Multi-Value Transmission Planning for a Clean Energy Future

Derek Stenclik
Ryan Deyoe
TELOS ENERGY
ESIG
ENERGY SYSTEMS INTEGRATION GROUP

May 2022

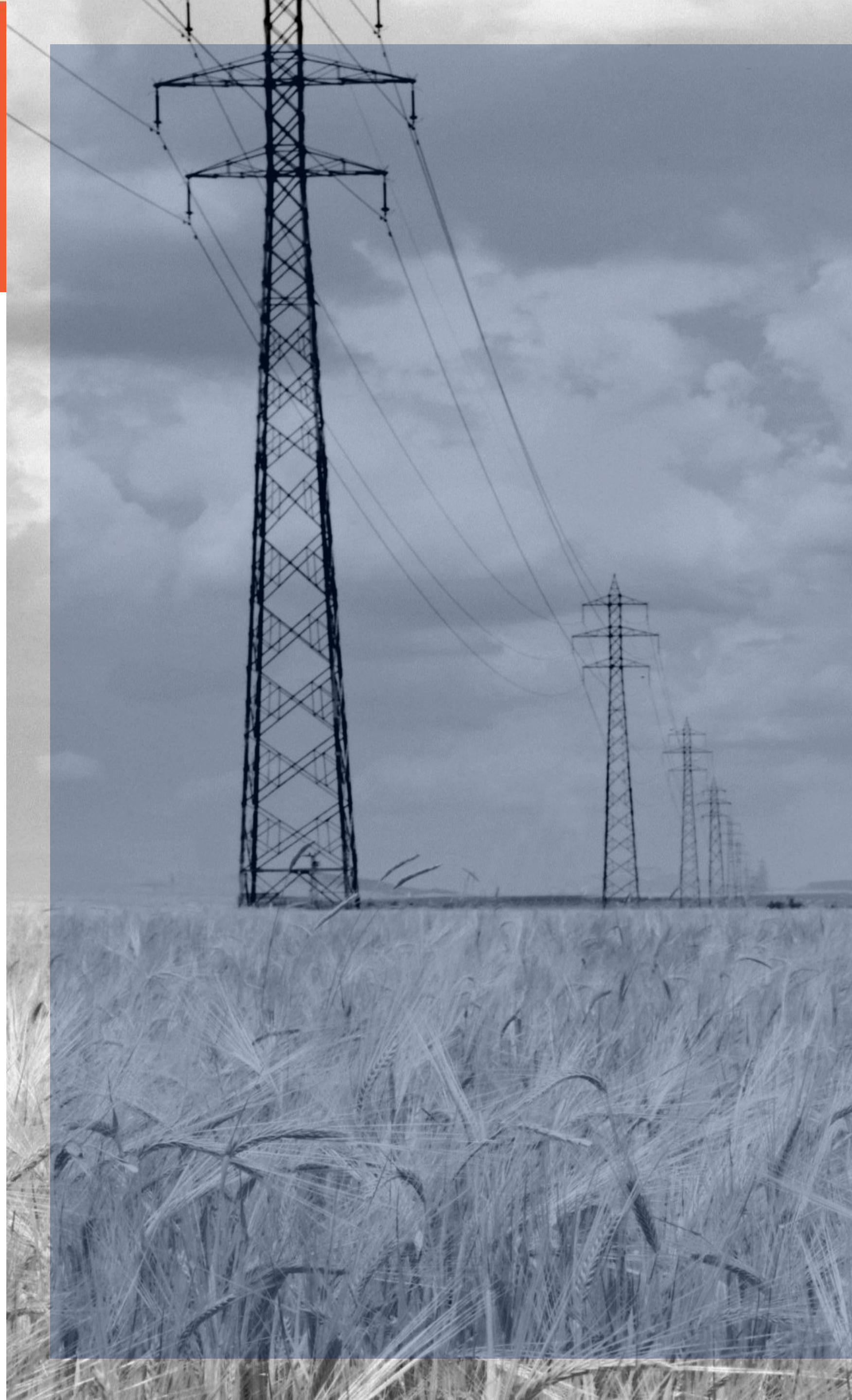
Four barriers to transmission planning for a clean energy future

A series of interviews with ESIG members and transmission planners highlighted four key barriers to transmission planning:

Focus of today

1. Focus on local reliability rather than regional economic efficiency, leaving value on the table
2. Interconnection queues favor short-term network upgrades rather than proactive planning
3. Lack of interregional planning and interstate coordination
4. Cost allocation is difficult, controversial and political

The transition to a high-renewables grid means that our conventional ways of planning transmission needs to be modified



Going beyond production cost savings

ESIG

Today's approach…

- Most economic transmission projects are evaluated based solely on production cost savings
- Only 10% of transmission is built based on economic planning
- As we integrate more wind and solar, production costs go down and transmission benefits erode, but the need only increases
- Exposes customers to long-term costs

Tomorrow's need…

- Multi-value benefits approach incorporates **risk**, **resource adequacy**, and **resiliency**
- Recognizes transmission as an insurance policy to future uncertainty
- **Invests in enabling infrastructure for the clean energy transition, rather than generating capacity (future stranded assets)**

Implementing a multi-value framework for valuing transmission upgrades:

Reframing Transmission Valuation Methods: ERCOT Case Study

Objective:

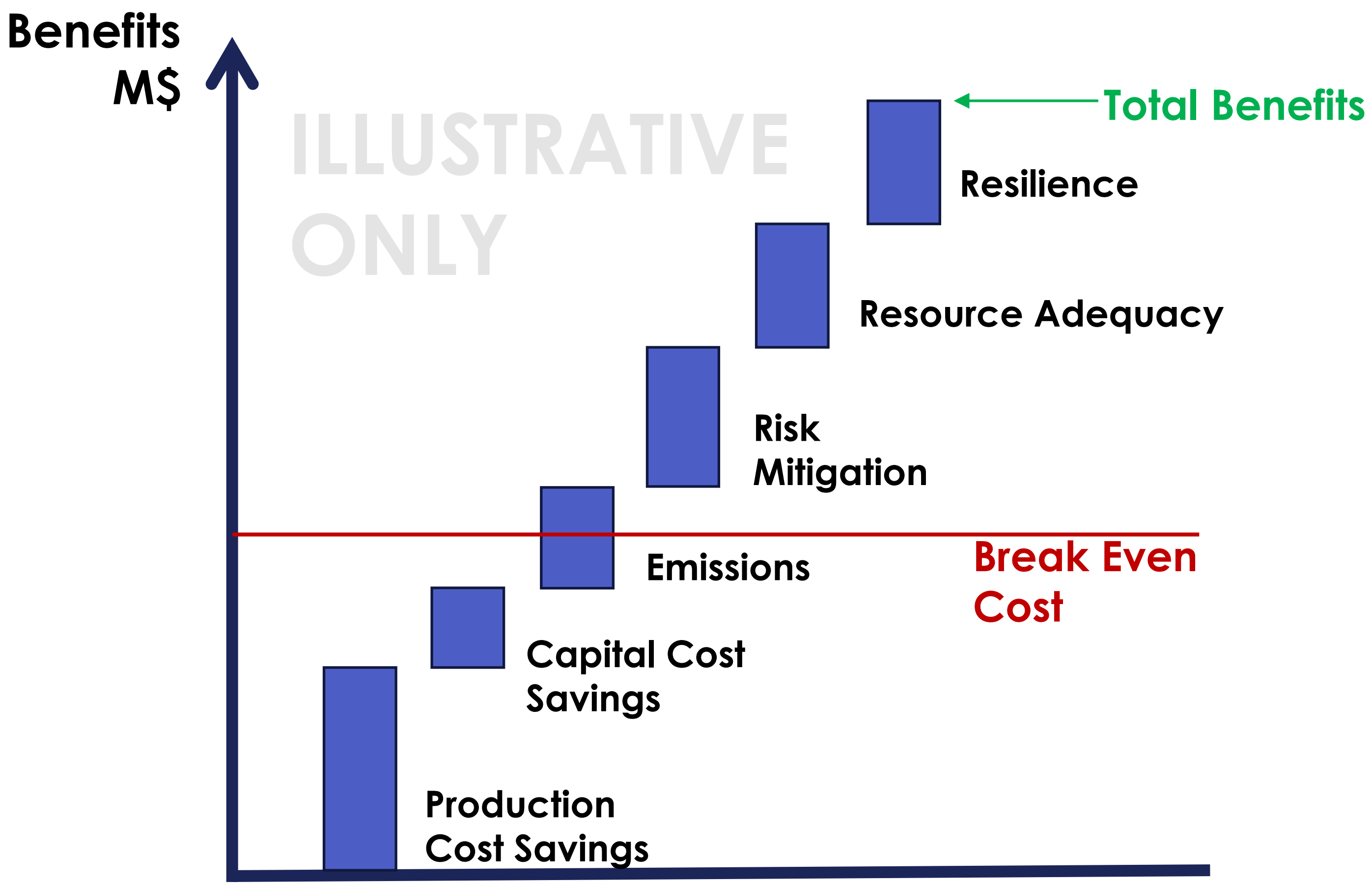
- Revitalize multi-value transmission planning
- Provide a playbook for transmission planners
- Simplify the message for key industry stakeholders
- Influence FERC NOPR and efforts at ISOs/RTOs

How:

Use the ERCOT West Texas Export and interregional transmission as a *case study* to illustrate the benefits of a multi-value framework

1. Production cost savings
2. Capital cost savings
3. Emissions benefits
4. Risk Mitigation
5. Resource Adequacy
6. Resilience

Our processes need to incorporate a value stacking & prioritization of benefits



- Transmission benefits are much broader than production cost savings, despite planning process in most regions
- Multi-value frameworks are not uniform, different transmission will have different benefits
- Early identification and prioritization of benefits in the transmission planning process is important

The FERC NOPR is a step forward for transmission planning

Key Topics of the FERC NOPR

III. Need for reform

IV. Regional Transmission Planning

- Scenario requirements (20-year horizon, multiple scenarios, geographic zones)
- Coordination with interconnection queue
- Multi-benefit approach (see right)
- Portfolio planning approach

