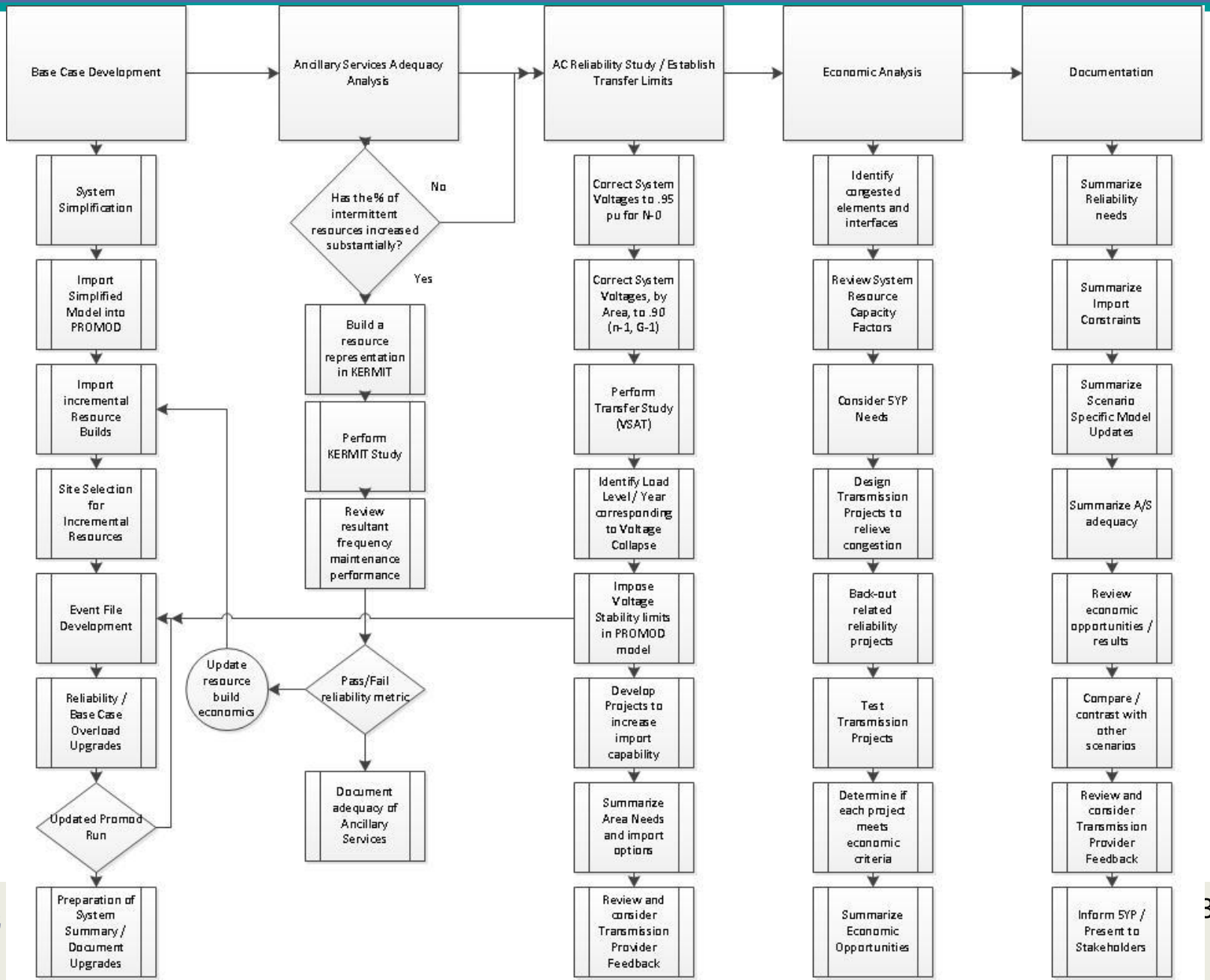
Transmission Needs Analysis
Scenario 2/3 Update

ERCOT/DOE Long Term Study
October 12, 2012

Agenda

- **Review Major Process Steps**
- **Review Base Case Upgrades**
- **Economic Analysis**

Major Process Steps



Study Scenarios

Scenario 2: Base with All Tech and Retirements

- Retirement of legacy natural gas-fired generators on their 50th anniversary of commercial operations.

- Retirements in load pockets lead to increasing stress on import paths

Description	2016-2022	2023-2032
Gas Adds (MW)	14,500	13,800
Solar Adds (MW)	2,000	8,000
Wind Adds (MW)	-	1,500
Admin Gas Adds(MW)	13430	1360
Retirements (MW)	9,426	4,339

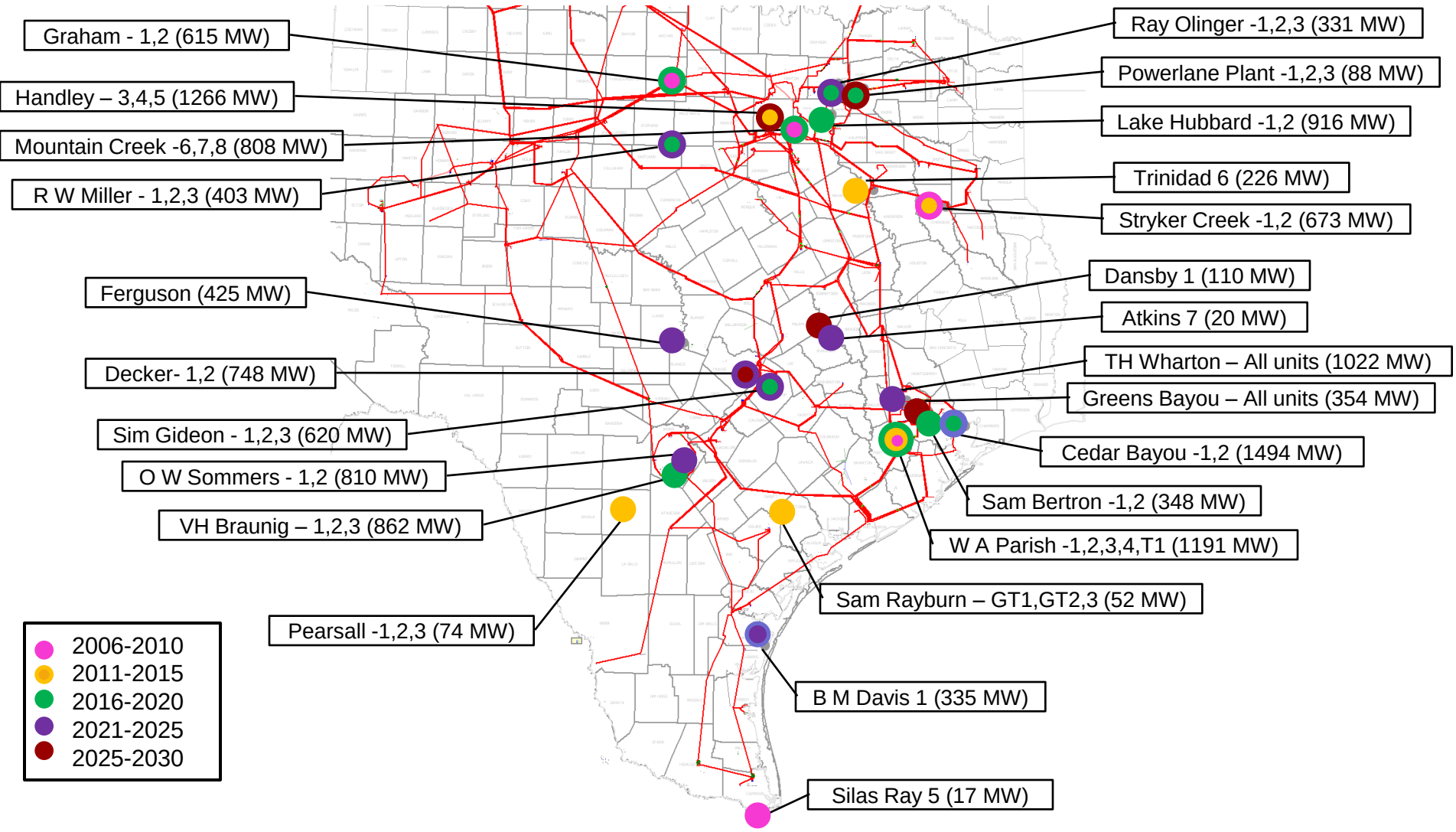
Scenario 3: Base with All Tech and Incremental Wind

