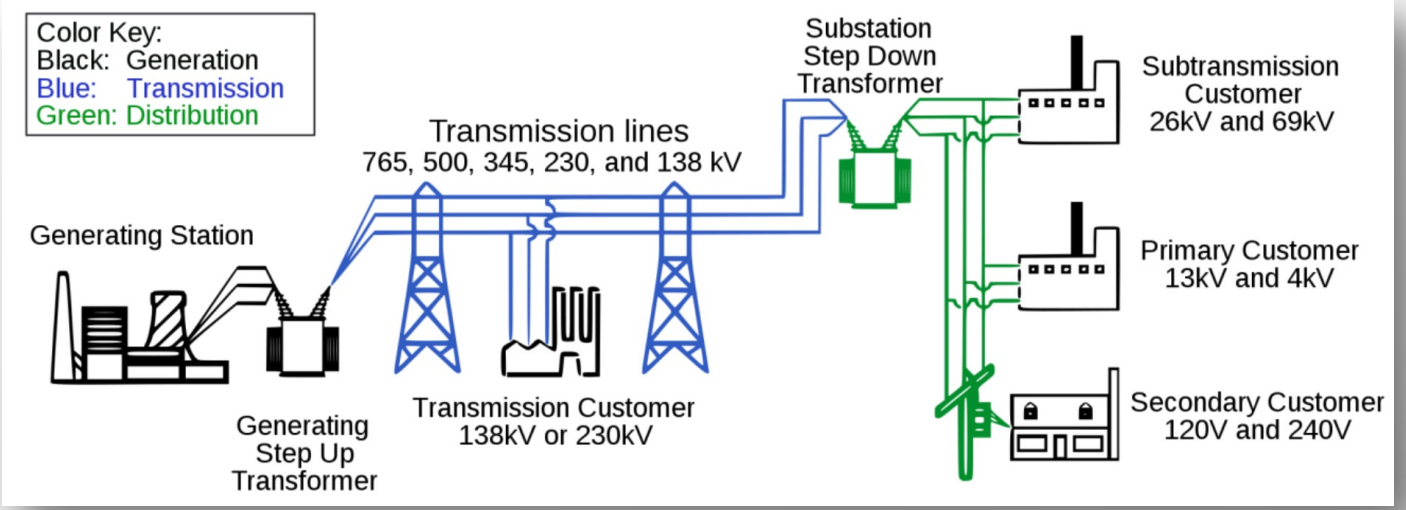
POWER MARKETER PERSPECTIVE

- A POWER MARKETER IS A BROKER BETWEEN GENERATORS AND CONSUMERS
- DETERMINE RETAIL AND COMMERCIAL LOAD (DEMAND) REQUIREMENTS
- PURCHASE WHOLESALE POWER TO MEET THE DEMAND
- PURCHASE TRANSMISSION RIGHTS



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POWER MARKET ECONOMICS

- PROFIT = REVENUE – COSTS
- MARKETERS SEEK TO MAXIMIZE PROFIT BY MAXIMIZING REVENUE AND MINIMIZING COSTS
- REVENUE IS DRIVEN BY CONSUMER AND COMMERCIAL MARKET PRESSURES (E.G. MARKETERS COULD RAISE RATES BUT THEY WOULD LOSE OUT TO COMPETITION)
- COSTS IS DRIVEN BY PURCHASING CAPACITY TO MEET FORECASTED LOAD (DEMAND)
- COSTS ARE A FUNCTION OF GENERATION, TRANSMISSION, DISTRIBUTION COSTS, AND FORECASTED LOAD

LOAD FORECAST

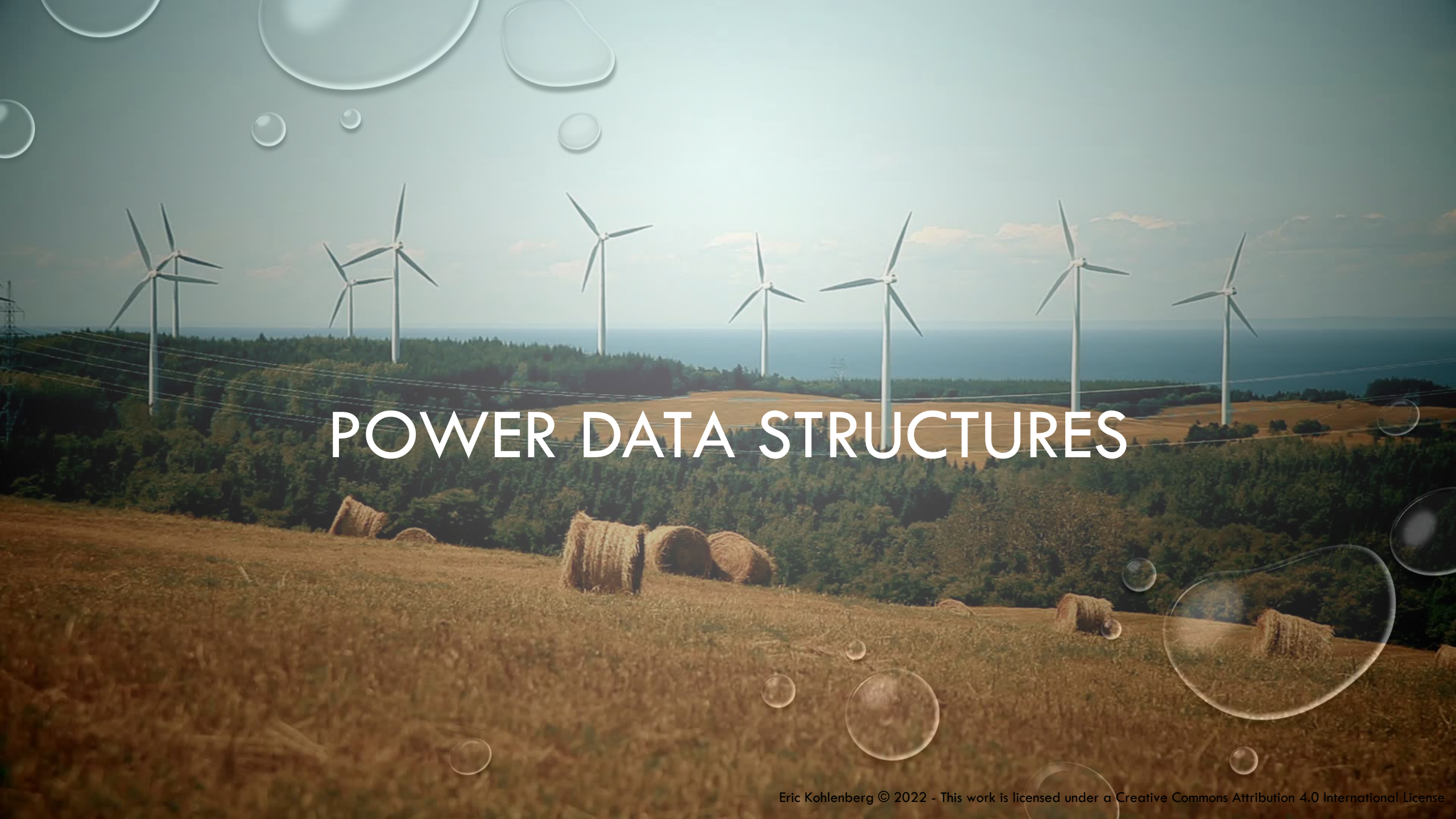
- LOAD – L(CUSTOMER TYPE, TIME OF DAY, DAY OF WEEK, WEATHER, [, SEASON])
- CUSTOMER TYPES GROUP CONSUMERS INTO USAGE PATTERNS, E.G.
  - URBAN RESIDENTIAL
  - SUBURBAN RESIDENTIAL
  - SMALL COMMERCIAL
  - INDUSTRIAL
- DATA SCIENCE OPPORTUNITY – DETERMINE BETTER WAYS TO FORECAST DEMAND