V. Cost Allocation

IX. Interregional Coordination

FERC NOPR Multi-benefits proposals

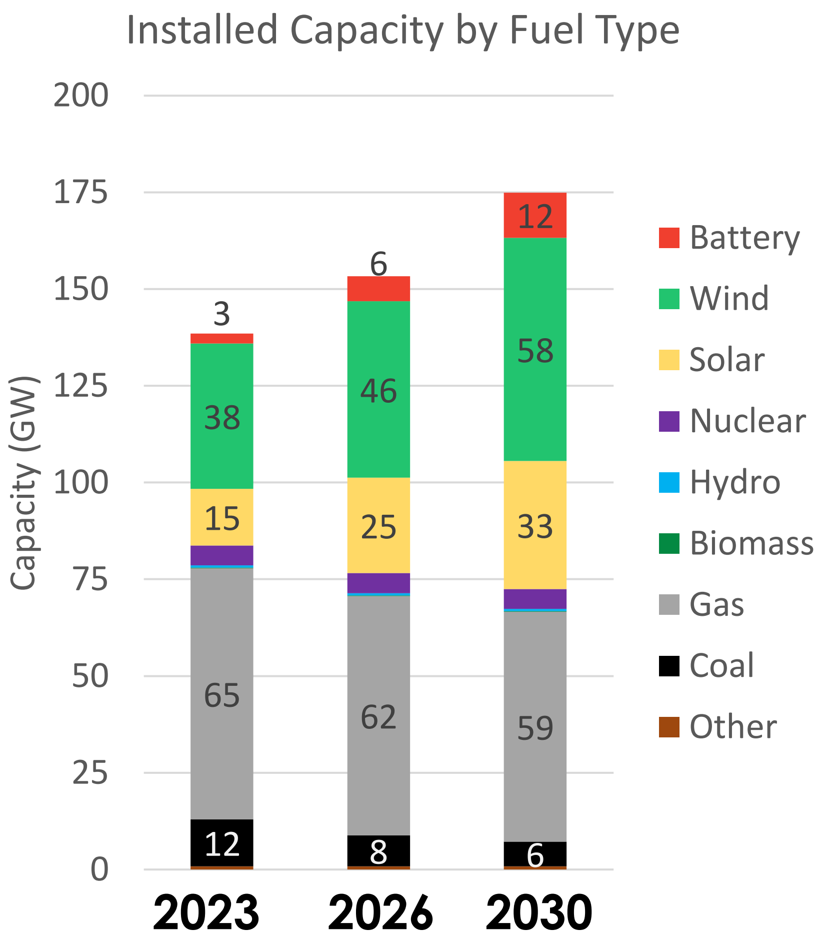
Avoided costs are permissible

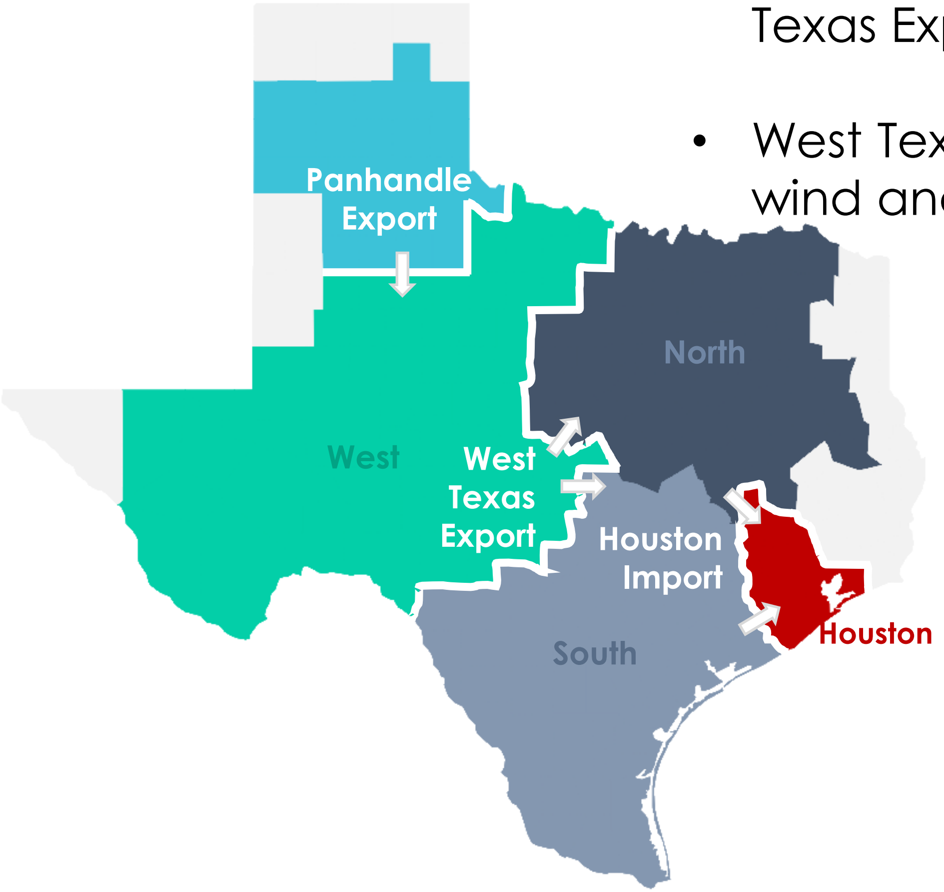
1. **Avoided thermal reliability upgrades**
2. **Reduced loss of load events (RA)**
3. **Adjusted production cost savings or adjusted load payments**
4. Reduced losses
5. Reduced congestion due to transmission outages
6. **Mitigation of extreme events and system contingencies**
7. **Mitigation of weather and load uncertainty**
8. Reduced peak energy losses,
9. **Deferred generation capacity investments**
10. **Access to lower-cost generation**
11. Increased competition
12. Market liquidity

*bolded benefits represent ones calculated in our study

West Texas Export Case Study

Why an ERCOT Case Study?

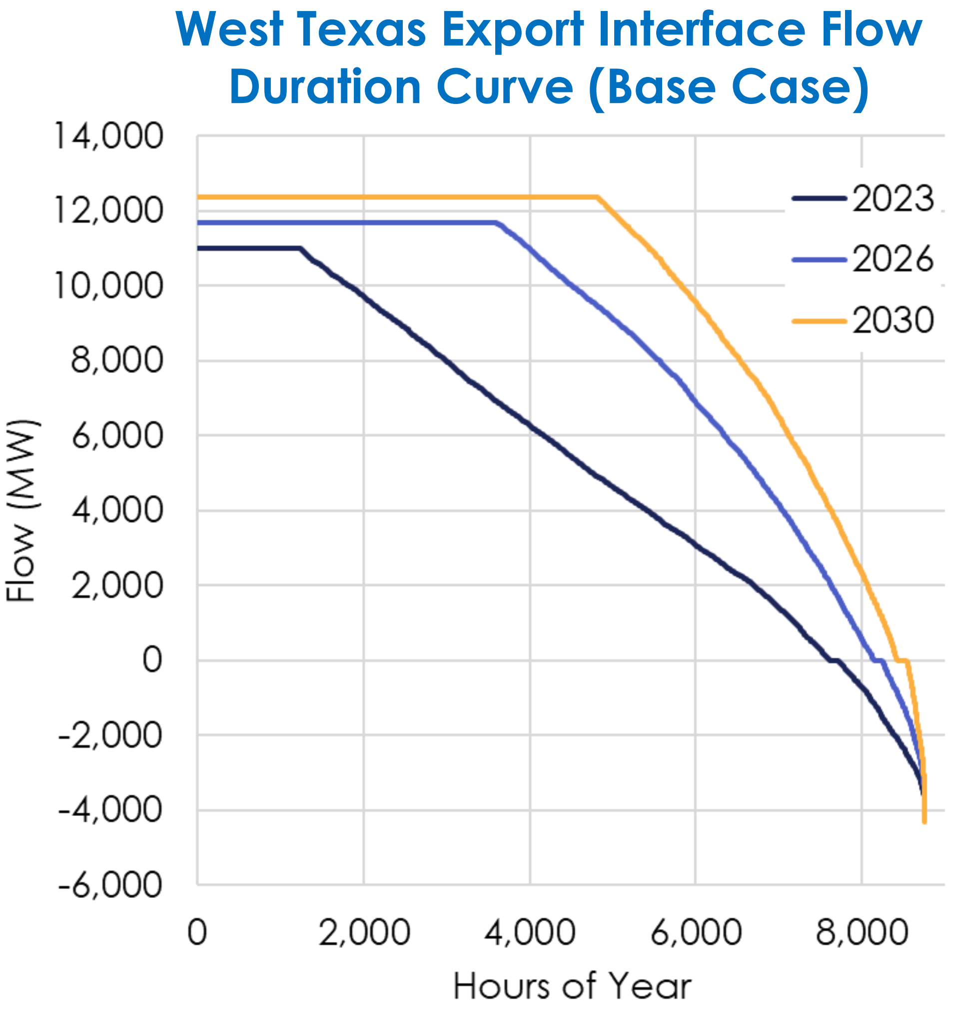




- 77% of all Texas wind and solar capacity is behind the West Texas Export.
- West Texas GTC threatens future wind and solar deployment
  - Developers are already shifting projects East
  - Previous transmission planning could only consider production cost savings, but new legislation is allowing broader benefits

ERCOT West Texas studies assume 39.5 GW of new capacity, 73% in West Texas

Without transmission expansion, West Texas Export will become severely constrained