- 17 GW of new wind capacity added by 2032

- Reduced build-out of gas-fired units

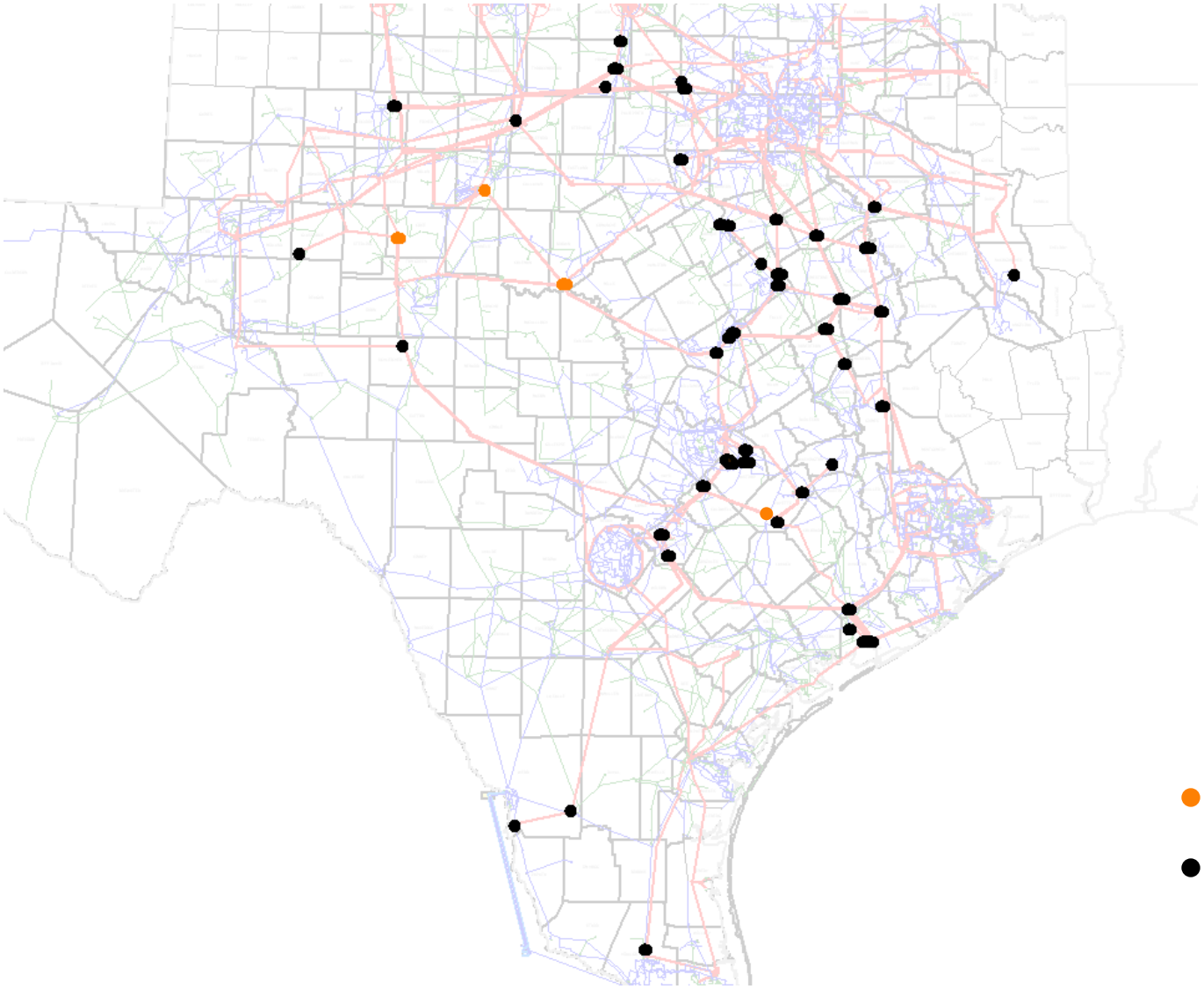
Description	2016-2022	2023-2032
Gas Adds (MW)	3,980	6,760
Solar Adds (MW)	4,500	5,500
Admin Gas Adds(MW)	13,940	3,910
Wind Adds (MW)	6,968	9,887