POWER GENERATION TYPES

- MARKETERS PURCHASE POWER TO MEET SPECIFIC LOAD REQUIREMENTS
- BASE LOAD
  - PROVIDES STEADY FLOW OF GENERATION
  - CANNOT CHANGE AMOUNT OF POWER PRODUCED; CANNOT RESPOND TO CHANGING DEMAND CONDITIONS
- PEAKER LOAD
  - DESIGNED TO MEET CHANGING DEMANDS ON SHORT NOTICE
  - PRICING IS HIGHLY VOLATILE AND IMMEDIATELY REFLECTS MARKET CONDITIONS
- VARIABLE LOAD
  - GENERATION CANNOT BE WELL CONTROLLED
  - OFTEN GENERATES OPPOSITE OF DEMAND
- PRICING IS LIKE LOAD FUNCTION
- P = (LOCATION, TIME OF DAY, DAY OF WEEK, WEATHER[, SEASON])

POWER WHOLESALE PRICE FORECASTING

- POWER GENERATORS PAY FOR THE FACILITIES, MAINTENANCE AND FUEL TO PRODUCE ELECTRICITY
- WIND GENERATORS PAY FOR THE COST OF THE TURBINE(S), ROYALTIES TO THE LAND OWNER, AND MAINTENANCE OF THE EQUIPMENT
- HIGHEST-DEMAND PERIODS ARE SERVED BY PEAKER GENERATORS. COST OF ELECTRICITY IS TIGHTLY CORRELATED TO THE PRICE OF NATURAL GAS
- WHOLESALE PRICES REFLECT THE COST TO PRODUCE ELECTRICITY PLUS A SMALL PROFIT MARGIN
- WEATHER AND LOAD FORECASTS DRIVE THE MIX OF GENERATORS USED IN A GIVEN TIMEFRAME
- MARKETERS CONSIDER THE WHOLESALERS' PRICE COMPONENTS WHEN FORECASTING PRICING OF FUTURE CAPACITY
- DATA SCIENCE OPPORTUNITY - CREATE SMART MODELS TO COMBINE GENERATION TYPES AND FORECAST POWER PRICING



POWER DATA STRUCTURES

PHYSICAL POWER DEAL MODEL

SIMPLEST FORM

Deal Header

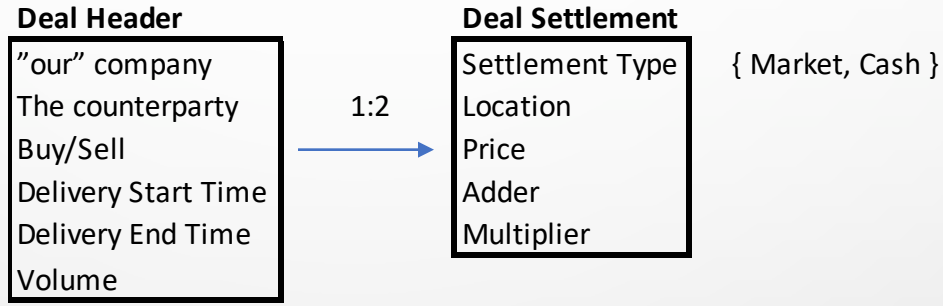
”our” company
The counterparty
Buy/Sell
Location
Delivery Start Time
Delivery End Time
Volume
Price

COMMODITY DEAL VALUATION

- DEAL VALUATION CALCULATES THE ECONOMIC VALUE OF A TRANSACTION
- IT CALCULATES THE DIFFERENCE OF A MARKET VALUE FOR A DEAL VS THE AGREED-UPON VALUE
- IN POWER, MARKET VALUE IS DETERMINED BY POWER PRICES AT A LOCATION AT A SPECIFIC TIME
- THEREFORE, THERE ARE ALWAYS AT LEAST TWO SIDES TO ANY COMMODITY DEAL (INCLUDING POWER) – THE MARKET SIDE AND THE CASH SETTLEMENT SIDE
- THE CASH SETTLEMENT SIDE CAN BE A FLAT RATE, OR BASED ON A FORMULA CALCULATION

POWER DEAL SETTLEMENT TYPES

- SETTLEMENT INFORMATION IS BROKEN OUT FROM THE HEADER
- THE DATA MODEL CAPTURES BOTH THE “CASH” SIDE AND THE “MARKET” SIDE



LOAD SHAPES

- LOADSHAPES DEPICT VARIED DEMAND BASED ON TIME OF DAY, DAY OF WEEK AND CUSTOMER TYPE
- EXAMPLES
  - SUBURBAN RESIDENTIAL WEEKDAYS – HIGHER VOLUME 6:00AM TO 8:00AM, NO VOLUME IN THE MIDDLE OF THE DAY, HIGHER VOLUME 4:00PM TO 10:00PM. NO VOLUME FROM 10:00PM TO 6:00AM
  - SUBURBAN RESIDENTIAL WEEKENDS – HIGHER VOLUME 8:00AM TO 10:00PM, NO VOLUME 10:00PM TO 8:00AM
  - SMALL COMMERCIAL WEEKDAY – HIGH VOLUME 7:00AM TO 5:00PM
  - SMALL COMMERCIAL WEEKEND – NO VOLUME
- HIGH VOLUME == PEAK
- LOWER OR NO VOLUME == OFF-PEAK
- LOAD SHAPES ARE TYPICALLY ASSOCIATED WITH RETAIL AND ARE AGGREGATED TO CREATE TOTAL WHOLESALE DEMAND