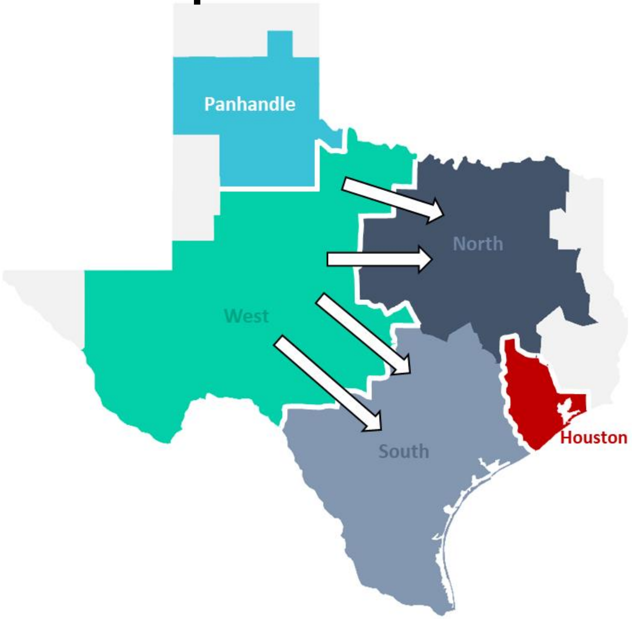


West Texas Interface Results	Unit	2023	2026	2030
Export Limit*	MW	11,016	11,670	12,375
Hours Congested	Hrs	1,223	3,606	4,815
Hours Congested	%	14	41	55
Loading	%	51	71	79
Congestion Rent	M$	257	838	1,356
Shadow Price	$/MWh	2.67	8.20	12.51
Curtailment	%	3%	14%	29%

West Texas Transmission Upgrade Options

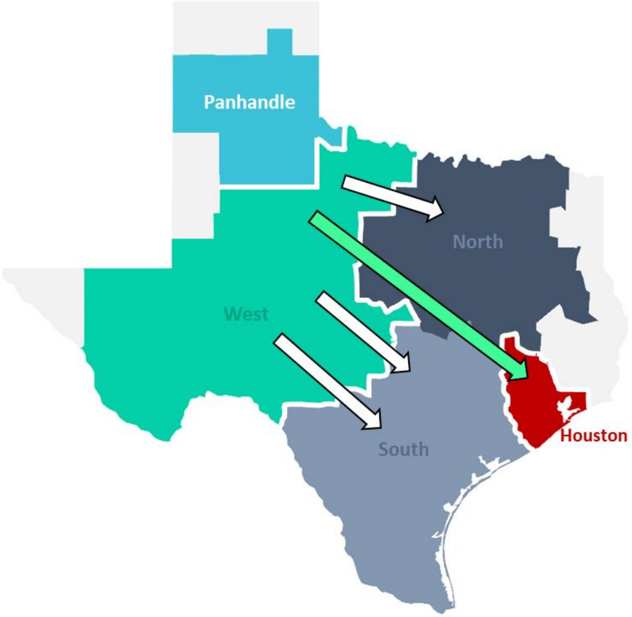
- Considered two transmission upgrade options proposed by ERCOT[1]
- Option 2, with HVDC direct to load center has the potential to avoid downstream congestion and increase resource adequacy benefits
- Transmission upgrades would increase the 2030 limit from 12.3 GW to 16.5 – 17 GW

Option 1: 4 AC



- Four 345 kV lines totaling ~1,027 miles from West to East
- Total Cost: ~$2.9 Billion
- **Annualized Cost: $312 M$/year**

Option 2: 3 AC, 1 DC

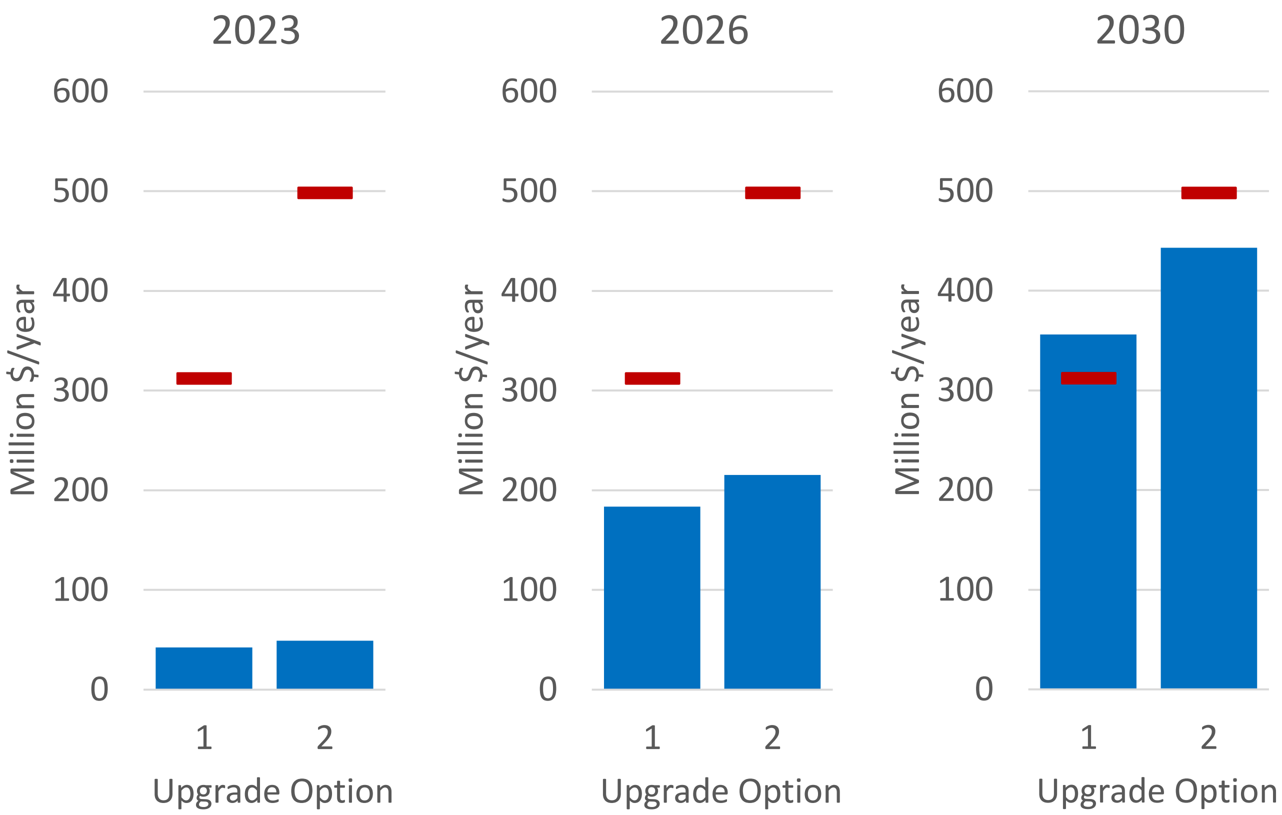


- Three 345 kV lines totaling ~721 miles from West to East
- One 545-mile 500 kV VSC-HVDC line from West to Houston
- Total Cost: ~$4.7 Billion
- **Annualized Cost: $498 M$/year**

[1]Source: J. Haesler, *Long-Term West Texas Export Special Study*, ESIG 2021 Fall Workshop

Production costs alone do not show all the benefits of transmission

Annualized Costs and Benefits of Transmission Upgrades



- Long-term planning horizons are needed for long-term investments
- Production cost benefits alone may not justify new transmission investments
- Increased renewables reduce total production cost benefits, squeezing traditional value from transmission, despite growing need
- Need to evaluate additional benefits to accurately reflect transmission value

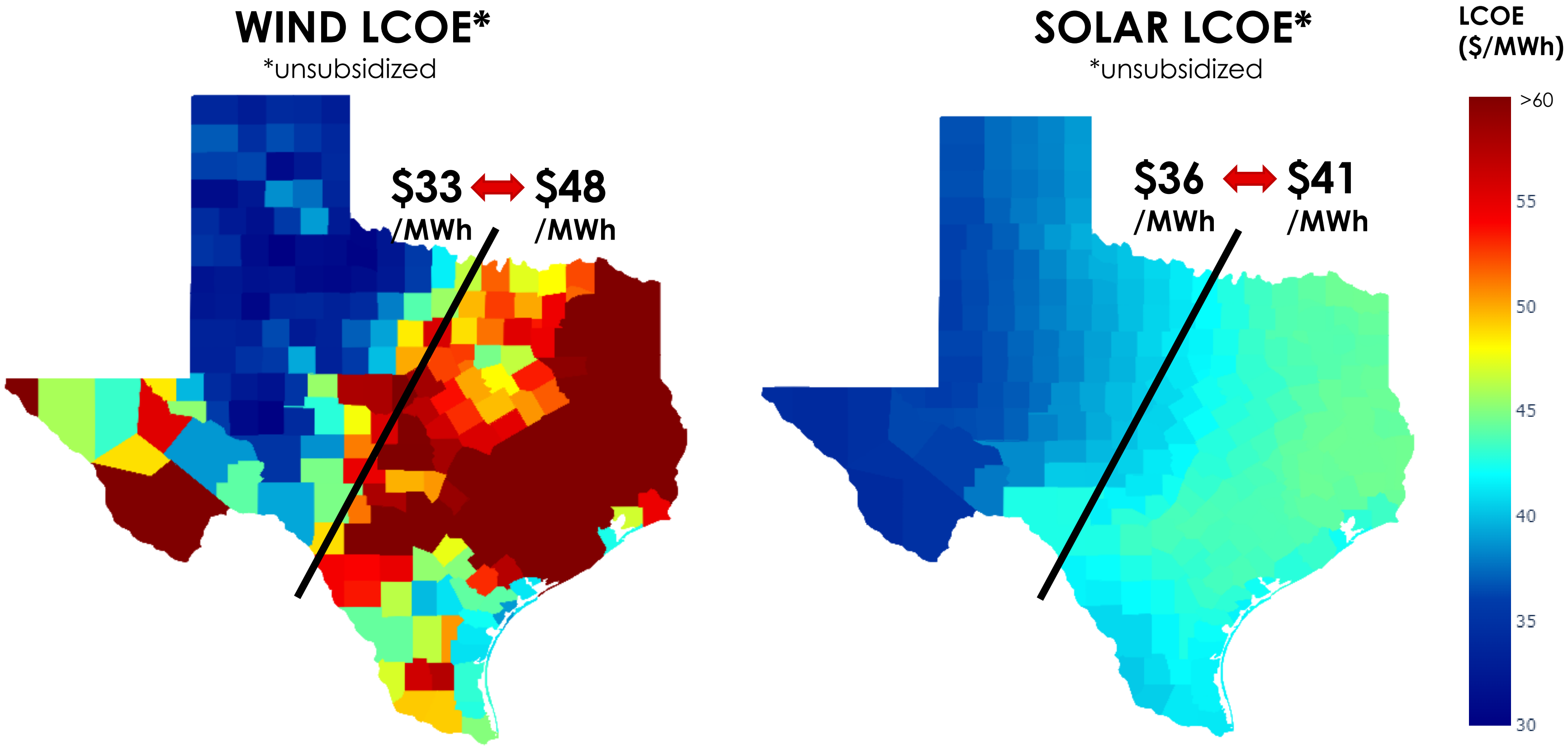
Emissions Benefits

	CO_2			SO_X	NO_X			
Upgrade Option	**$15/metric ton CO_2 (k$)**	**$25/metric ton CO2 (k$)**	**$35/metric ton CO2 (k$)**	**CSAPR SOX Group 2 (k$)**	**NOX Annual (k$)**	**NOX Ozone Seasonal (k$)**	**TCEQ NOX (k$)**	**Total Emissions Benefit ($000)**
Option 1 (4AC)	112,886	188,143	263,400	7	9	77	28	**188,264**
Option 2 (3AC + 1 HVDC)	116,580	194,301	272,021	4	8	92	10,897	**205,302**

