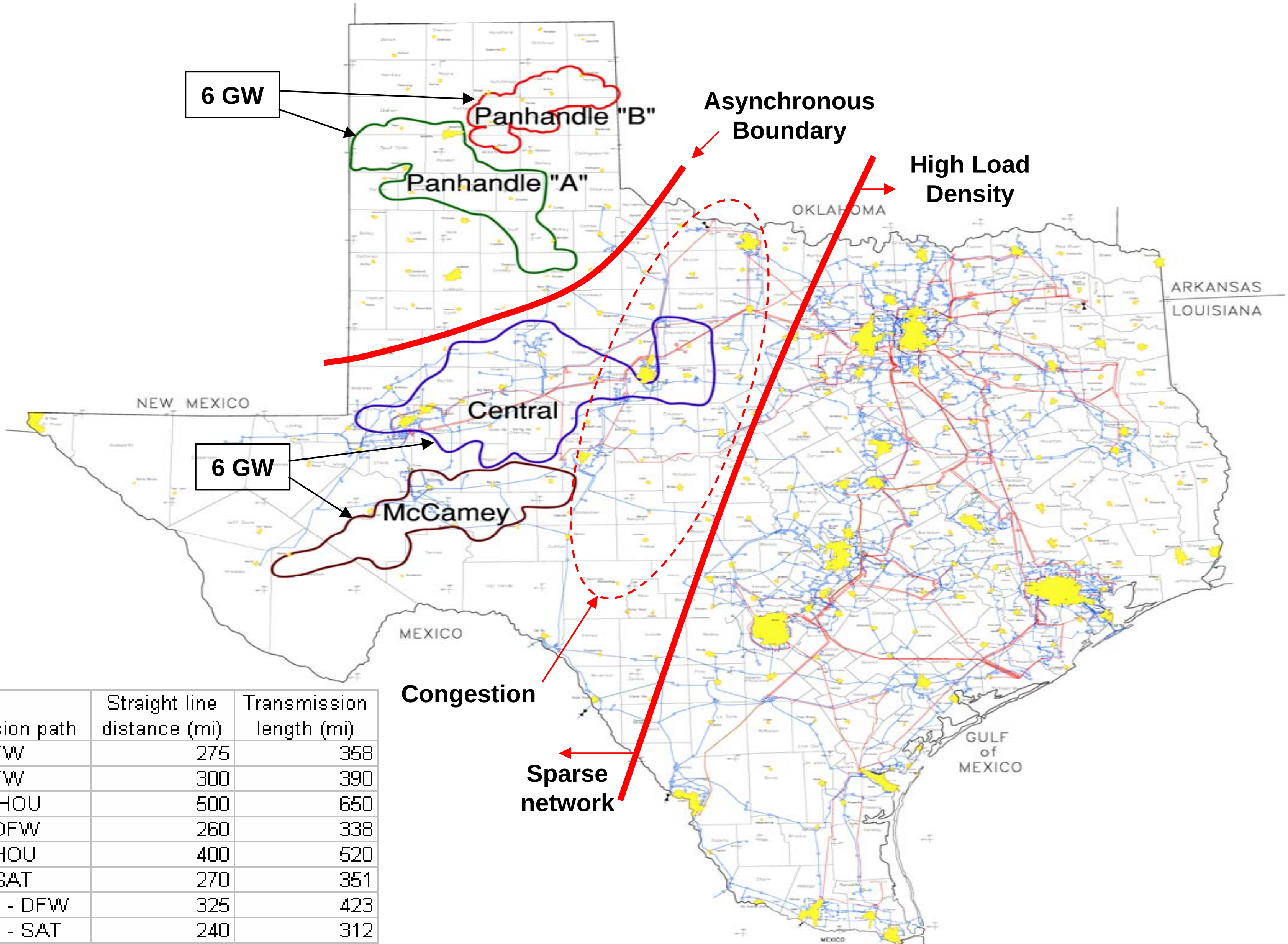
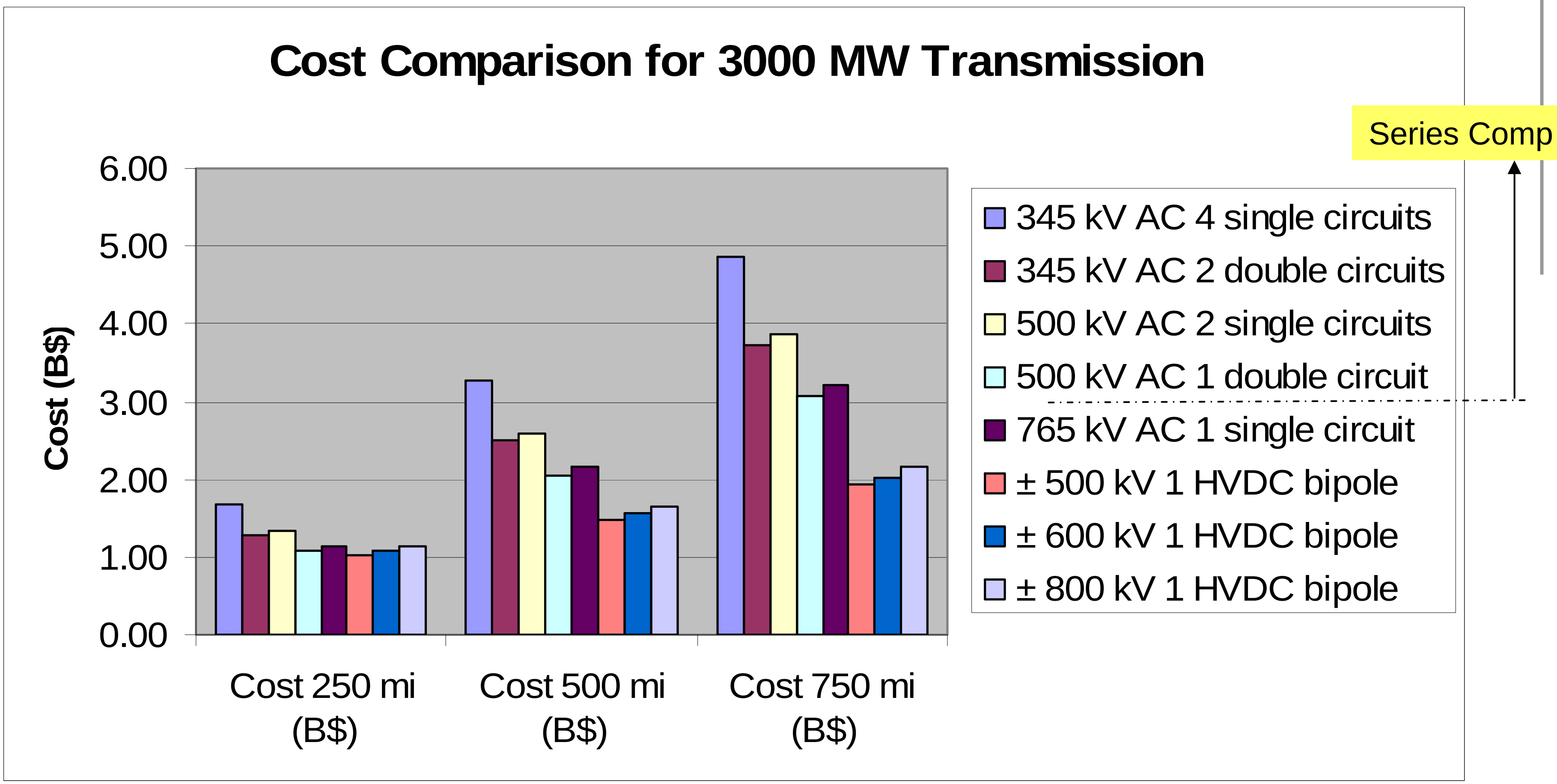
CREZ Transmission Challenges



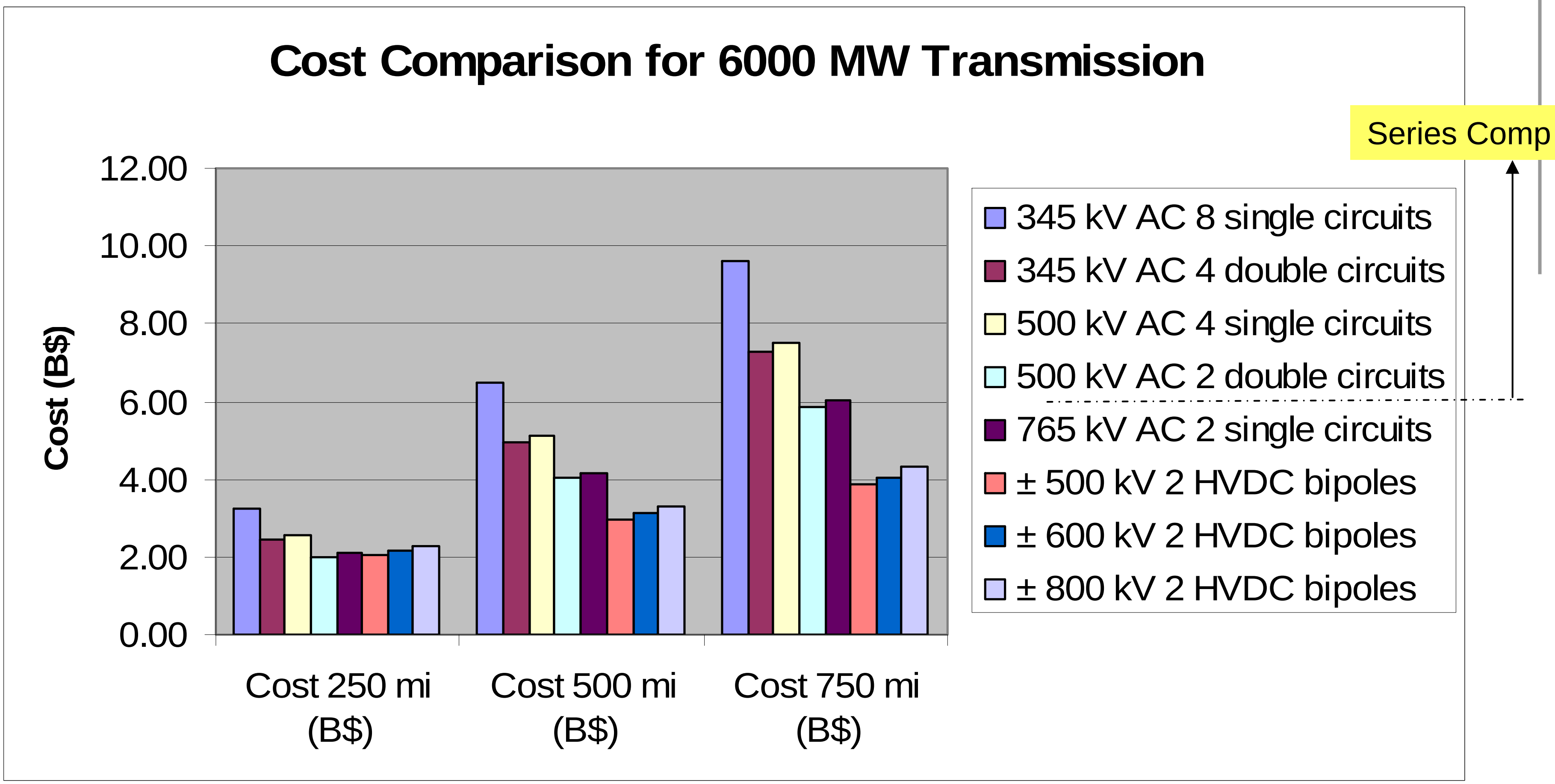