WHOLESALE POWER PRICING

- POWER PRICING IS A TIME SERIES THAT
- LOCATION MARGINAL PRICING
- PRICE BANDS FOR PEAK AND OFF-PEAK
- HOURLY OR 15-MIN INCREMENTS
- ERCOT POWER PRICING IS $USD/MWH

POWER DEAL MODEL W/ PRICE BANDS AND LOAD SHAPES

Deal Header

”our” company
The counterparty
Buy/Sell
Delivery Start Time
Delivery End Time
Total Volume

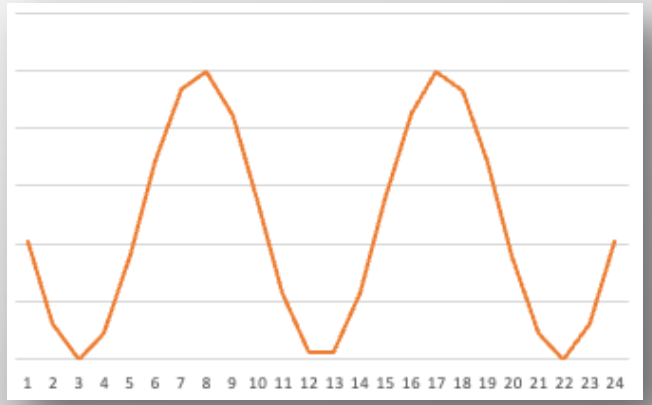
1:4

Deal Settlement

Settlement Type	{ Market, Cash }
Location	
Price	
Price Band	{ Peak, Off-Peak }
Adder	
Multiplier	

Delivery Volume

Date/Time	
Price Band	{ Peak, Off-Peak }
Voume	



VALUATION AND REPORTING

VALUATION

- ALL PARTICIPANTS IN COMMODITY MARKETS MUST VALUE THEIR DEALS ON A DAILY BASIS
- VALUATION CALCULATES THE MARKET VALUE OF THEIR DEALS AND PROVIDES DAY-OVER-DAY RESULTS OF THEIR PROFIT OR LOSS USING A PRICE*VOLUME FORMULA
- VALUATION ALSO CALCULATES THEIR TIME-VALUE ADJUSTED EXPOSURE TO THE MARKET
- CREDIT VALUATION CALCULATES THEIR EXPOSURE TO COUNTERPARTIES BASED ON CREDIT RATING AND CONTRACTUAL AGREEMENTS
- VALUATION EXPANDS EACH DEAL'S SETTLEMENT AND DELIVERY VOLUME EACH DAY
- VALUATION GENERATES A LOT OF DATA THAT MUST BE REPORTED AND STORED
- VALUATION DATA SETS REPRESENT A GOLD MINE OF ANALYSIS OPPORTUNITY

EXAMPLE DEAL STRUCTURE

Deal Header

"our" company	CheapPower.com
The counterparty	Windy Hill Wind Farm
Buy/Sell	Buy
Delivery Start Time	6/1/2022
Delivery End Time	6/30/2022
Total Volume	90000 MWh

Deal Settlement

Settlement Type	Cash	Market	Cash	Market
Location	CALHOUN_UN1	CALHOUN_UN1	CALHOUN_UN1	CALHOUN_UN1
Price	$ 40.00	-not known-	$ 120.00	-not known-
Price Band	Peak	Peak	Off-Peak	Off-Peak
Adder	$ 0.01	$ -	$ 0.01	$ -
Multiplier	1.00	1.00	1.00	1.00

Delivery Volume

Date/Time	Volume	Price Band	
6/1/22 12:00 AM	145 MWh	Off-Peak	
6/1/22 1:00 AM	43 MWh	Off-Peak	
6/1/22 2:00 AM	0 MWh	Off-Peak	
6/1/22 3:00 AM	33 MWh	Off-Peak	
6/1/22 4:00 AM	129 MWh	Off-Peak	
6/1/22 5:00 AM	246 MWh	Peak	
6/1/22 6:00 AM	334 MWh	Peak	
6/1/22 7:00 AM	356 MWh	Peak	
6/1/22 8:00 AM	302 MWh	Peak	
6/1/22 9:00 AM	195 MWh	Peak	X 30 Days
6/1/22 10:00 AM	82 MWh	Off-Peak	
6/1/22 11:00 AM	10 MWh	Off-Peak	
6/1/22 12:00 PM	10 MWh	Off-Peak	
6/1/22 1:00 PM	83 MWh	Off-Peak	
6/1/22 2:00 PM	197 MWh	Peak	
6/1/22 3:00 PM	303 MWh	Peak	
6/1/22 4:00 PM	356 MWh	Peak	
6/1/22 5:00 PM	333 MWh	Peak	
6/1/22 6:00 PM	244 MWh	Peak	
6/1/22 7:00 PM	127 MWh	Off-Peak	
6/1/22 8:00 PM	32 MWh	Off-Peak	
6/1/22 9:00 PM	0 MWh	Off-Peak	
6/1/22 10:00 PM	45 MWh	Off-Peak	
6/1/22 11:00 PM	146 MWh	Off-Peak	

PRICING DATA

- PUBLISHED AS TIME SERIES DATA
- PRICING DATA IS AVAILABLE FROM ERCOT FOR DAY-AHEAD, REAL-TIME, AND SETTLED PRICES
- SETTLED PRICES ARE PUBLISHED FOR 15,000 LOCATIONS IN 5 MINUTE INCREMENTS
- BALANCE-OF-THE-MONTH AND FORWARD PRICES ARE LEFT UP TO THE MARKETER TO ESTIMATE
- DATA SCIENCE OPPORTUNITY – INVENT MORE EFFICIENT PRICING METHODS AND HEDGING INSTRUMENTS