Scenario 2 – BAU with NG Retirements

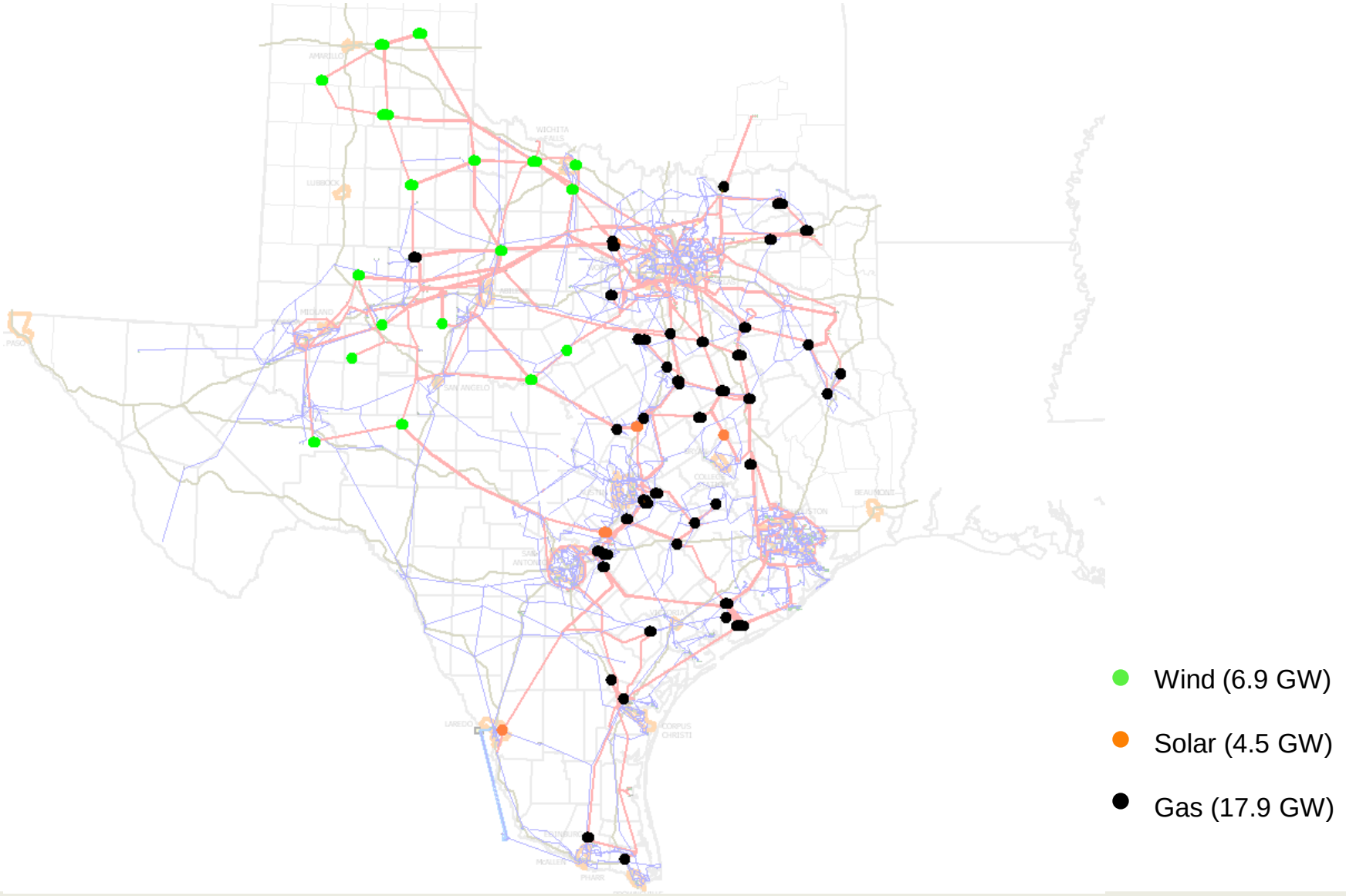


Scenario 2 assumes retirement of NG fired resources after 50 years

Scenario 2 Incremental Resources - 2022



Scenario 3: Incremental Resources - 2022



Base Case Thermal Reliability Upgrades 2022

To build a solvable 2022 model, certain upgrades were necessary to replicate what would typically be resolved in shorter term planning horizons. In certain instances (primarily near major load zones) major upgrades were necessary to build a useable case:

2022		Scenario 1		Scenario 2		Scenario 3	
Lines	Voltage (kV)	Miles	Cost ($M)	Miles	Cost ($M)	Miles	Cost ($M)
	345	376	700	411	904	97	173
	138	360	278	376	381	204	187
Transformers	Voltage (kV)	MVA	Cost ($M)	MVA	Cost ($M)	MVA	Cost ($M)
	345/138	10363	175	15000	193	3300	49

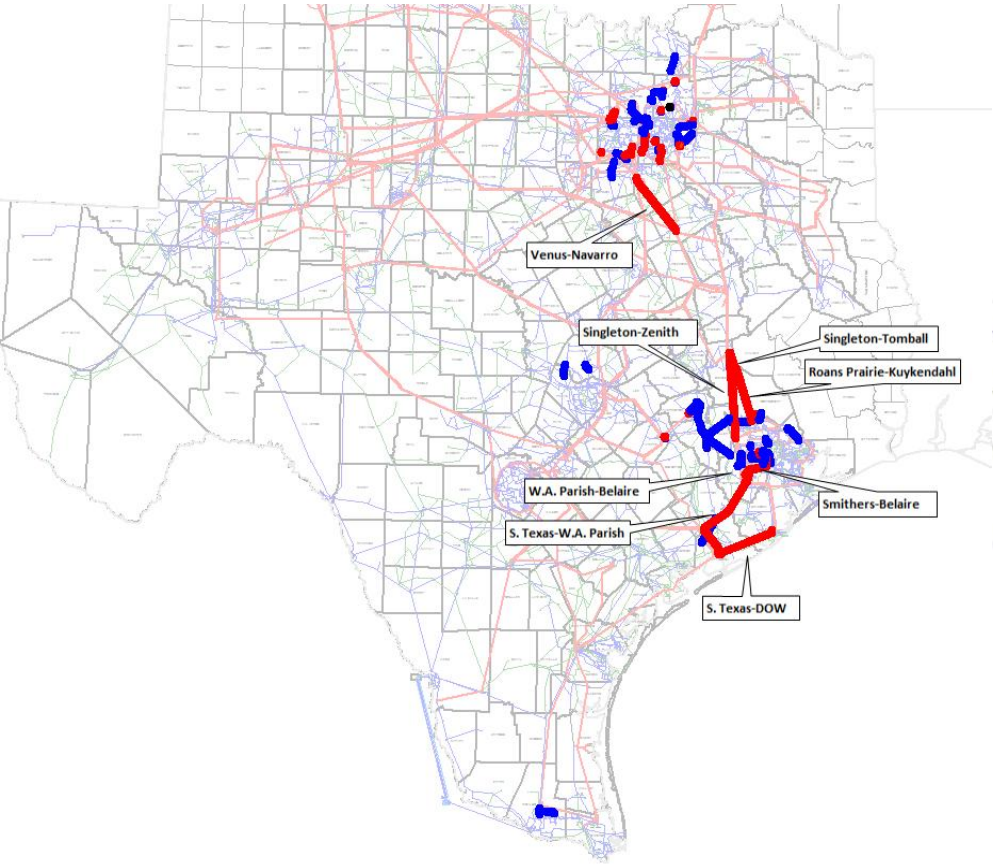
Including:

- *Upgrades of existing 345kV Imports into Houston**
- *Expanded connections between the 345kV and 138kV systems in Dallas and Houston*
- *Upgrade of an existing import into the DFW Region*

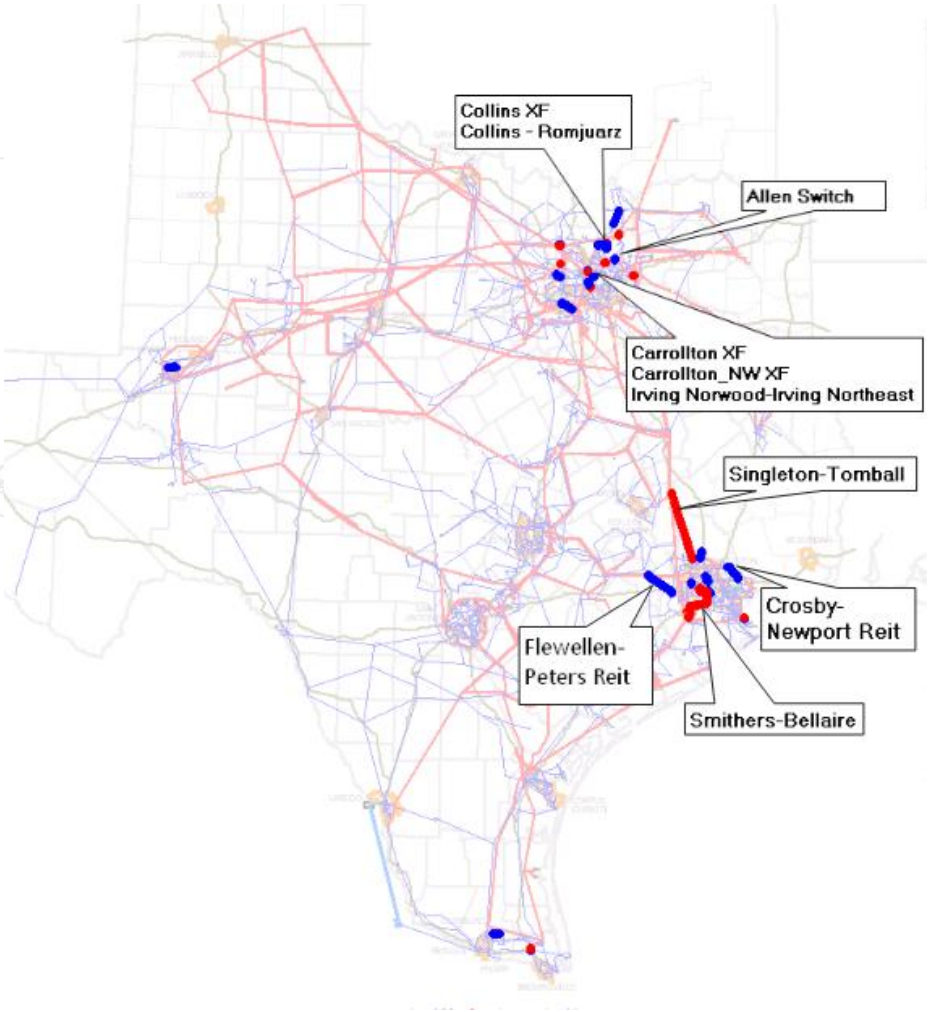
*For the purpose of this study, ERCOT did not consider the feasibility / costs associated with the outages required for these upgrades. The incumbent transmission provider has indicated outages would be lengthy, difficult and costly.