- Reducing harmful pollutants improves health and reduces risk associated with potential future environmental policies
- The upgrades bring greater amounts of zero emission fuel resources to ERCOT load centers, providing for substantial CO2 benefits
- Delivering energy directly to load centers can mitigate harmful pollutants in congested areas that have higher pollution impacts

Reduced Capital Cost Benefits

How do we capture the benefits of accessing lower cost resources?



Assumptions:

Absent new transmission, renewables would shift east

33% of additions 2023-2026

66% of additions 2026-2030

13.5 GW of capacity shifted east by 2030…*energy is unchanged*

To get the same amount of energy from higher cost resources (lower resource, higher land cost, etc.)

Benefits

$179 million in 2026

$493 million in 2030

Who gets this benefit?

Source: The Energy Institute at The University of Texas at Austin, *Levelized Cost of Electricity in the United States by County*, version 1.4.0, https://calculators.energy.utexas.edu/lcoe_map/#/county/tech

Transmission may be a no-regrets investment when you look across a range of futures

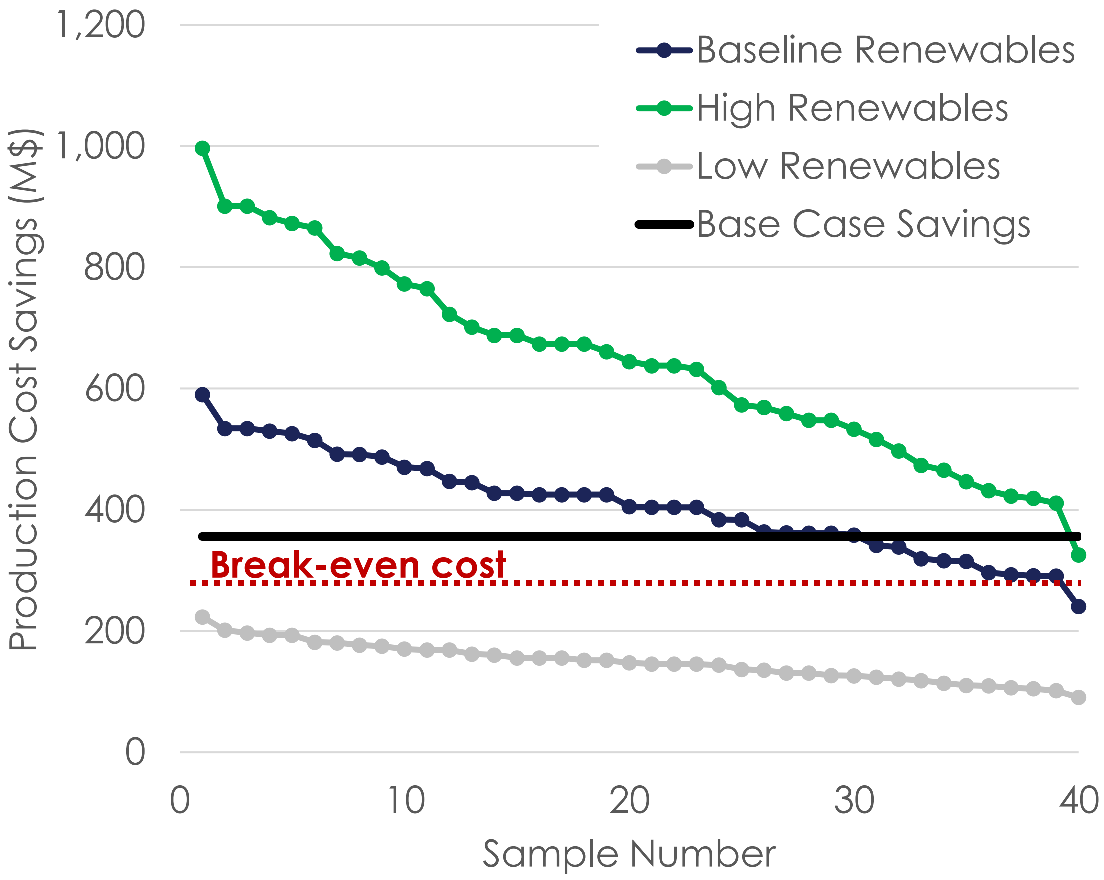
3 Renewable and Retirement Levels

x40 Stochastic Gas Price & Load Levels

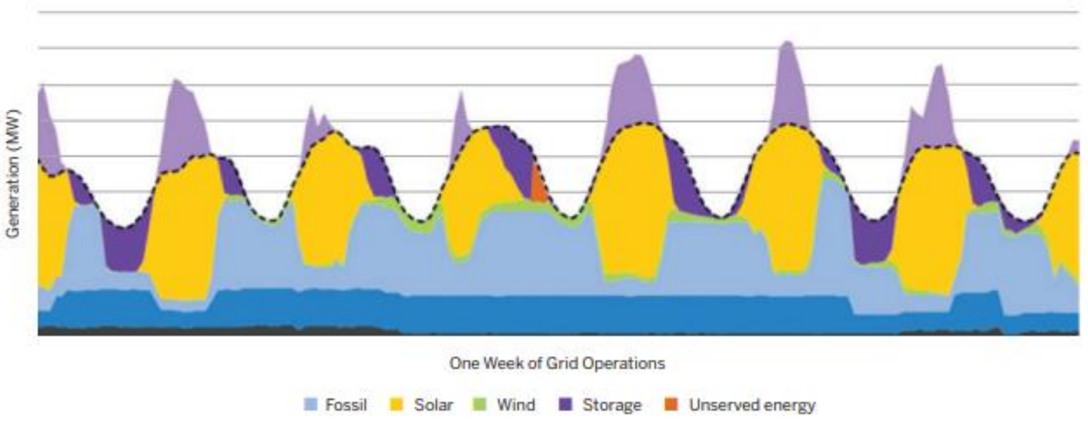
120 Different Futures Evaluated

over 1 million hours of chronological modeling

Transmission may be a Low Regrets asset for Future Uncertainty



Transmission can be a capacity resource to improve resource adequacy



X **Repeated across all weeks, many weather years, outage draws**

- Hundreds of production cost simulations across 40-weather years and 400 forced outage samples
- Limited benefits for renewable energy pockets (West-Texas), but significant benefits for inter-regional transmission that captures geographic diversity
- Monetization = avoided capital cost of new generation and storage
- **Invest in infrastructure that enables long-term clean energy transition --or-- generating capacity & future stranded asset**

LOLEv by Sample

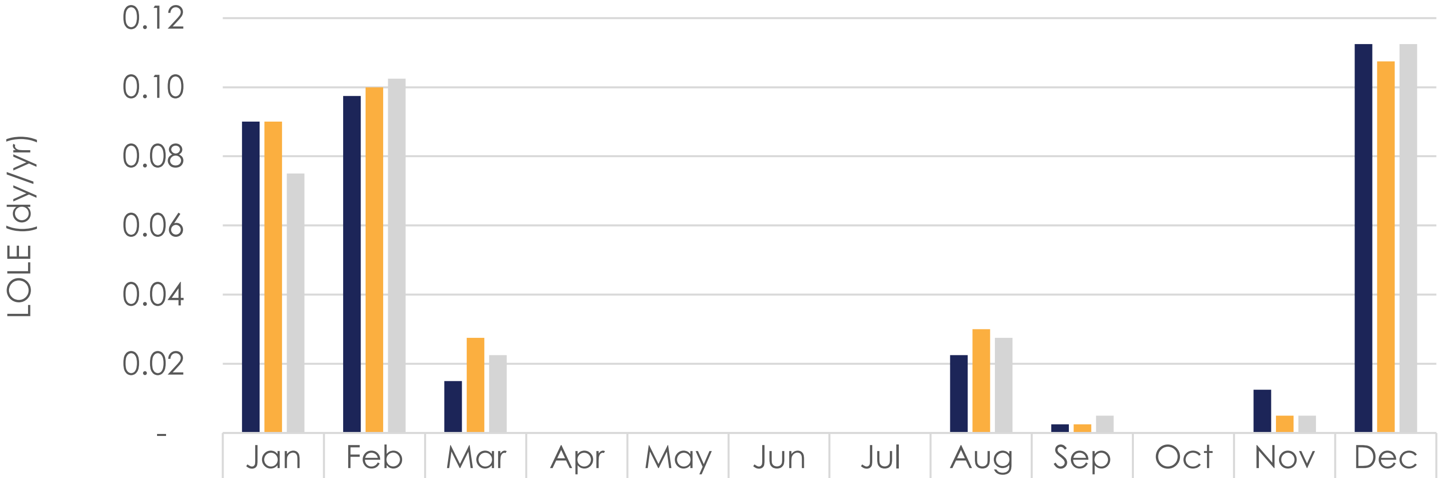
Weather	Outage Draw							
Year	1	2	3	4	5	…	N	Total
1980	0	0	0	0	0			
1981	0	0	0	0	0			
1982	0	0	0	0	0			
1983	1	0	0	0	1			2
1984	0	0	0	0	0			
1985	0	0	0	0	0			
1986	0	0	0	0	2			2
1987	0	0	0	0	0			
1988	2	3	1	1	1			8
1989	0	0	0	0	0			
1990	0	0	1	1	2			4
1991	0	0	0	0	0			
1992	0	0	0	0	0			
1993	0	1	0	0	0			1
1994	0	0	0	0	0			
1995	0	0	1	1	1			3
1996	0	0	0	0	0			
1997	0	0	0	0	0			
1998	0	0	1	1	0			2
1999	0	0	0	0	0			
2000	2	1	2	2	2			9
2001	0	0	0	0	0			
2002	0	0	0	0	0			
2003	2	3	1	1	1			8
2004	0	0	0	0	0			
2005	0	0	1	1	0			2
2006	0	0	0	0	0			
2007	0	0	0	0	0			
2008	0	0	0	0	0			
2009	0	0	0	0	0			
2010	0	2	2	1	3			8
2011	0	1	3	4	4			12
2012	3	2	2	1	2			10
2013	1	0	0	0	0			1
2014	0	0	0	0	0			
2015	0	3	0	0	0			3
2016	0	0	0	0	0			
2017	0	0	0	0	0			
2018	0	0	0	0	0			
2019	0	0	0	0	0			
Total	11	16	15	14	19			75