SAMPLE PRICING DATA

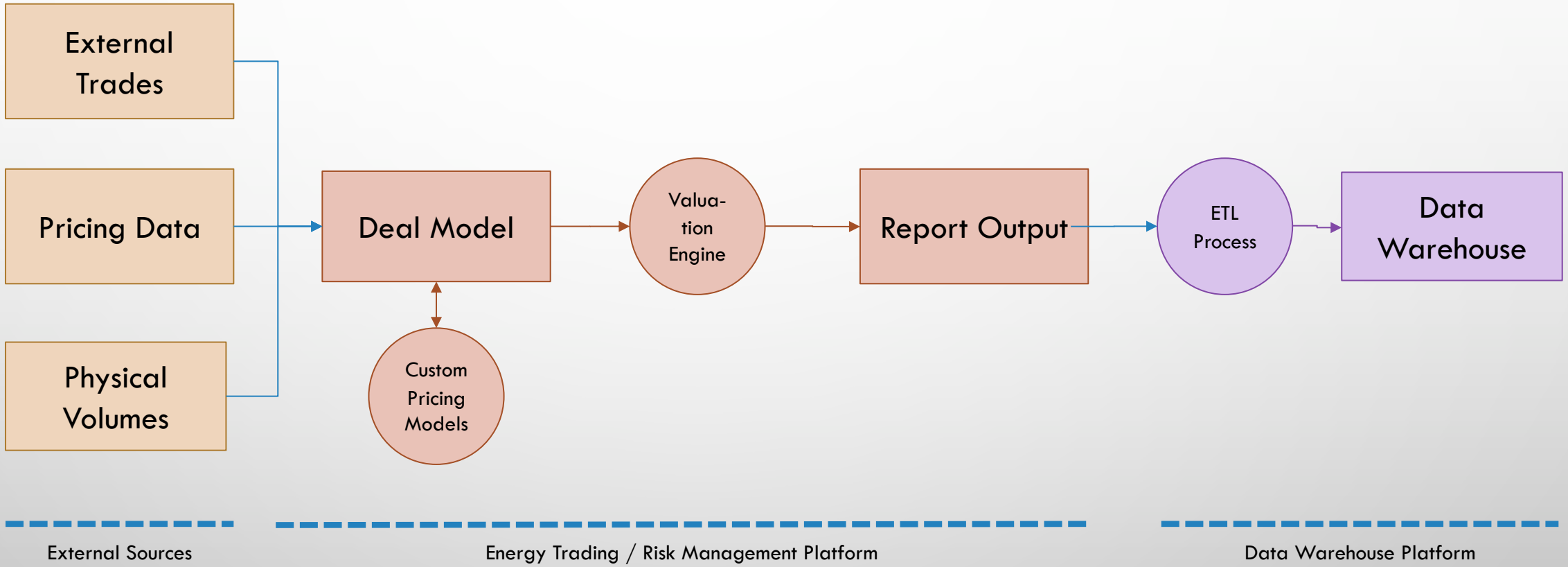
- SAMPLE DAY-AHEAD PRICING
- PUBLISHED IN HOURLY INCREMENTS BY LOCATION
- INCLUDES A DAYLIGHT SAVINGS TIME FLAG TO HANDLE THE TWO ANNUAL TIME CHANGES

DeliveryDate	HourEnding	BusName	LMP	DSTFlag
6/21/22	1:00	CALHOUN_UN1	56.14	N
6/21/22	2:00	CALHOUN_UN1	51.25	N
6/21/22	3:00	CALHOUN_UN1	49.99	N
6/21/22	4:00	CALHOUN_UN1	47.4	N
6/21/22	5:00	CALHOUN_UN1	48.22	N
6/21/22	6:00	CALHOUN_UN1	51.44	N
6/21/22	7:00	CALHOUN_UN1	52.89	N
6/21/22	8:00	CALHOUN_UN1	53.91	N
6/21/22	9:00	CALHOUN_UN1	57.03	N
6/21/22	10:00	CALHOUN_UN1	61.88	N
6/21/22	11:00	CALHOUN_UN1	71.37	N
6/21/22	12:00	CALHOUN_UN1	83.14	N
6/21/22	13:00	CALHOUN_UN1	113.03	N
6/21/22	14:00	CALHOUN_UN1	104.86	N
6/21/22	15:00	CALHOUN_UN1	112.77	N
6/21/22	16:00	CALHOUN_UN1	109.59	N
6/21/22	17:00	CALHOUN_UN1	105.21	N
6/21/22	18:00	CALHOUN_UN1	92.41	N
6/21/22	19:00	CALHOUN_UN1	66.67	N
6/21/22	20:00	CALHOUN_UN1	79.07	N
6/21/22	21:00	CALHOUN_UN1	90.24	N
6/21/22	22:00	CALHOUN_UN1	85.32	N
6/21/22	23:00	CALHOUN_UN1	65.57	N
6/21/22	24:00:00	CALHOUN_UN1	59.82	N

PNL CALCULATION

- DEAL VALUE IS CALCULATED AS MARKETPRICE*VOLUME FOR THE MARKET SIDE OF THE DEAL, OR DEALPRICE*VOLUME FOR THE CASH SIDE OF THE DEAL FOR EACH DELIVERY PERIOD
- IF THE DEAL IS A “BUY”, THE CASH SIDE IS NEGATIVE AND THE MARKET SIDE IS POSITIVE
- IF THE DEAL IS A “SELL”, THE CASH SIDE IS POSITIVE AND THE MARKET SIDE IS NEGATIVE
- THE TOTAL VALUE IS BASED ON THE SUM OF THE VALUE FOR EACH DELIVERY PERIOD
- THE SUMMATION COMPARES THE AGREED-UPON PRICE TO THE FAIR MARKET VALUE; POSITIVE MEANS A PROFIT, NEGATIVE MEANS A LOSS.