Transmission path	Straight line distance (mi)	Transmission length (mi)
PH A - DFW	275	358
PH B - DFW	300	390
PH A,B - HOU	500	650
Central - DFW	260	338
Central - HOU	400	520
Central - SAT	270	351
McCamey - DFW	325	423
McCamey - SAT	240	312
McCamey - HOU	400	520

Cost of 3000 MW Transmission Alternatives



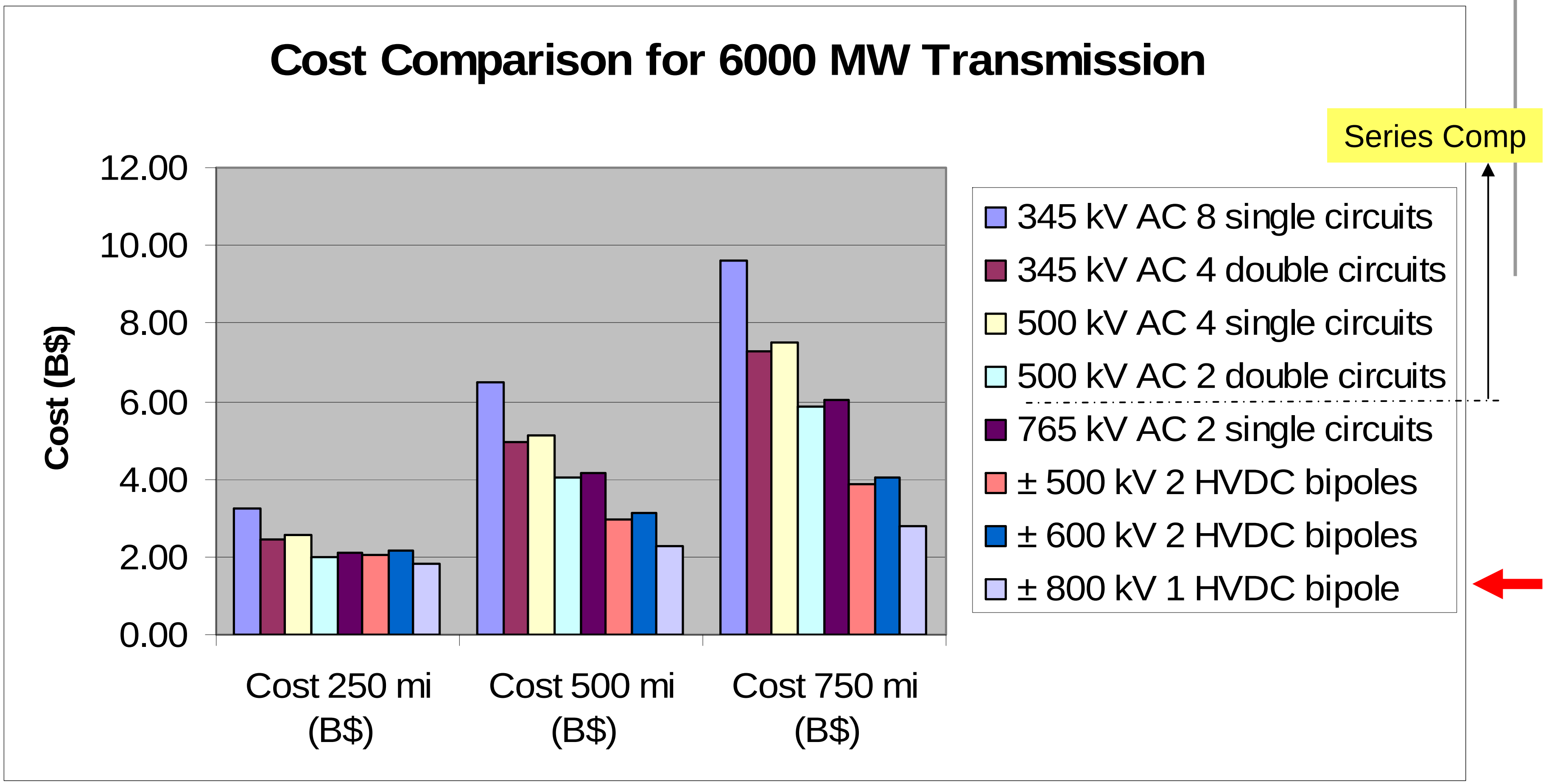
Note: Transmission line and substation costs based on Frontier Line transmission subcommittee and NTAC unit cost data.