(illustrative purposes only)

West Texas Resource Adequacy Results

	Samples	Events*	LOLE	LOLEv	LOLH	LOLP	EUE	EUE/LOLE	LOLH/LOLE
	Years	Days	Days/yr	Events/yr	Hours/yr	% of Days	MWh/yr	MWh/event	Hours/event
Base Case	400	141	0.35	0.40	1.75	0.01%	5,230	13,074	4.4
Option 1	400	145	0.36	0.42	1.77	0.01%	5,411	12,722	4.2
Option 2	400	140	0.35	0.40	1.73	0.01%	5,130	12,906	4.4

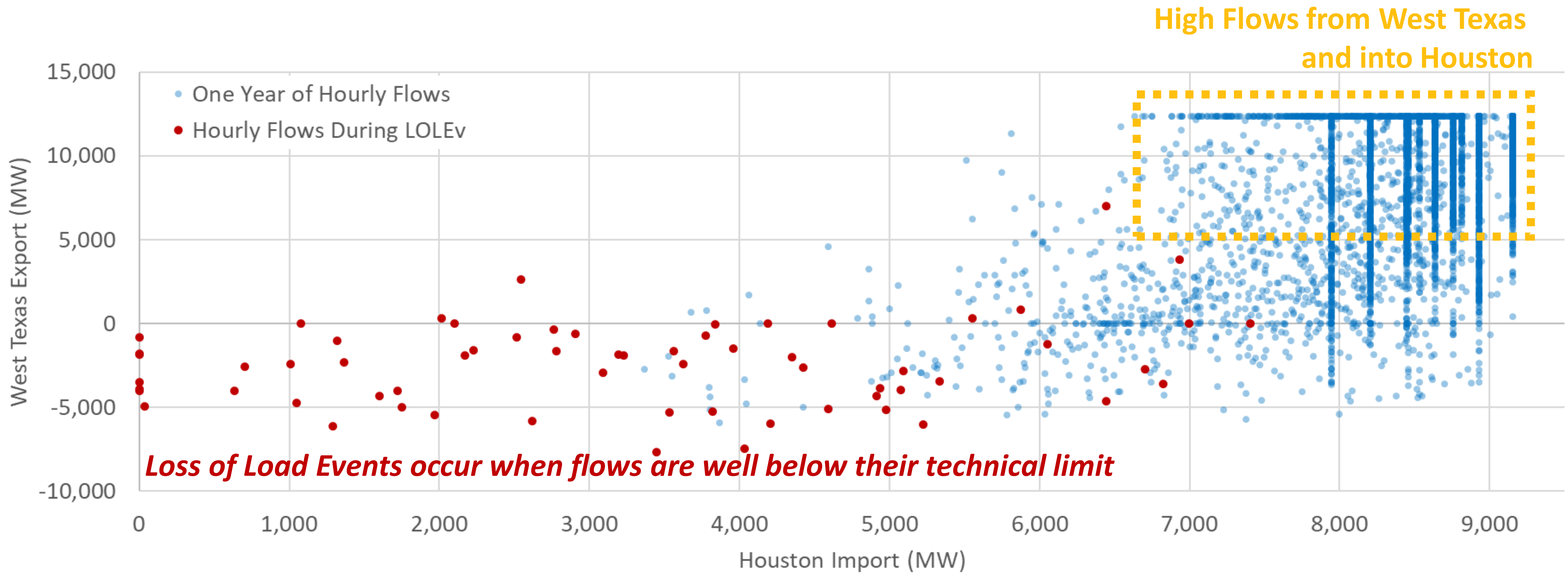
frequency (LOLE, LOLEv, LOLH, LOLP) **size** (EUE, EUE/LOLE) **duration** (LOLH/LOLE)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2030-Base	0.09	0.10	0.02	-	-	-	-	0.02	0.00	-	0.01	0.11
2030-Opt-1	0.09	0.10	0.03	-	-	-	-	0.03	0.00	-	0.01	0.11
2030-Opt-2	0.08	0.10	0.02	-	-	-	-	0.03	0.01	-	0.01	0.11

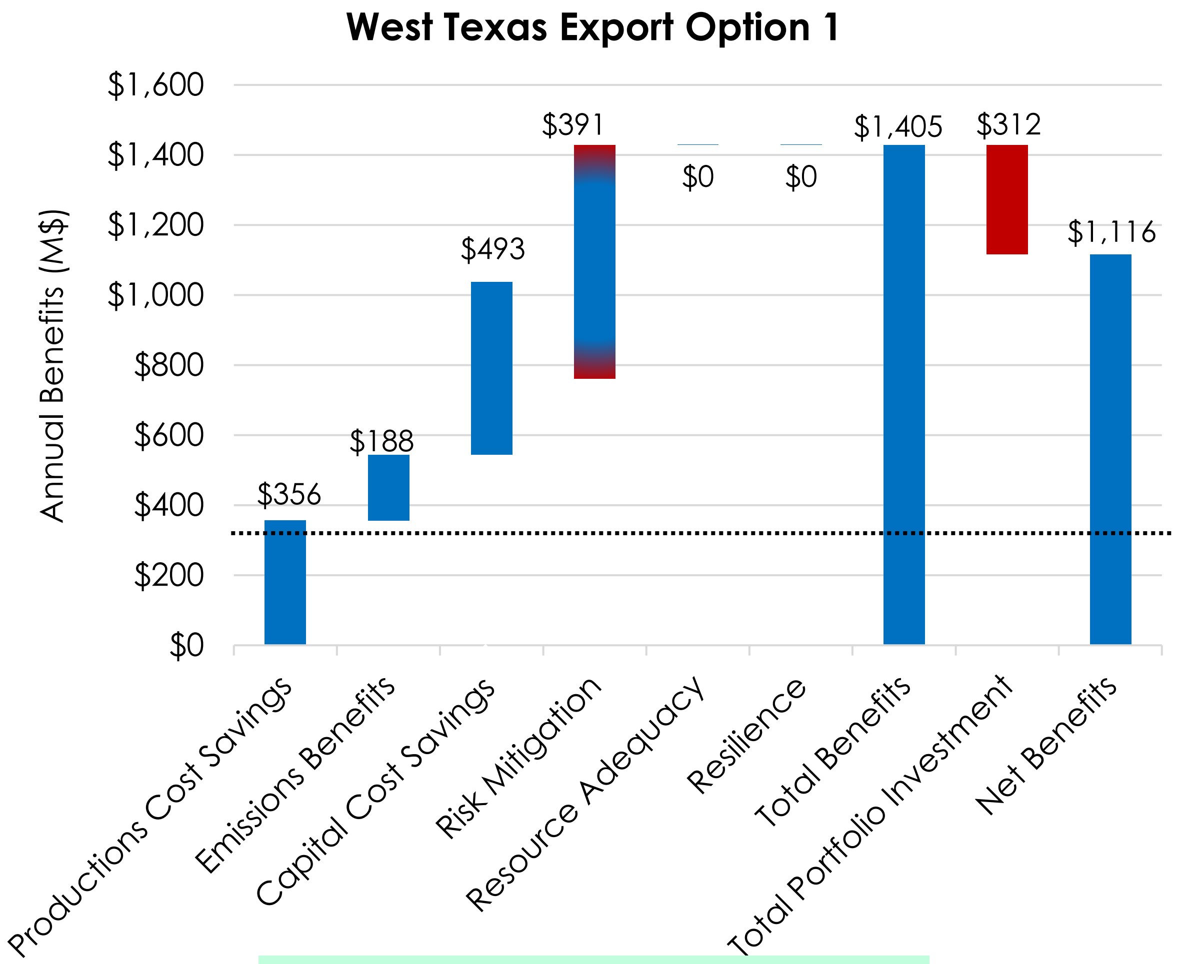
- Did not add capacity to meet specific reserve margin or LOLE target (LOLE is still below "economic optimal reserve margin" target)
- No discernable difference to Loss of Load events due to transmission additions
- HVDC import in Option 2 to Houston does not overcome Houston Import congestion
- This makes sense… WTE is only binding during high wind and solar events, when surplus capacity is likely

Why don't we see more resource adequacy benefits with West Texas Export?