Base Case Reliability Upgrades 2022 S2 & S3

S2



S3



2022 Study Case AC Stability Implications

Region	Scenario 1		Scenario 2		Scenario 3	
	Interface Limit	Violated Year	Interface Limit	Violated Year	Interface Limit	Violated Year
Austin	3839	2028	3839	2028	4572	Beyond 2032
Dallas	18890	2022	19949	2022	20318	2026
Houston	8827	2024	8735	2018	9440	2028
San Antonio	3033	2028	4048	2024	3796	2030
LRGV	2512	2021	2512	2021	2512	2021

Incremental Reactive Support Assumptions (S2)

Area	Reactive Power Support Needed by 2022 (MVAR)	Reactive Power Support Needed by 2032 (MVAR)	Year of Instability without Reactive Power Support
Austin	0	3000*	2028
Dallas	600	10000	2022
Houston	1800	6000	2018
San Antonio	0	*	2024

*Austin and San Antonio were studied as one area for 2032

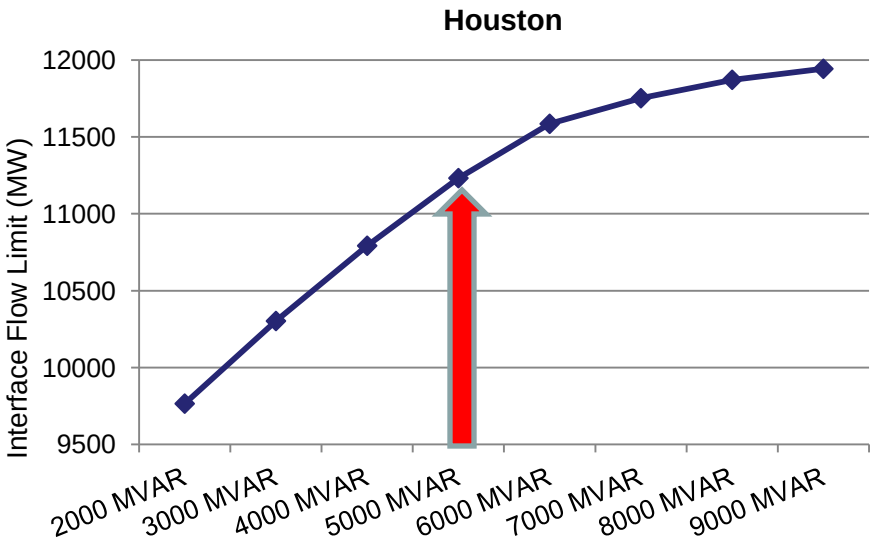
Dynamic Reactive Compensation

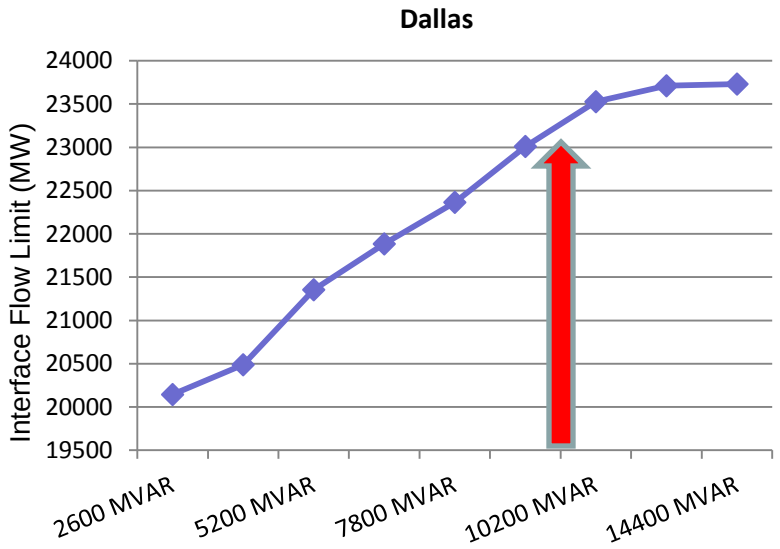
How much is too much?

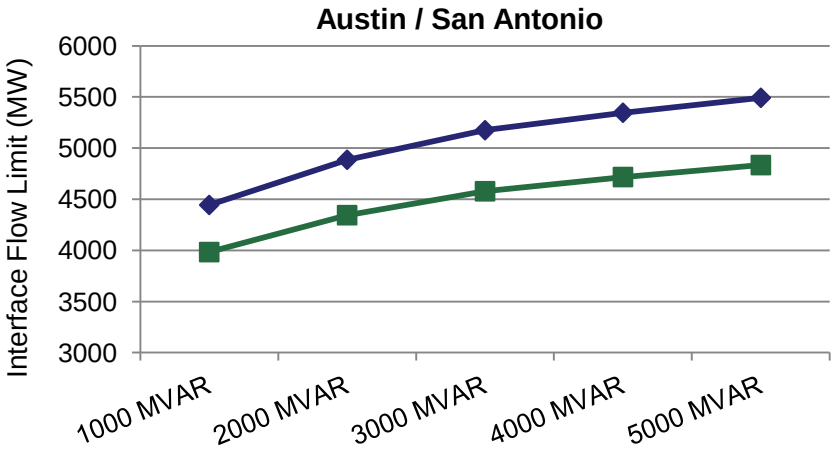
Typically, Static Var Compensators (SVC) provide dynamic reactive solutions at a lesser cost than that of incremental transmission sources.

For scenario 2, with resources internal to the load pocket retired, reactive needs became increasingly large. To "right-size" dynamic reactive support, ERCOT performed a regional assessment to determine the "point of diminishing returns" for incremental dynamic reactive support.