PNL CALCULATION DATA FLOW



PNL RESULTS

company	counterparty	buy_sell	delivery_start_time	delivery_end_time	total_volume	settlement_type	location	price	price_band	adder	multiplier	date_time	volume	price_band_1	hour	DeliveryDate	HourEnding	BusName	LMP	DSTFlag	sign	value
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Cash	CALHOUN_UN1	120	Peak	0.01	1	6/21/22 14:00	197	Peak	15	6/21/22	15	CALHOUN_UN1	112.77	N	-1	23641.97
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Cash	CALHOUN_UN1	120	Peak	0.01	1	6/21/22 15:00	303	Peak	16	6/21/22	16	CALHOUN_UN1	109.59	N	-1	36363.03
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Cash	CALHOUN_UN1	120	Peak	0.01	1	6/21/22 16:00	356	Peak	17	6/21/22	17	CALHOUN_UN1	105.21	N	-1	42723.56
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Cash	CALHOUN_UN1	120	Peak	0.01	1	6/21/22 17:00	333	Peak	18	6/21/22	18	CALHOUN_UN1	92.41	N	-1	39963.33
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Cash	CALHOUN_UN1	120	Peak	0.01	1	6/21/22 18:00	244	Peak	19	6/21/22	19	CALHOUN_UN1	66.67	N	-1	29282.44
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Cash	CALHOUN_UN1	120	Peak	0.01	1	6/21/22 5:00	246	Peak	6	6/21/22	6	CALHOUN_UN1	51.44	N	-1	29522.46
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Cash	CALHOUN_UN1	120	Peak	0.01	1	6/21/22 6:00	334	Peak	7	6/21/22	7	CALHOUN_UN1	52.89	N	-1	40083.34
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Cash	CALHOUN_UN1	120	Peak	0.01	1	6/21/22 7:00	356	Peak	8	6/21/22	8	CALHOUN_UN1	53.91	N	-1	42723.56
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Cash	CALHOUN_UN1	120	Peak	0.01	1	6/21/22 8:00	302	Peak	9	6/21/22	9	CALHOUN_UN1	57.03	N	-1	36243.02
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Cash	CALHOUN_UN1	120	Peak	0.01	1	6/21/22 9:00	195	Peak	10	6/21/22	10	CALHOUN_UN1	61.88	N	-1	23401.95
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Market	CALHOUN_UN1	0	Peak	0	1	6/21/22 14:00	197	Peak	15	6/21/22	15	CALHOUN_UN1	112.77	N	1	22215.69
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Market	CALHOUN_UN1	0	Peak	0	1	6/21/22 15:00	303	Peak	16	6/21/22	16	CALHOUN_UN1	109.59	N	1	33205.77
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Market	CALHOUN_UN1	0	Peak	0	1	6/21/22 16:00	356	Peak	17	6/21/22	17	CALHOUN_UN1	105.21	N	1	37454.76
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Market	CALHOUN_UN1	0	Peak	0	1	6/21/22 17:00	333	Peak	18	6/21/22	18	CALHOUN_UN1	92.41	N	1	30772.53
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Market	CALHOUN_UN1	0	Peak	0	1	6/21/22 18:00	244	Peak	19	6/21/22	19	CALHOUN_UN1	66.67	N	1	16267.48
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Market	CALHOUN_UN1	0	Peak	0	1	6/21/22 5:00	246	Peak	6	6/21/22	6	CALHOUN_UN1	51.44	N	1	12654.24
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Market	CALHOUN_UN1	0	Peak	0	1	6/21/22 6:00	334	Peak	7	6/21/22	7	CALHOUN_UN1	52.89	N	1	17665.26
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Market	CALHOUN_UN1	0	Peak	0	1	6/21/22 7:00	356	Peak	8	6/21/22	8	CALHOUN_UN1	53.91	N	1	19191.96
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Market	CALHOUN_UN1	0	Peak	0	1	6/21/22 8:00	302	Peak	9	6/21/22	9	CALHOUN_UN1	57.03	N	1	17223.06
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Market	CALHOUN_UN1	0	Peak	0	1	6/21/22 9:00	195	Peak	10	6/21/22	10	CALHOUN_UN1	61.88	N	1	12066.6
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Cash	CALHOUN_UN1	40	Off-Peak	0.01	1	6/21/22 0:00	145	Off-Peak	1	6/21/22	1	CALHOUN_UN1	56.14	N	-1	5801.45
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Cash	CALHOUN_UN1	40	Off-Peak	0.01	1	6/21/22 10:00	82	Off-Peak	11	6/21/22	11	CALHOUN_UN1	71.37	N	-1	3280.82
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Cash	CALHOUN_UN1	40	Off-Peak	0.01	1	6/21/22 11:00	10	Off-Peak	12	6/21/22	12	CALHOUN_UN1	83.14	N	-1	400.1
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Cash	CALHOUN_UN1	40	Off-Peak	0.01	1	6/21/22 12:00	10	Off-Peak	13	6/21/22	13	CALHOUN_UN1	113.03	N	-1	400.1
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Cash	CALHOUN_UN1	40	Off-Peak	0.01	1	6/21/22 13:00	83	Off-Peak	14	6/21/22	14	CALHOUN_UN1	104.86	N	-1	3320.83
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Cash	CALHOUN_UN1	40	Off-Peak	0.01	1	6/21/22 19:00	127	Off-Peak	20	6/21/22	20	CALHOUN_UN1	79.07	N	-1	5081.27
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Cash	CALHOUN_UN1	40	Off-Peak	0.01	1	6/21/22 1:00	43	Off-Peak	2	6/21/22	2	CALHOUN_UN1	51.25	N	-1	1720.43
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Cash	CALHOUN_UN1	40	Off-Peak	0.01	1	6/21/22 20:00	32	Off-Peak	21	6/21/22	21	CALHOUN_UN1	90.24	N	-1	1280.32
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Cash	CALHOUN_UN1	40	Off-Peak	0.01	1	6/21/22 21:00	0	Off-Peak	22	6/21/22	22	CALHOUN_UN1	85.32	N	-1	0
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Cash	CALHOUN_UN1	40	Off-Peak	0.01	1	6/21/22 22:00	45	Off-Peak	23	6/21/22	23	CALHOUN_UN1	65.57	N	-1	1800.45
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Cash	CALHOUN_UN1	40	Off-Peak	0.01	1	6/21/22 23:00	146	Off-Peak	24	6/21/22	24	CALHOUN_UN1	59.82	N	-1	5841.46
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Cash	CALHOUN_UN1	40	Off-Peak	0.01	1	6/21/22 2:00	0	Off-Peak	3	6/21/22	3	CALHOUN_UN1	49.99	N	-1	0
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Cash	CALHOUN_UN1	40	Off-Peak	0.01	1	6/21/22 3:00	33	Off-Peak	4	6/21/22	4	CALHOUN_UN1	47.4	N	-1	1320.33
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Cash	CALHOUN_UN1	40	Off-Peak	0.01	1	6/21/22 4:00	129	Off-Peak	5	6/21/22	5	CALHOUN_UN1	48.22	N	-1	5161.29
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Market	CALHOUN_UN1	0	Off-Peak		1	6/21/22 0:00	145	Off-Peak	1	6/21/22	1	CALHOUN_UN1	56.14	N	1	8140.3
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Market	CALHOUN_UN1	0	Off-Peak		1	6/21/22 10:00	82	Off-Peak	11	6/21/22	11	CALHOUN_UN1	71.37	N	1	5852.34
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Market	CALHOUN_UN1	0	Off-Peak		1	6/21/22 11:00	10	Off-Peak	12	6/21/22	12	CALHOUN_UN1	83.14	N	1	831.4
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Market	CALHOUN_UN1	0	Off-Peak		1	6/21/22 12:00	10	Off-Peak	13	6/21/22	13	CALHOUN_UN1	113.03	N	1	1130.3
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Market	CALHOUN_UN1	0	Off-Peak		1	6/21/22 13:00	83	Off-Peak	14	6/21/22	14	CALHOUN_UN1	104.86	N	1	8703.38
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Market	CALHOUN_UN1	0	Off-Peak		1	6/21/22 19:00	127	Off-Peak	20	6/21/22	20	CALHOUN_UN1	79.07	N	1	10041.89
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Market	CALHOUN_UN1	0	Off-Peak		1	6/21/22 1:00	43	Off-Peak	2	6/21/22	2	CALHOUN_UN1	51.25	N	1	2203.75
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Market	CALHOUN_UN1	0	Off-Peak		1	6/21/22 20:00	32	Off-Peak	21	6/21/22	21	CALHOUN_UN1	90.24	N	1	2887.68
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Market	CALHOUN_UN1	0	Off-Peak		1	6/21/22 21:00	0	Off-Peak	22	6/21/22	22	CALHOUN_UN1	85.32	N	1	0
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Market	CALHOUN_UN1	0	Off-Peak		1	6/21/22 22:00	45	Off-Peak	23	6/21/22	23	CALHOUN_UN1	65.57	N	1	2950.65
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Market	CALHOUN_UN1	0	Off-Peak		1	6/21/22 23:00	146	Off-Peak	24	6/21/22	24	CALHOUN_UN1	59.82	N	1	8733.72
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Market	CALHOUN_UN1	0	Off-Peak		1	6/21/22 2:00	0	Off-Peak	3	6/21/22	3	CALHOUN_UN1	49.99	N	1	0
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Market	CALHOUN_UN1	0	Off-Peak		1	6/21/22 3:00	33	Off-Peak	4	6/21/22	4	CALHOUN_UN1	47.4	N	1	1564.2
CheapPower.com	Windy Hill Wind Farm	Buy	6/1/22	6/30/22	90000	Market	CALHOUN_UN1	0	Off-Peak		1	6/21/22 4:00	129	Off-Peak	5	6/21/22	5	CALHOUN_UN1	48.22	N	1	6220.38
																						$ 657,334.85