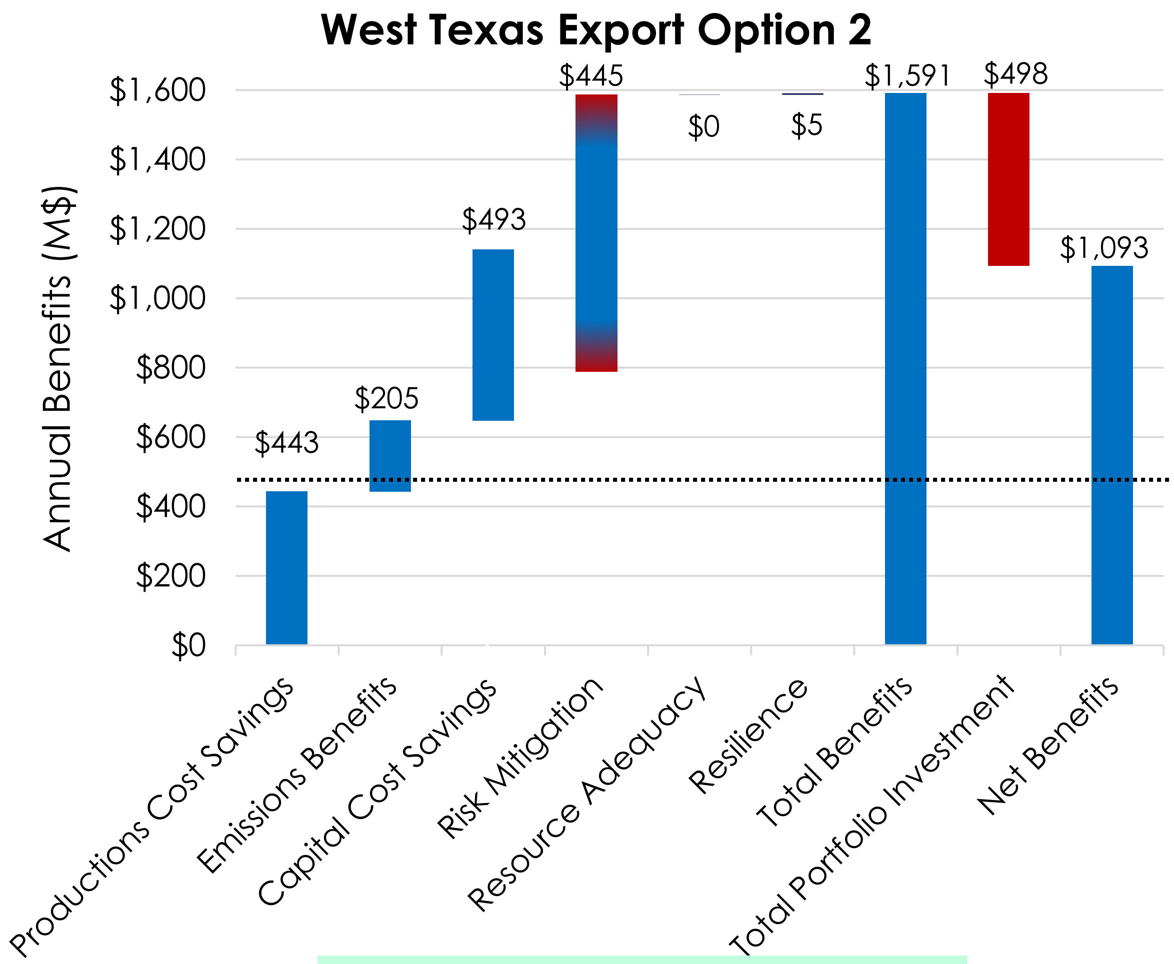


Loss of load events occur when wind and solar output is low, and transmission interface has low (reverse) loading