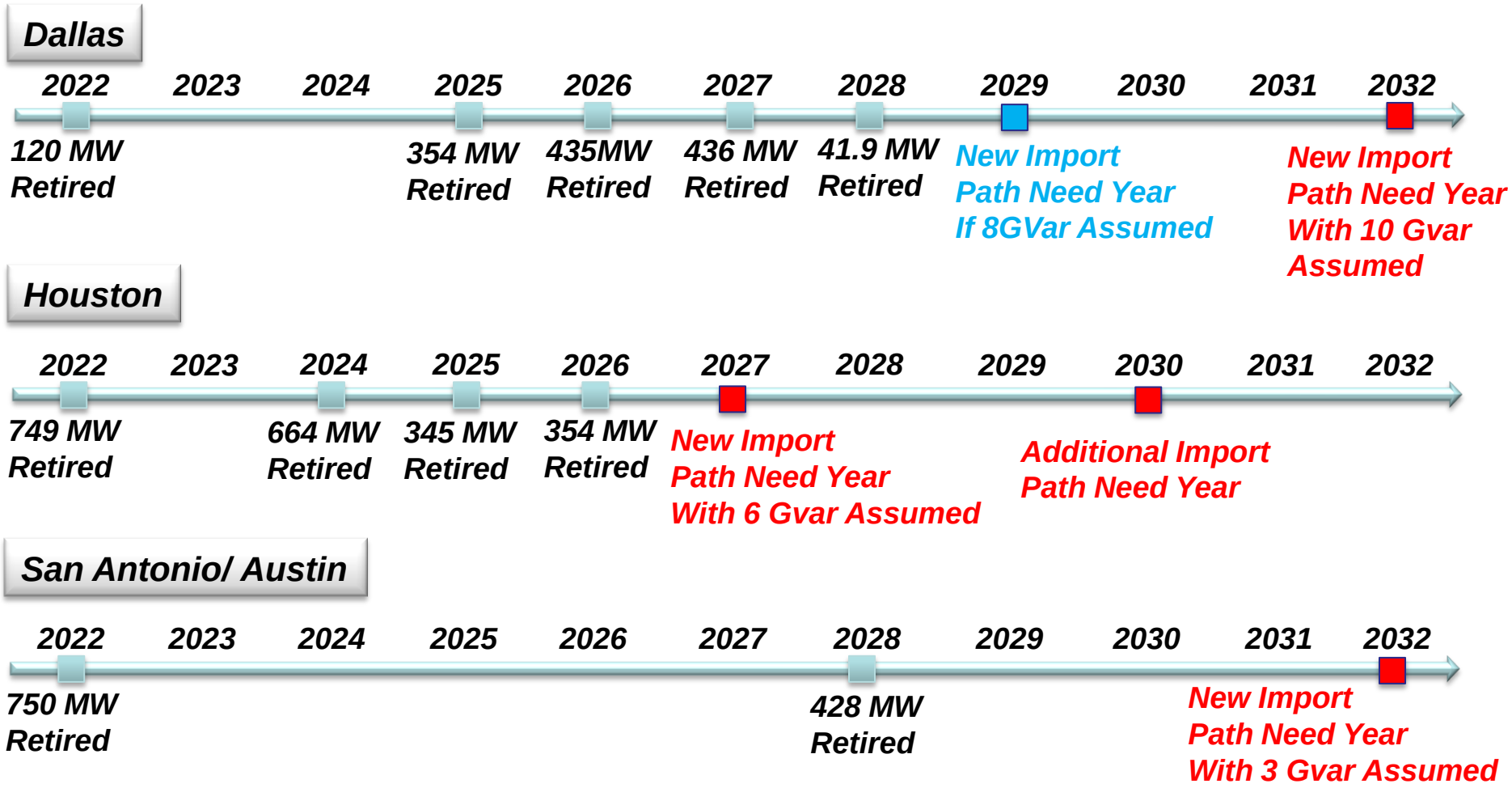
Interface Limit (MW) into Metro Areas at Each Dynamic Reactive Power Source Level







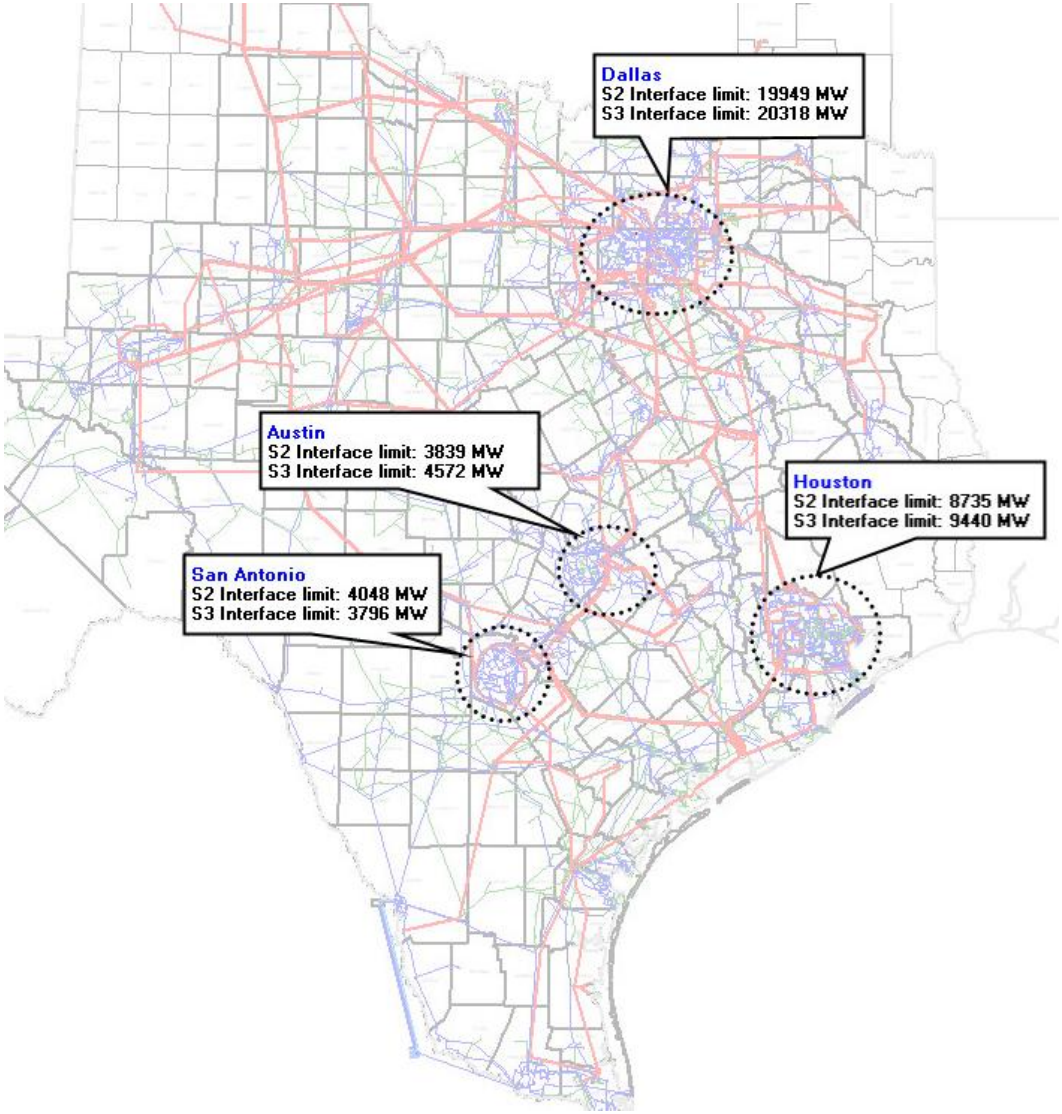
Incremental Transmission Timeline for Voltage Stability (S2) 2022-2032



Incremental retirements in major ERCOT load pockets create increasing dependence on existing and incremental import paths. If the assumed levels of dynamic reactive support are unachievable, new import paths would be required in earlier years. (Study in Progress)

Economic Analysis by Area: S2&S3 2022

Methodology:



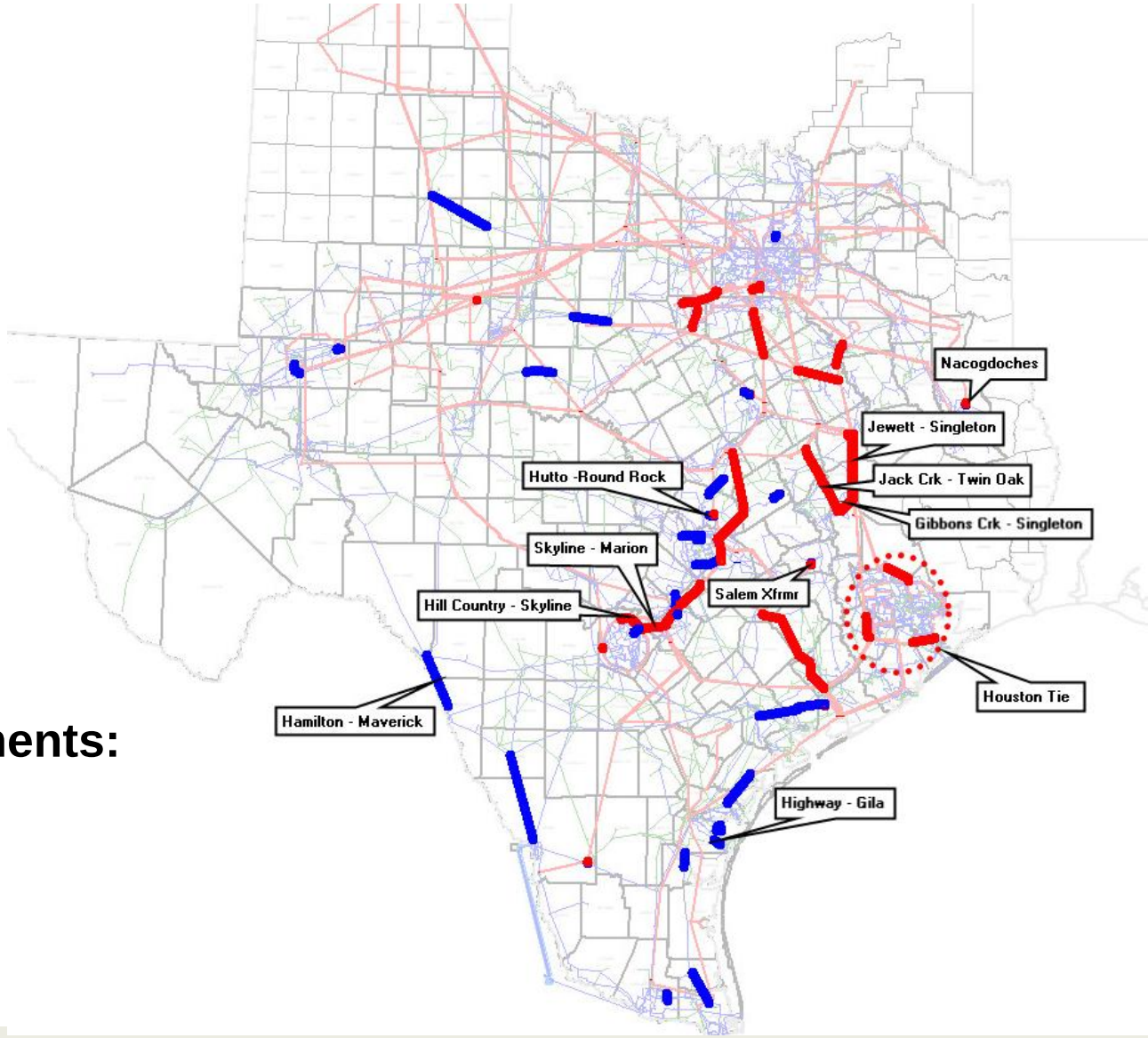
1. Develop a base-case with irresolvable constraints upgraded.

2. Identify scenario-specific import limitations into major load zones given most severe resource and element contingencies.

3. Create binding constraints to represent AC voltage stability limits in the DC / PROMOD Model.

4. Identify must-have reliability upgrades and economic supplements / alternatives.

Scenario 2 Congestion



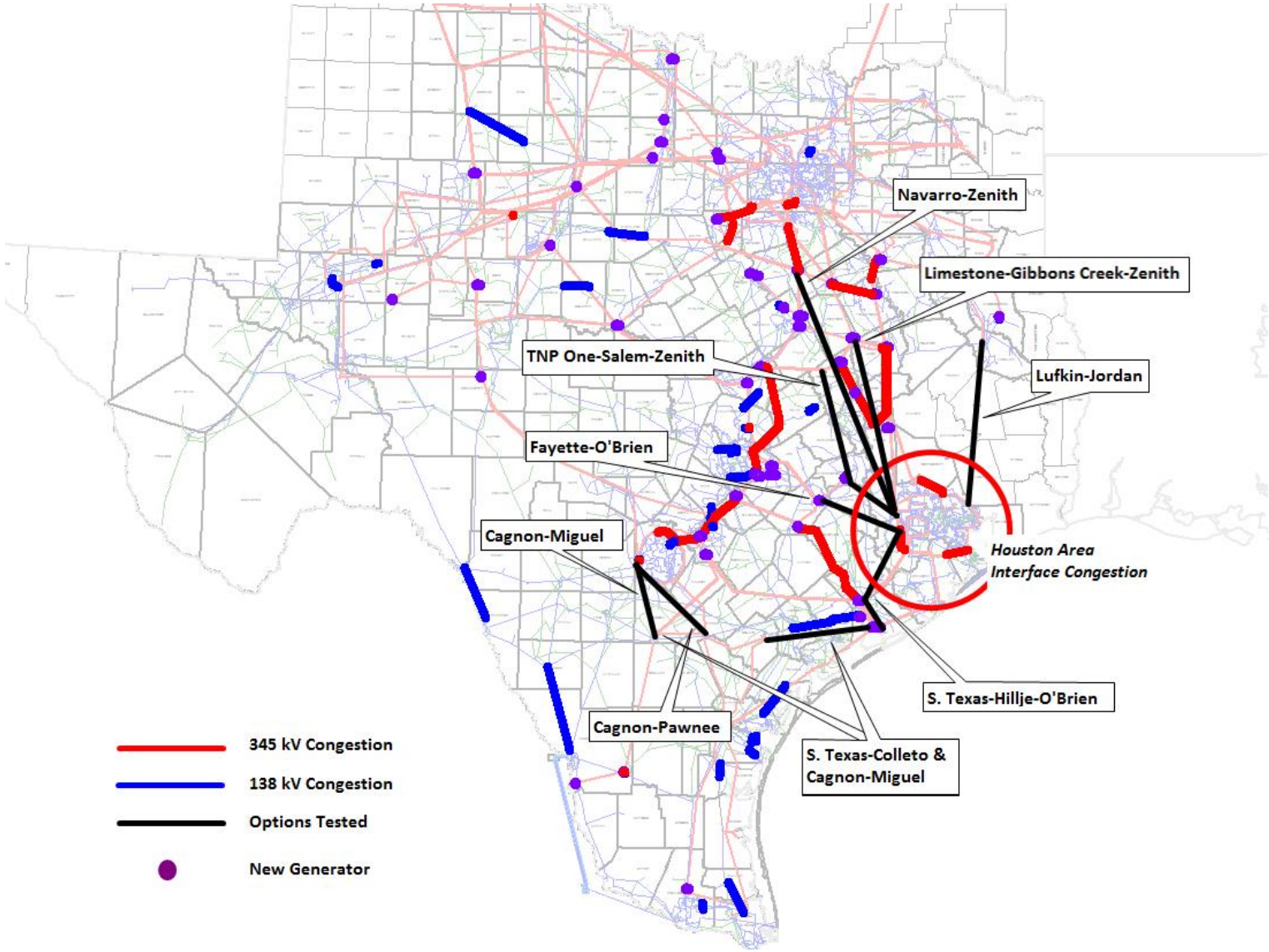
Most Congested Elements:

Houston interface

Hill Country - Skyline

Skyline - Marion

Economic Projects S2



Economic Results: Houston S2*

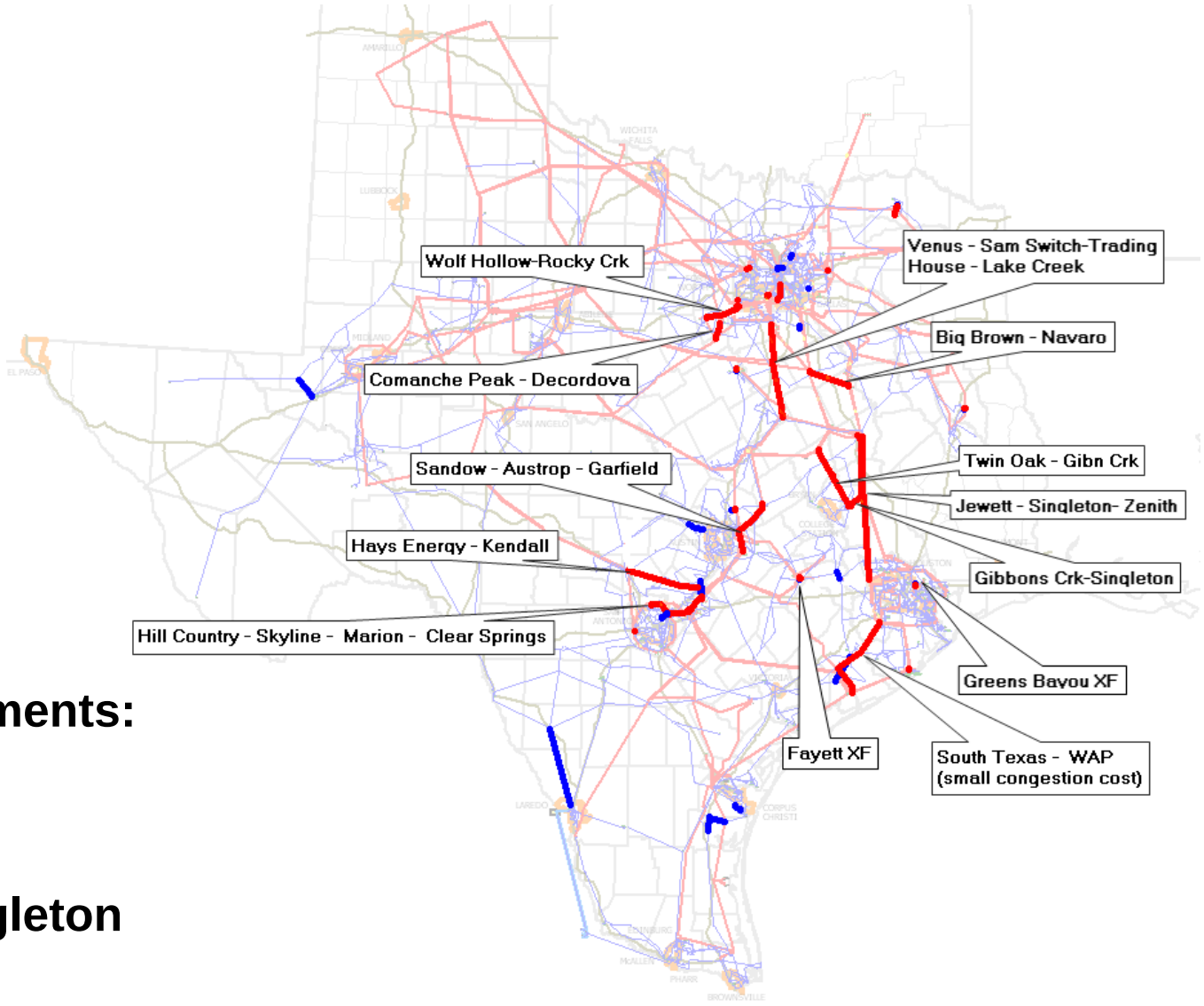
Test Project	2022 capital cost ($M)	Reliability benefit of test project ($M)	Capital Cost Adjusted for Reliability Benefit ($M)	Production Cost Savings ($M)	1/6 of Capital Cost ($M)	1/6 of Adjusted Capital Cost ($M)	Meet ERCOT Economic Criteria ?
Fayette-O Brien	$ 241.7	$ 345.2	$ (103.5)	$ 30.8	$ 40.3	$ (17.3)	YES
Lufkin-Jordan	$ 439.1	$ 138.5	$ 300.6	$ 28.0	$ 73.2	$ 50.1	NO
TNP One-Salem-Zenith	$ 444.6	$ 520.4	$ (75.7)	$ 37.5	$ 74.1	$ (12.6)	YES
Hillje-Obrien and South Texas-Hillje upgrade	$ 265.3	$ 262.3	$ 3.0	$ 28.3	$ 44.2	$ 0.5	YES
Navarro-Zenith	$ 597.8	$ 101.1	$ 496.7	$ 29.7	$ 99.6	$ 82.8	NO
Limestone - Gibbons Creek -Zenith	$ 327.2	$ 361.6	$ (34.4)	$ 40.9	$ 54.5	$ (5.7)	YES

*Note Singleton-Tomball & Singleton to Zenith were upgraded in this scenario's base-case, and "backed-out" in reliability benefit testing.

Economic Results: San Antonio S2

Test Project	2022 capital cost ($M)	Reliability benefit of test project ($M)	Capital Cost Adjusted for Reliability Benefit ($M)	Production Cost Savings ($M)	1/6 of Capital Cost ($M)	1/6 of Adjusted Capital Cost ($M)	Meet ERCOT Economic Criteria ?
Cagnon-Miguel	$ 193.0	$ (3.4)	$ 196.4	$ 5.2	$ 32.2	$ 32.7	NO
Cagnon-Pawnee	$ 242.0	$ (8.0)	$ 250.0	$ 2.8	$ 40.3	$ 41.7	NO
Cagnon-Miguel & South Texas-Coleto	$ 290.0	$ -	$ 290.0	$ 6.2	$ 48.3	$ 48.3	NO

Scenario 3 Congestion



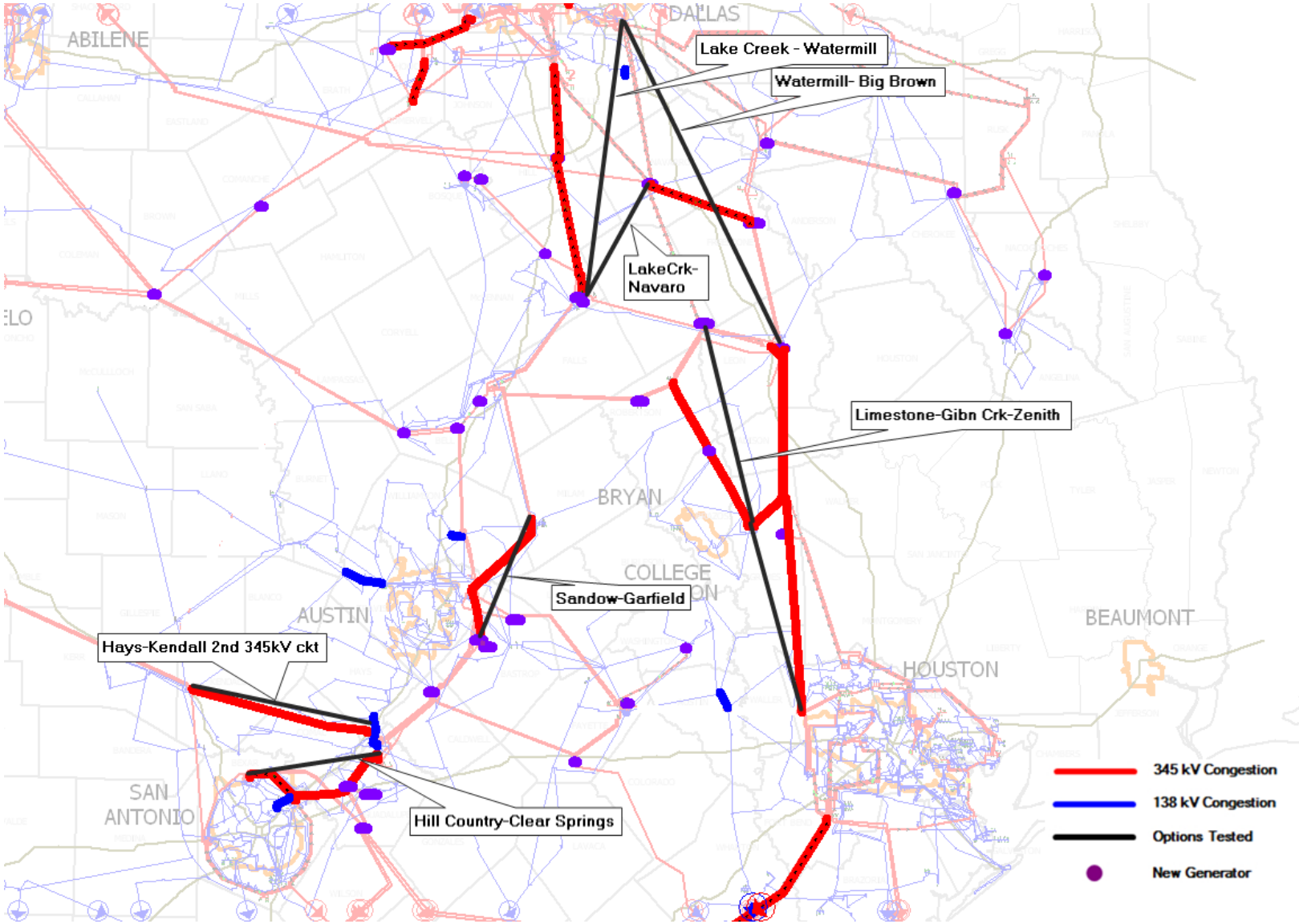
Most Congested Elements:

Greens Bayou Auto

Singleton to Zenith

Gibbons Creek - Singleton

Economic Projects S3



Economic Results: S3

Test Project	2022 capital cost ($M)	Reliability benefit of test project ($M)	Capital Cost Adjusted for Reliability Benefit ($M)	Production Cost Savings ($M)	1/6 of Capital Cost ($M)	1/6 of Adjusted Capital Cost ($M)	Meet ERCOT Economic Criteria ?
Limestone-Gibbons Creek-Zenith	327.2	120.6	206.6	36.6	54.5	34.4	Yes
Watermill-Big Brown	208.2	23.1	185.1	0.1	34.7	30.9	No
Lake Creek – Navarro	104.1	42.1	62.0	1.7	17.3	10.3	No
Lake Creek – Watermill	297.4	19.0	278.4	0.4	49.6	46.4	No
Clear Spring - Hill County	104.1	0.0	104.1	4.1	17.4	17.4	No
Hays - Kendall second 345kV circuit	41.8	0.0	41.8	3.2	7.0	7.0	No
Sandow - Garfield	133.8	0.0	133.8	4.0	22.3	22.3	No

Conclusions

Should the legacy, gas-fired, urban located fleet be retired (and not repowered), expansive import paths and large amounts of dynamic reactive resources will be needed in Houston and Dallas

Houston:
2 GVAR Dynamic Reactive Support (2022),
6 GVAR 2032

1st Additional Import Path by 2027

2nd Additional Import Path by 2030

Dallas/Fort Worth:
600 MVAR Dynamic Reactive Support (2022),
10 GVAR 2032

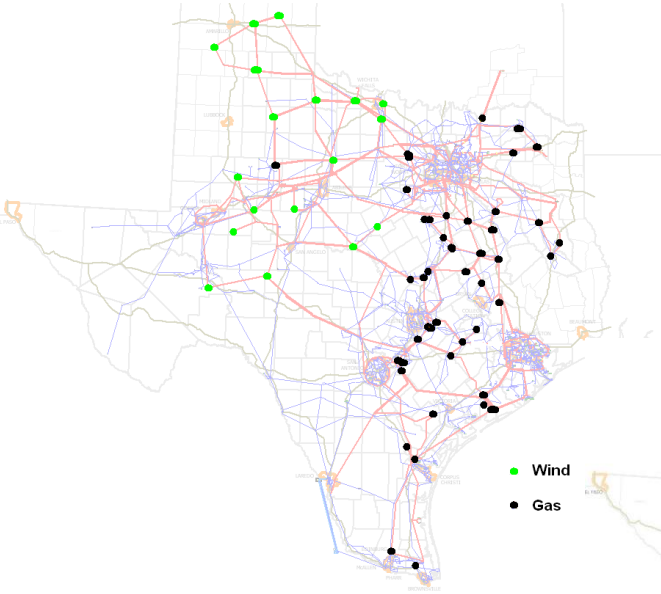
1st Additional Import Path by 2029 (w/8GVAR)

2nd Additional Import Path by 2032

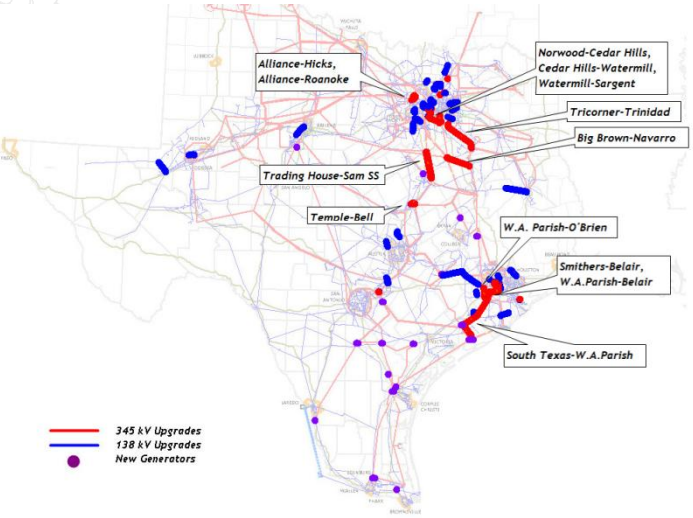
If the assumed reliability upgrades or dynamic reactive levels are not attainable, additional import paths will be required sooner.

Conclusions

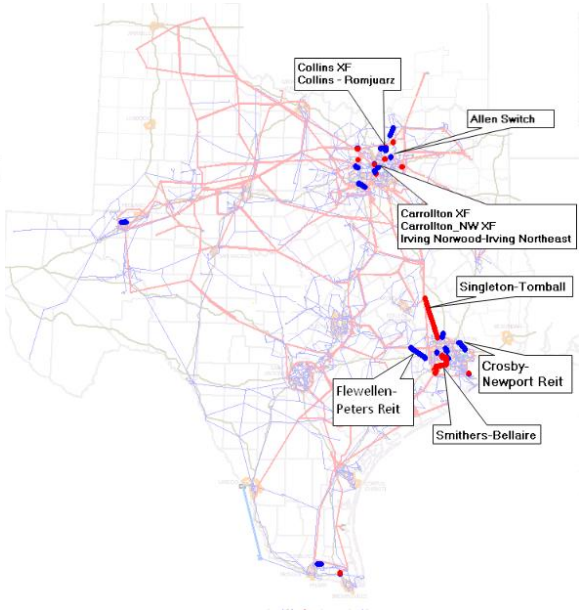
Should incremental traditional or renewable resources utilize the CREZ system as modeled in Scenario 3, certain incremental import needs in Scenario 1 (East-to-Dallas) are partially offset.



S1



S3



Conclusions

Expanded imports into the Houston Region are needed across all scenarios.

- In Scenarios 1, 2, and 3, at least one major Houston import was considered a must-have, reliability base-case upgrade by 2022. (3 for extensive NG retirements)
- In Scenario 2, multiple options demonstrate economy by 2022.
- In Scenario 3, Limestone – Gibbons Creek – Zenith demonstrates economy by 2022.

Questions?