DATA OBSERVATIONS

- VALUATION IS COMPLETED ON A DAILY BASIS
- A SINGLE HOURLY DEAL WITH A 1 MONTH TENOR WOULD GENERATE AT LEAST 1008 RECORDS PER DAY.
- A TYPICAL MARKETER COULD HAVE 50,000 OR MORE ACTIVE DEALS, ALL WITH VARYING DEGREES OF GRANULARITY AND TENOR
- USERS TEND TO QUERY THE DATA ON A DAILY BASIS
- USUALLY USERS CANNOT COMPROMISE ON DETAIL

COMPUTE CONSIDERATIONS

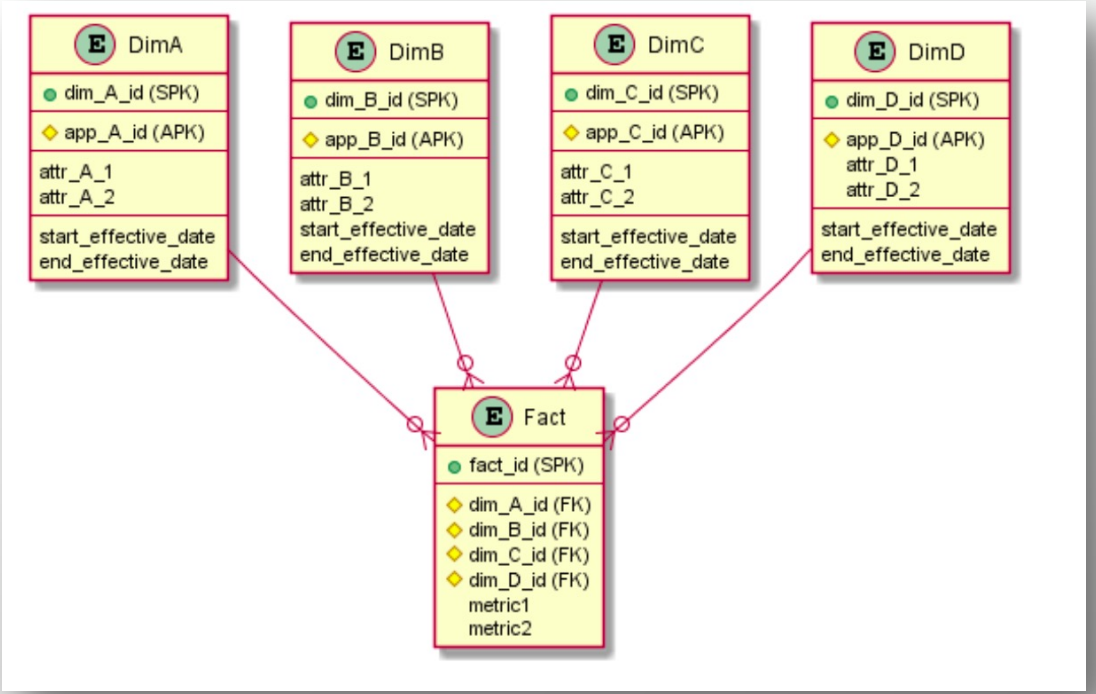
- EACH DEAL SIDE AND DELIVERY VOLUME IS ATOMIC; IT CAN BE COMPUTED IN ISOLATE
- EXISTING COMMERCIAL APPLICATIONS PROCESS COMMODITY DEALS IN PARALLEL
- NOTE THAT THE PRICING MODEL IN THIS EXAMPLE IS SIMPLE SCALAR MULTIPLICATION. ACTUAL PRICING WOULD ALSO ACCOUNT FOR DISCOUNTING AND/OR USE FORMULA OR DERIVATIVE PRICING MODELS, THEREBY INCREASING THE COMPUTE LOAD
- A BESPOKE WAY TO ADDRESS THE COMPUTE BURDEN WOULD BE TO APPLY A MAP-REDUCE ALGORITHM
- MAP ALL THE DEAL SIDES BY PRICING TYPE AND LOCATION & COMPUTE THE VALUE
- THE REDUCE STEP DOES NOT ELIMINATE ANY DATA BUT ONLY COMBINES THE RESULTS

STORAGE CONSIDERATIONS

- GIVEN THAT
  - THE DATA FOOTPRINT IS LARGE
  - USERS CANNOT SACRIFICE DETAIL
  - USERS EXPECT GOOD QUERY PERFORMANCE
- THE DATA STORAGE LAYER MUST HAVE A GOOD COST-PERFORMANCE BALANCE
- THE DATA PHYSICAL LAYER IS TYPICALLY PARTITIONED AND COMPRESSED TO PROVIDE REASONABLE QUERY RESPONSE TIMES WHILE OCCUPYING THE MINIMUM AMOUNT OF SPACE
- CLOUD COSTS ARE TRENDING DOWNWARD AND MAY OFFER VIABLE ALTERNATIVES TO HOSTING HARDWARE AND HIRING STAFF