Bringing it all together, the multi-value stack



BCR adj-PC only: 1.1 | total: 4.5

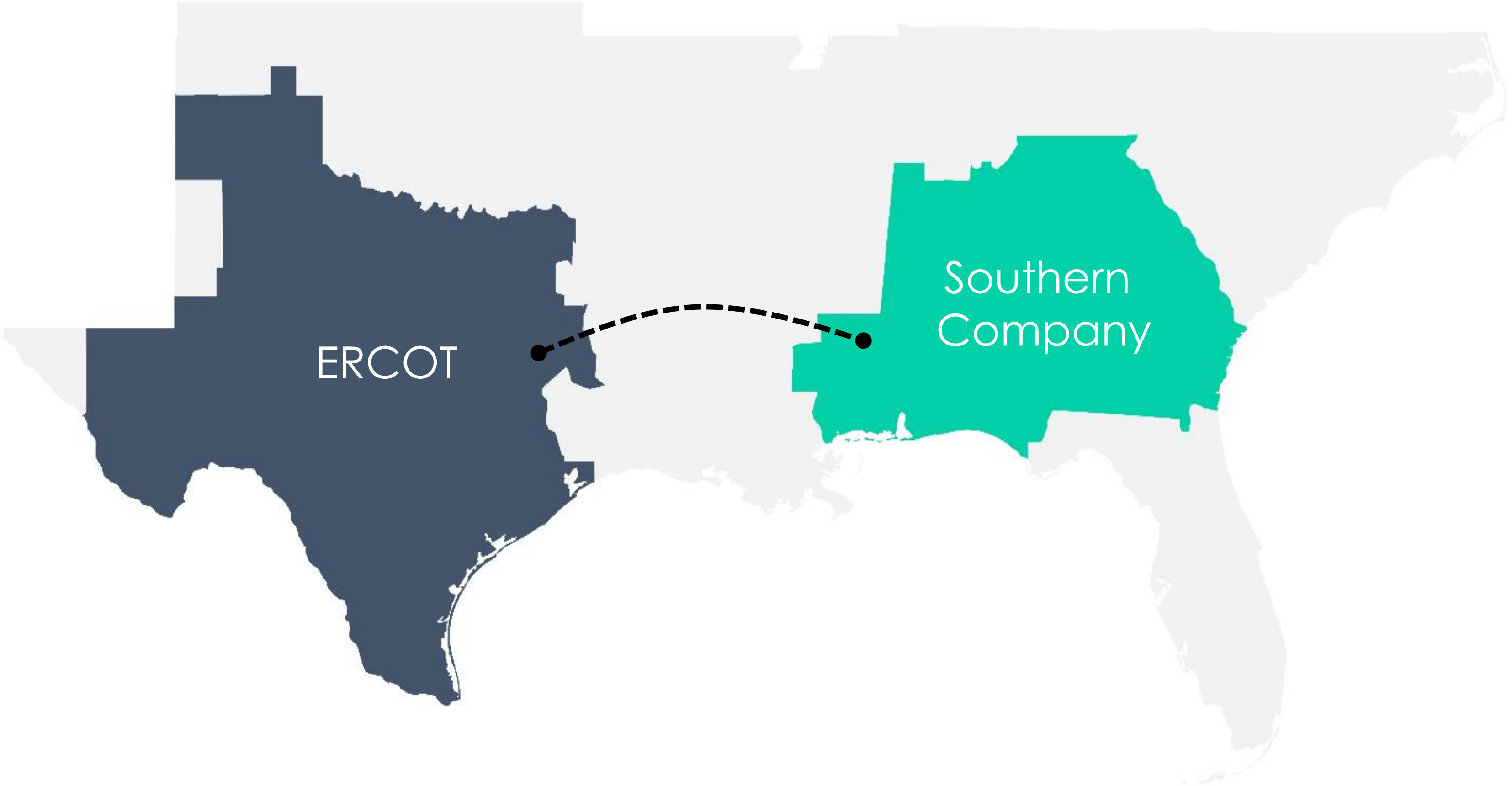


BCR adj-PC only: 0.9 | total: 3.2

Taking Multi-value Planning Interregional

ESIG
ENERGY SYSTEMS INTEGRATION GROUP

Interregional Transmission Topology

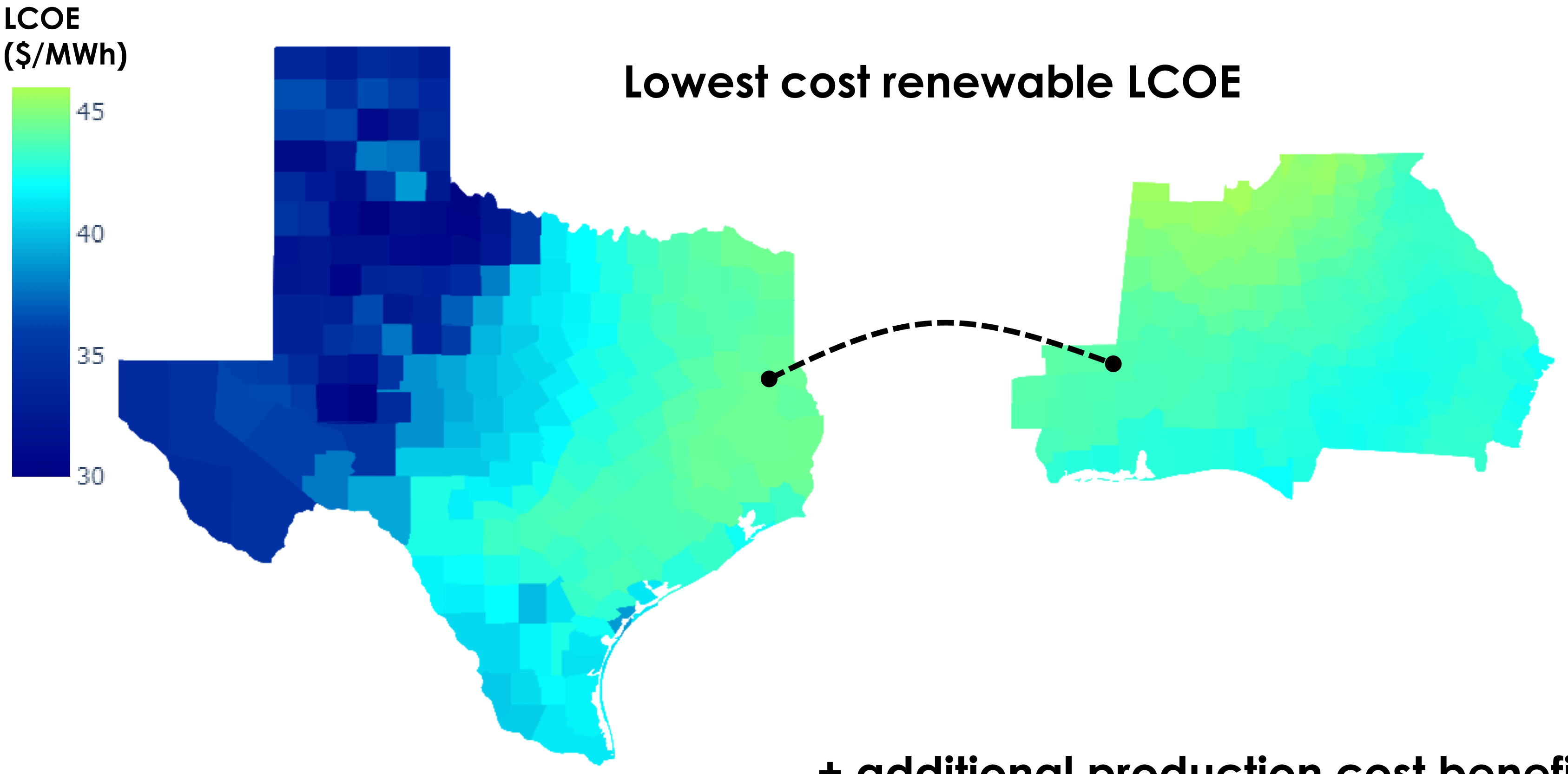


Southern Company – ERCOT Link

- Interregional line evaluated to highlight opportunities for resource adequacy and resilience
- Proposed “shovel-ready” transmission project
- ERCOT + Southern Company (MS, AL, GA) Southern Company
- Connection modeled as a 2 GW HVDC line to ERCOT North
- Independent and combined production cost and resource adequacy modeling

Interregional Capital Cost Savings

What are the capital cost benefits of trading Southern solar for Texas wind?



2 GW transmission line

2 GW of contracted wind*
<u>x43% capacity factor</u>
7500 GWh/year

x$10/MWh price differential
= 75M$/year capital cost savings

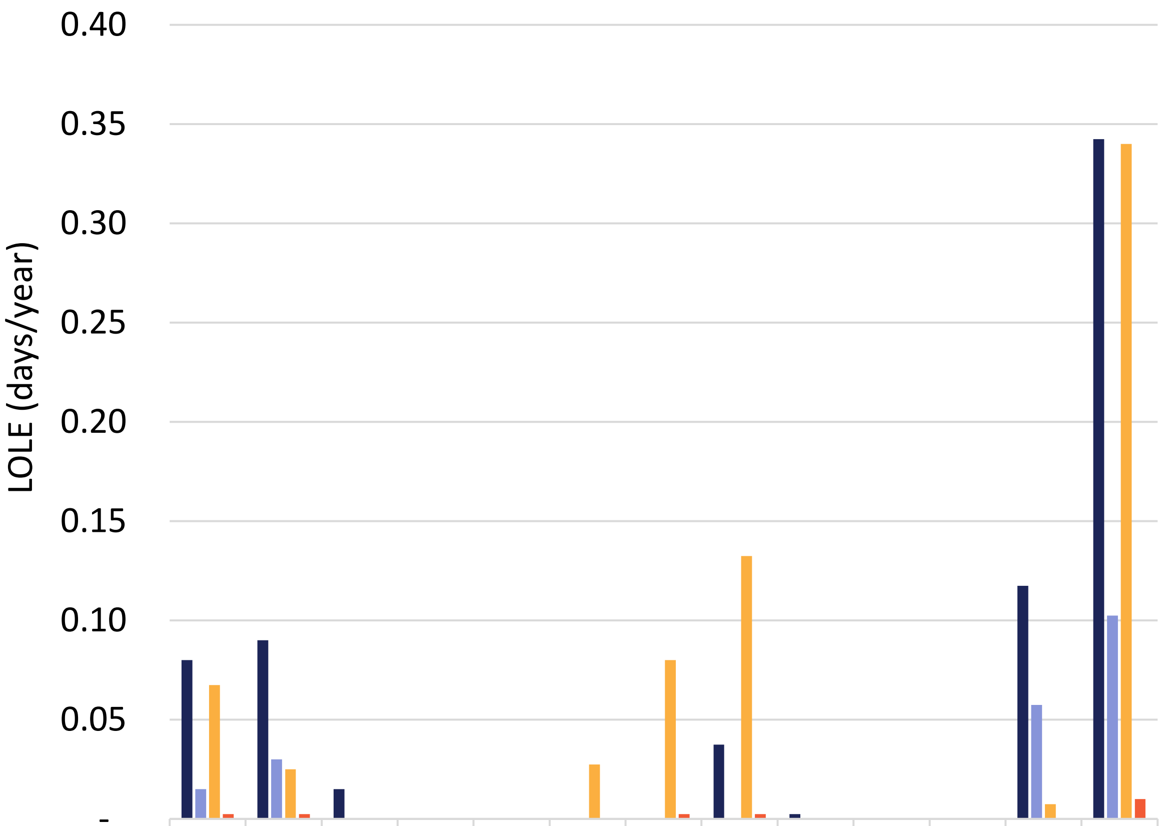
**conservative assumption, could fill the line by overbuilding with minimal spilled energy*

+ additional production cost benefits attributed to renewables with a different diurnal profile (not quantified)

Interregional Resource Adequacy Benefits

- **With additional Southern retirements, the connected system sees RA benefits at both ends of the HVDC line *without adding any new resources***
- Interregional transmission accesses load diversity and renewable resource diversity
- Improves ERCOT resource adequacy and enables deferral of new gas capacity and additional coal retirements in southeastern US
- Transmission can improve resource adequacy similar to 4 GW of new natural gas capacity [2 GW in ERCOT + 2 GW in Southern Company]

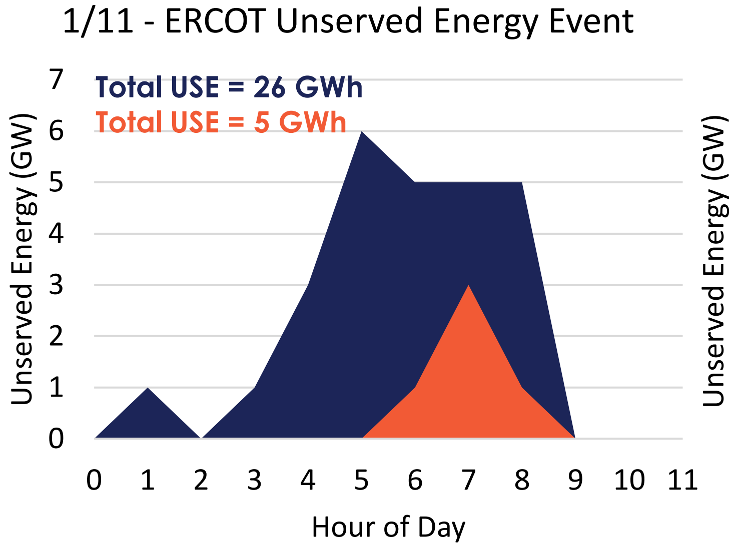
$240 Million/year of avoided capital cost*

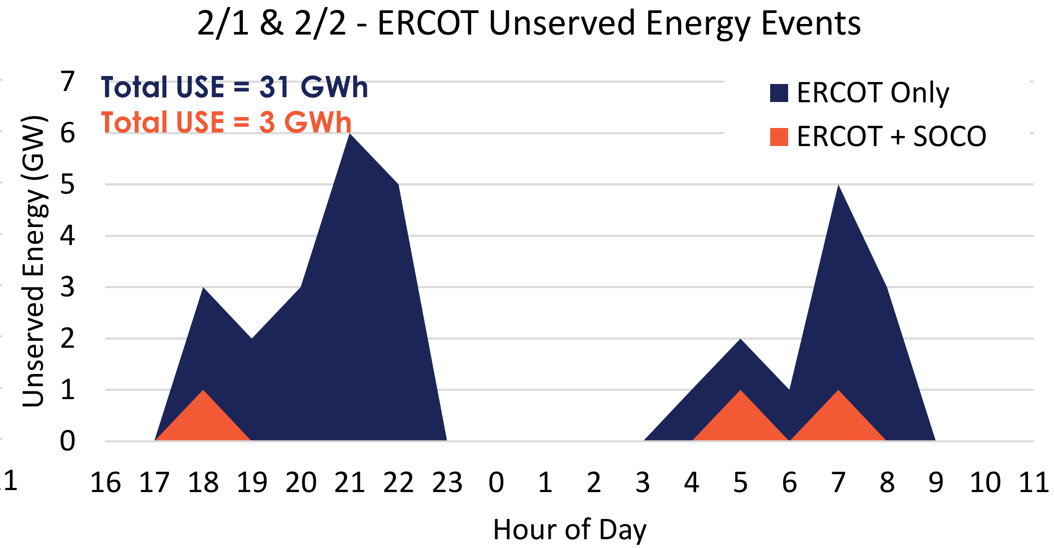


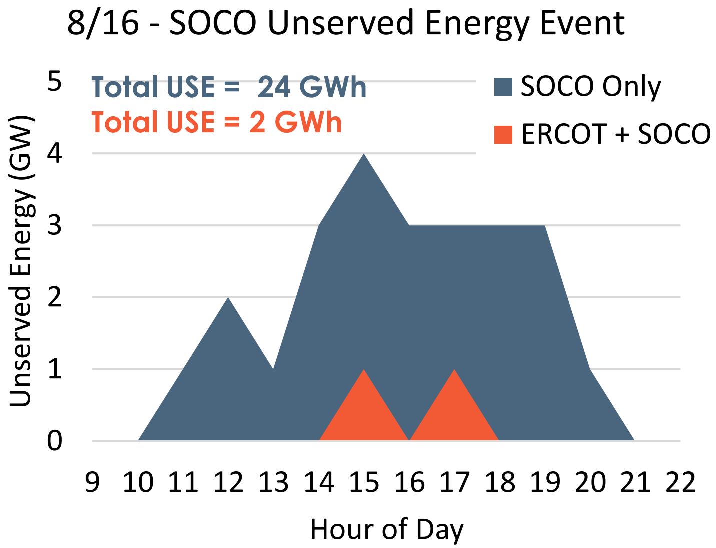
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yr
ERCOT Only	0.08	0.09	0.02	-	-	-	-	0.04	0.00	-	-	0.12	0.34
ERCOT (Combined w/ Retires)	0.02	0.03	-	-	-	-	-	-	-	-	-	0.06	0.10
SOCO Only (w/ Retires)	0.07	0.03	-	-	-	0.03	0.08	0.13	-	-	-	0.01	0.34
SOCO (Combined w/ Retires)	0.00	0.00	-	-	-	-	0.00	0.00	-	-	-	-	0.01

*based on Net-CONE of new gas of $60/kW-yr

Valuing Resilience Avoided Costs







- Resource Adequacy = capacity benefit of avoiding new generating capacity to bring system to 0.1 days/year
- How do we differentiate with resilience?
- Resilience = when there is an event, what can transmission do to avoid additional loadshedding?
- Avoided cost of load shedding x VoLL
- ***Additional methods are needed for resilience***

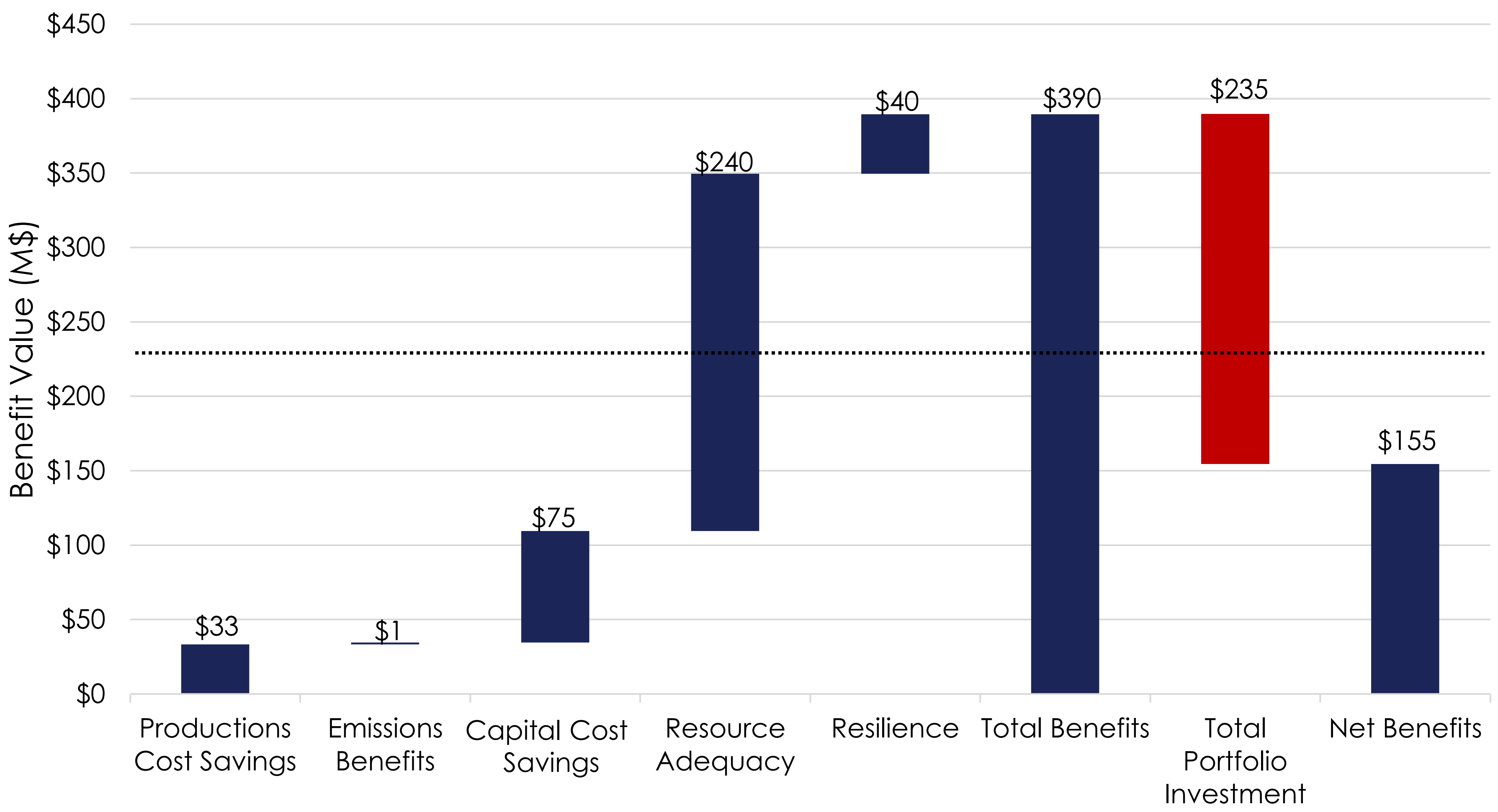
*USE = Unserved Energy

System Component	Avoided USE (MWh)	Total Resilience Value (B$)	Annual Resilience Value (M$)
System-wide	737,662	16	40
ERCOT	691,304	14	35
SOCO	46,358	2	5

ERCOT VOLL = $20,000/MWh, SOCO VOLL = $40,000/MWh

Note: Reduction in unserved energy greater than the line capacity (2 GW) attributed to increased energy available for batteries

Bringing it all together, the multi-value stack



BCR adj-PC only: 0.14 | total: 1.66

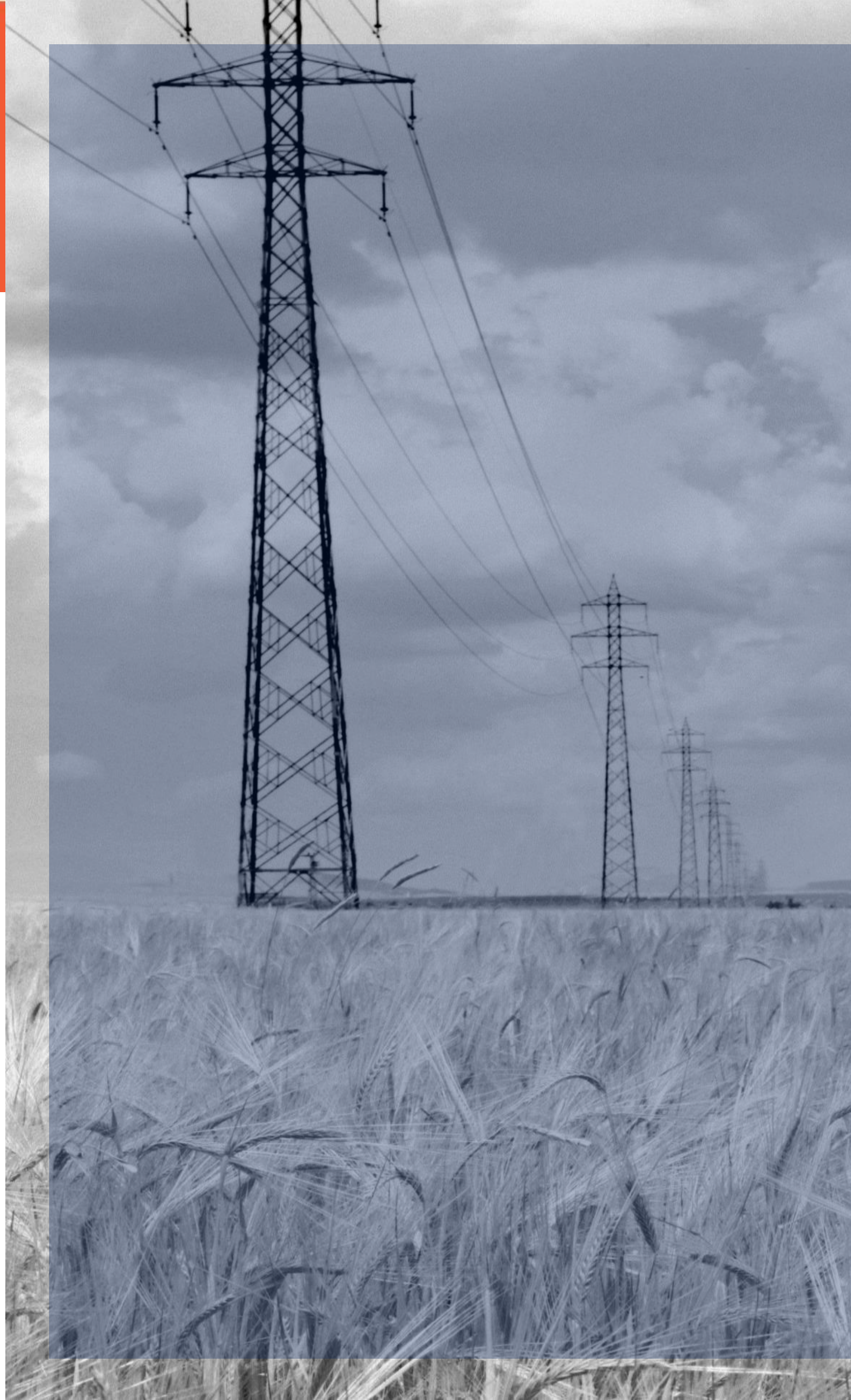
Interregional transmission captures more benefit from resource adequacy and resilience, less benefit from production cost savings and emissions

Risk mitigation benefits not evaluated in this example

Key Findings

Multi-value transmission planning is not just about capturing new benefits, but avoiding significant costs for ratepayers
… a low regrets insurance policy

1. Different transmission projects will have different benefits
2. Our processes need to incorporate a value stacking & prioritization of benefits early in the process
3. Long-term planning horizon is needed for long-term investments
4. Production costs alone may not show all the benefits of transmission, we need to think broader
5. Transmission may be a no-regrets investment when you look across a range of potential futures
6. Transmission can be a capacity resource – especially for inter-regional connections
7. Interregional transmission can reduce load shedding during scarcity events and avoid substantial costs



THANK YOU

Derek Stenclik, Ryan Deyoe

TELOS ENERGY