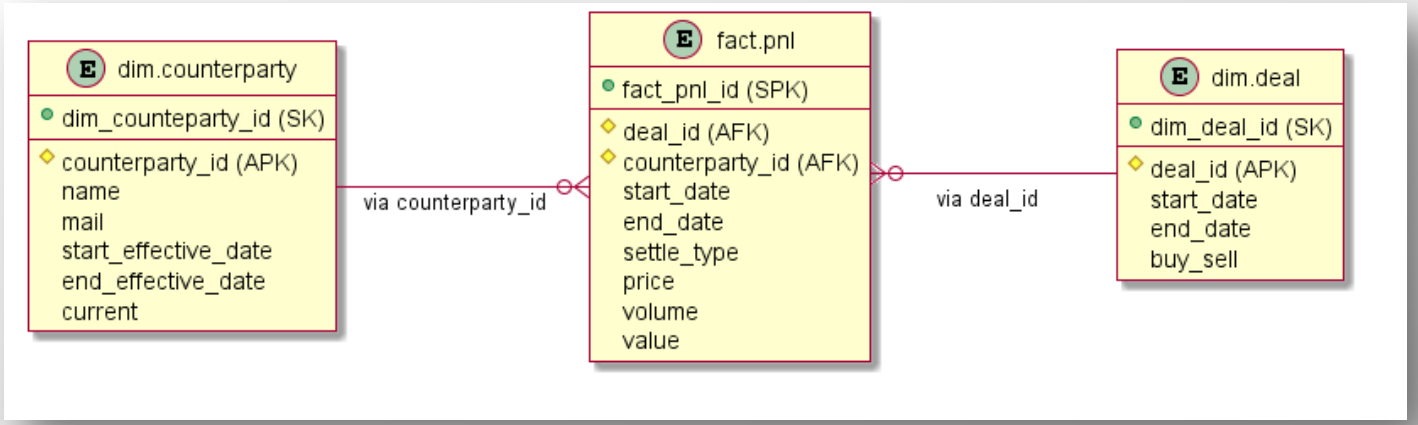
TRADITIONAL DATA WAREHOUSE DESIGN

- A ”KIMBAL” DESIGN SEPARATES REFERENCE DATA AND METRICS INTO DIMENSIONS AND FACTS RESPECTIVELY
- APPROACH REQUIRES
  - REFERENCE DATA TO BE LOADED FIRST,
  - OBTAIN WAREHOUSE-SPECIFIC KEYS,
  - LOAD THE METRICS AS FACT DATA,
  - THEN RE-REFERENCE THE FACT DATA USING WAREHOUSE SPECIFIC KEYS
- THIS DESIGN OPTIMIZES FOR STORAGE AND QUERYING REFERENCE DATA TO PARE DOWN FACT DATA



ALTERNATIVE DATA WAREHOUSE DESIGN

- AN ALTERNATIVE DESIGN KEEPS THE APPLICATION PRIMARY KEYS WITH THE DATA
- FACT DATA IS AVAILABLE AS SOON AS IT IS LOADED; NO NEED FOR A TWO STEP PROCESS
- HAS REDUCED LOADING TIME BY 9X IN PRACTICE
- DATA STRUCTURE TREATS DENORMALIZATION AS A"FIRST CLASS" APPROACH
- DESIGN COMPATIBLE WITH RELATIONAL AND NO-SQL TECHNOLOGY STACKS



DATA WAREHOUSE TECHNOLOGY STACKS

	ETL Tool	Storage	Visualization and Reporting
On-Prem	SSIS, BCP, SQL*Loader, Bespoke	SQL Server, Oracle	Excel, Tableau, PowerBI
AWS	S3, AWS Glue	Redshift, Snowflake	PowerBI, Tableau
Azure	Azure Data Bricks	SQL Server for Azure, Synapse Analytics	PowerBI, Tableau

OTHER TYPES OF REPORTING

- EXPOSURE REPORTING - DISCOUNT-ADJUSTED VOLUMES ASSOCIATED WITH MARKET LOCATIONS
- PNL EXPLAINED – DETAILED REPORT THAT SHOWS INDIVIDUAL CONTRIBUTIONS OF EACH FACTOR THAT AFFECT VALUE FROM ONE DAY TO THE NEXT
- MARKET RISK – CALCULATES AT-RISK VALUE DUE TO CHANGES IN MARKET PRICES
- CREDIT RISK – CALCULATES AT-RISK VALUE DUE TO COUNTERPARTY CREDIT-WORTHINESS

CHALLENGES AND OPPORTUNITIES

WIND CHALLENGES

- GENERATION CAPACITY DEPENDENT UPON WEATHER
- LIMITED NEGATIVE CORRELATION BETWEEN CAPACITY IN DEMAND – FOR EXAMPLE
  - DEMAND IS HIGH IN THE SUMMER
  - SUMMER TEMPERATURES ARE OFTEN ASSOCIATED WITH HIGH PRESSURE
  - HIGH PRESSURE SYSTEMS HAVE LOWER WIND VELOCITY COMPARED TO LOW PRESSURE SYSTEMS
  - LOWER WIND VELOCITY = LOWER GENERATION CAPACITY
- UNLIKE TRADITIONAL BASE LOAD SYSTEMS, WIND FLUCTUATES ABOVE AND BELOW NOMINAL OUTPUT
- WHEN OUTPUT IS LESS THAN DEMAND, MARKETERS MUST MAKE UP THE SHORTFALL BY BUYING POWER FROM PEAKER PRODUCERS
- WHEN OUTPUT IS MORE THAN DEMAND, MARKETERS FACE CONGESTION CHARGES

WIND BREAK-EVEN CHALLENGES

- COMMERCIAL WIND TURBINES GENERATE BETWEEN 2 AND 3 MEGAWATTS (MW), COSTING FROM $1MM TO $4MM
- WIND TURBINES EARN ABOUT $5000 PER MW PER YEAR
- IT TAKES ABOUT 10 TO 15 YEARS TO BREAK EVEN
- MOST TURBINES LAST ABOUT 25 YEARS
- CHALLENGE IS TO LOWER THE COST OF A TURBINE, IMPROVE THE EFFICIENCY, AND EXTEND THE PROFITABLE LIFE

MARKET CHALLENGES

- DURING THE FREEZE OF 2021:
- WIND TURBINES FROZE
- POWER PLANTS FAILED
- ERCOT WHOLESALE PRICES WENT THRU THE ROOF, UP TO $9000 PER MWH
- GRIDDY CUSTOMERS SAW $20K ELECTRIC BILLS.
- FIXED RATE RETAIL CUSTOMERS DIDN'T PAY ANYTHING ADDITIONAL
- THE CIRCUMSTANCE WAS A PERFECT STORM OF ENVIRONMENTAL AND MARKET VULNERABILITIES

WIND PRICING CHALLENGES

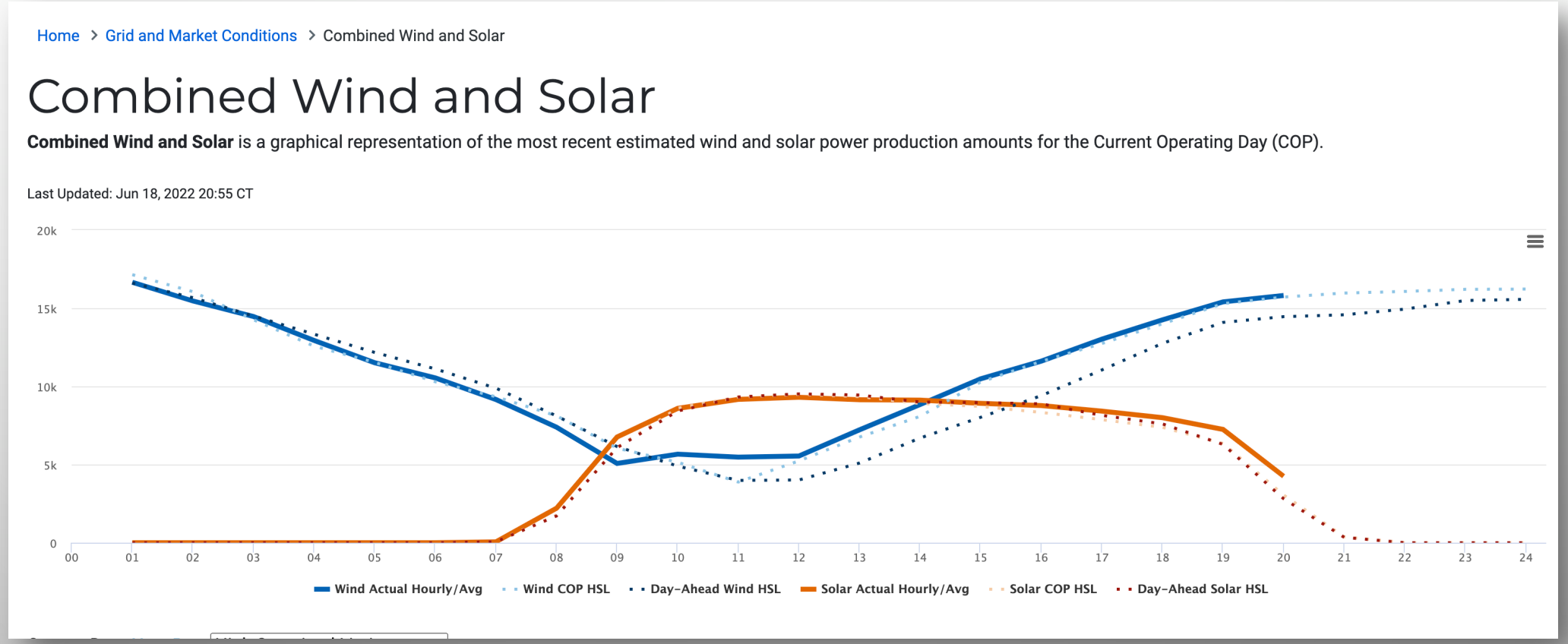
- THE PRICE OFTEN GOES NEGATIVE- DUE TO LOW DEMAND AND CONGESTION
- EXAMPLE BELOW SHOWS TEXAS PANHANDLE PRICE GO NEGATIVE AROUND MIDNIGHT

Operating Day: 06/18/2022

Oper Day	Interval Ending	HB_BUSAVG	HB_HOUSTON	HB_HUBAVG	HB_NORTH	HB_PAN	HB_SOUTH	HB_WEST	LZ_AEN	LZ_CPS	LZ_
06/18/2022	0015	52.87	52.87	52.87	52.87	-0.93	52.87	52.87	52.87	52.87	
06/18/2022	0030	63.62	63.62	63.62	63.62	0.05	63.62	63.62	63.62	63.62	
06/18/2022	0045	61.97	61.97	61.97	61.97	-0.10	61.97	61.97	61.97	61.97	
06/18/2022	0100	58.86	58.86	58.86	58.86	1.55	58.86	58.86	58.86	58.86	
06/18/2022	0115	51.71	51.71	51.71	51.71	18.80	51.71	51.71	51.71	51.71	
06/18/2022	0130	52.25	52.25	52.25	52.25	52.25	52.25	52.25	52.25	52.25	
06/18/2022	0145	54.47	54.47	54.47	54.47	54.47	54.47	54.47	54.47	54.47	
06/18/2022	0200	56.01	56.01	56.01	56.01	56.01	56.01	56.01	56.01	56.01	
06/18/2022	0215	52.49	52.49	52.49	52.49	52.49	52.49	52.49	52.49	52.49	
06/18/2022	0230	53.40	53.40	53.40	53.40	53.40	53.40	53.40	53.40	53.40	
06/18/2022	0245	53.71	53.71	53.71	53.71	53.71	53.71	53.71	53.71	53.71	
06/18/2022	0300	51.90	51.90	51.90	51.90	51.90	51.90	51.90	51.90	51.90	
06/18/2022	0315	53.12	53.12	53.12	53.12	53.12	53.12	53.12	53.12	53.12	
06/18/2022	0330	52.97	52.97	52.97	52.97	52.97	52.97	52.97	52.97	52.97	
06/18/2022	0345	53.07	53.07	53.07	53.07	53.07	53.07	53.07	53.07	53.07	

WIND PRODUCTION CHALLENGES

- WIND GENERATES MOST WHEN DEMAND IS LOWEST



CARBON NEUTRAL OPPORTUNITIES

- RENEWABLE ENERGY CERTIFICATES (ALSO KNOWN AS RENEWABLE ENERGY CREDITS, OR RECS) REPRESENT THE ENERGY GENERATED BY RENEWABLE ENERGY SOURCES, SUCH AS SOLAR OR WIND POWER FACILITIES.
- A REC IS PRODUCED WHEN A RENEWABLE ENERGY SOURCE GENERATES ONE MEGAWATT-HOUR (MWH) OF ELECTRICITY AND DELIVERS IT TO THE GRID.
- RECS PROVIDES CERTIFIED PROOF A BUSINESS IS USING RENEWABLE ENERGY
- HELPS CREATE DEMAND FOR RENEWABLE SOURCES
- CREATES MARKET OPPORTUNITY FOR RENEWABLE GENERATORS

DATA SCIENCE OPPORTUNITIES

- IMPROVE POWER GENERATION TYPE COMBINATIONS
- SINCE DEMAND AND PRICING ARE DERIVED FROM ALMOST SAME FACTORS, LOOK FOR LEADING INDICATORS THAT CORRELATE TO CURRENT LOAD FACTORS
- INVENT NEW WAYS TO VIEW AND ACT ON ECONOMIC PERFORMANCE DATA
- LOOK FOR WAYS TO BETTER MANAGE AND HEDGE RISK (PRICE, LOAD, WEATHER)
- ELECTRICITY STORAGE – INVENT NOVEL VALUATION MODELS TO OPTIMIZE POWER STORAGE ECONOMICS

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