Cost of 6000 MW Transmission Alternatives



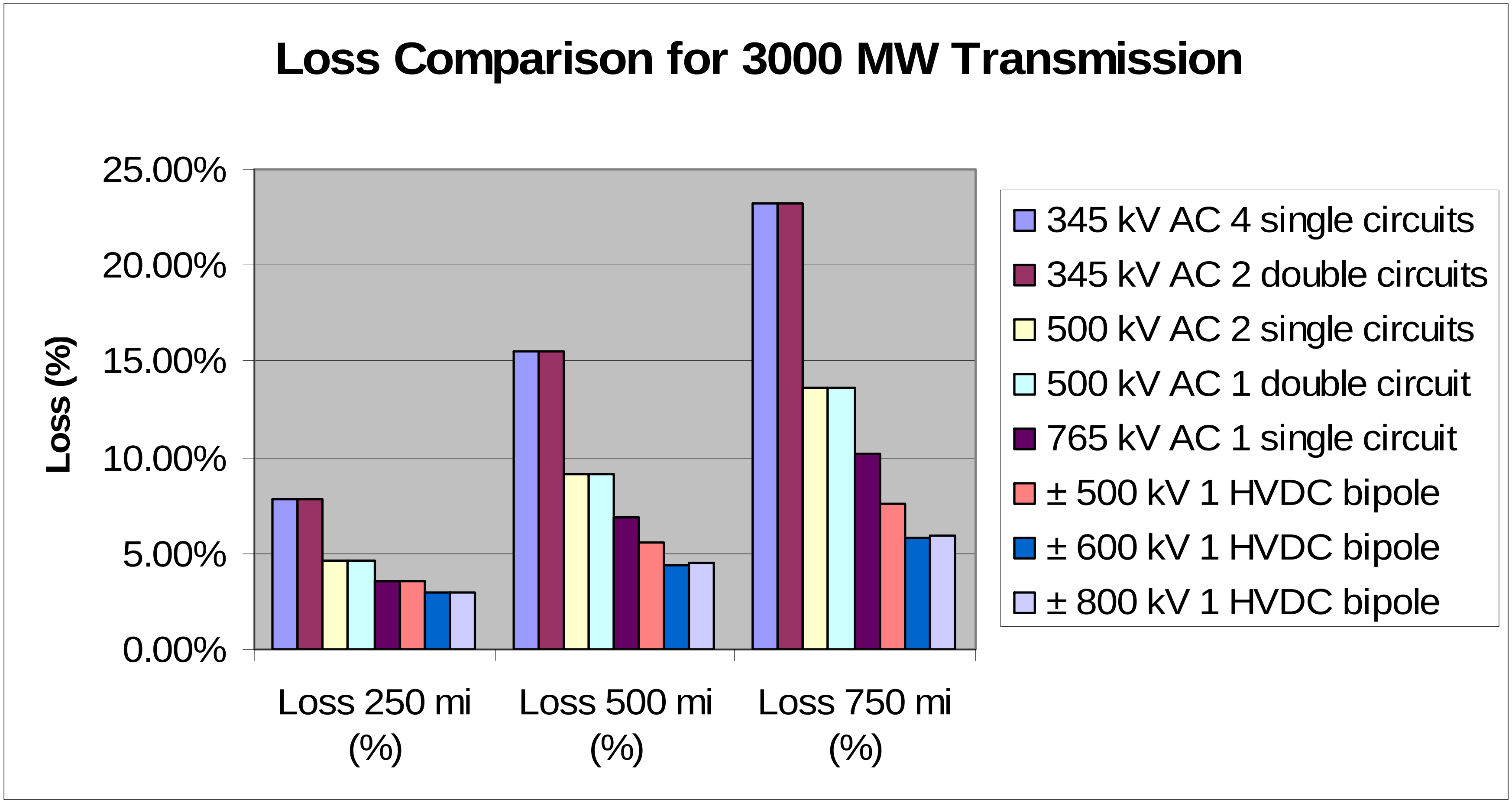
Note: Transmission line and substation costs based on Frontier Line transmission subcommittee and NTAC unit cost data.

Cost of 6000 MW Transmission Alternatives

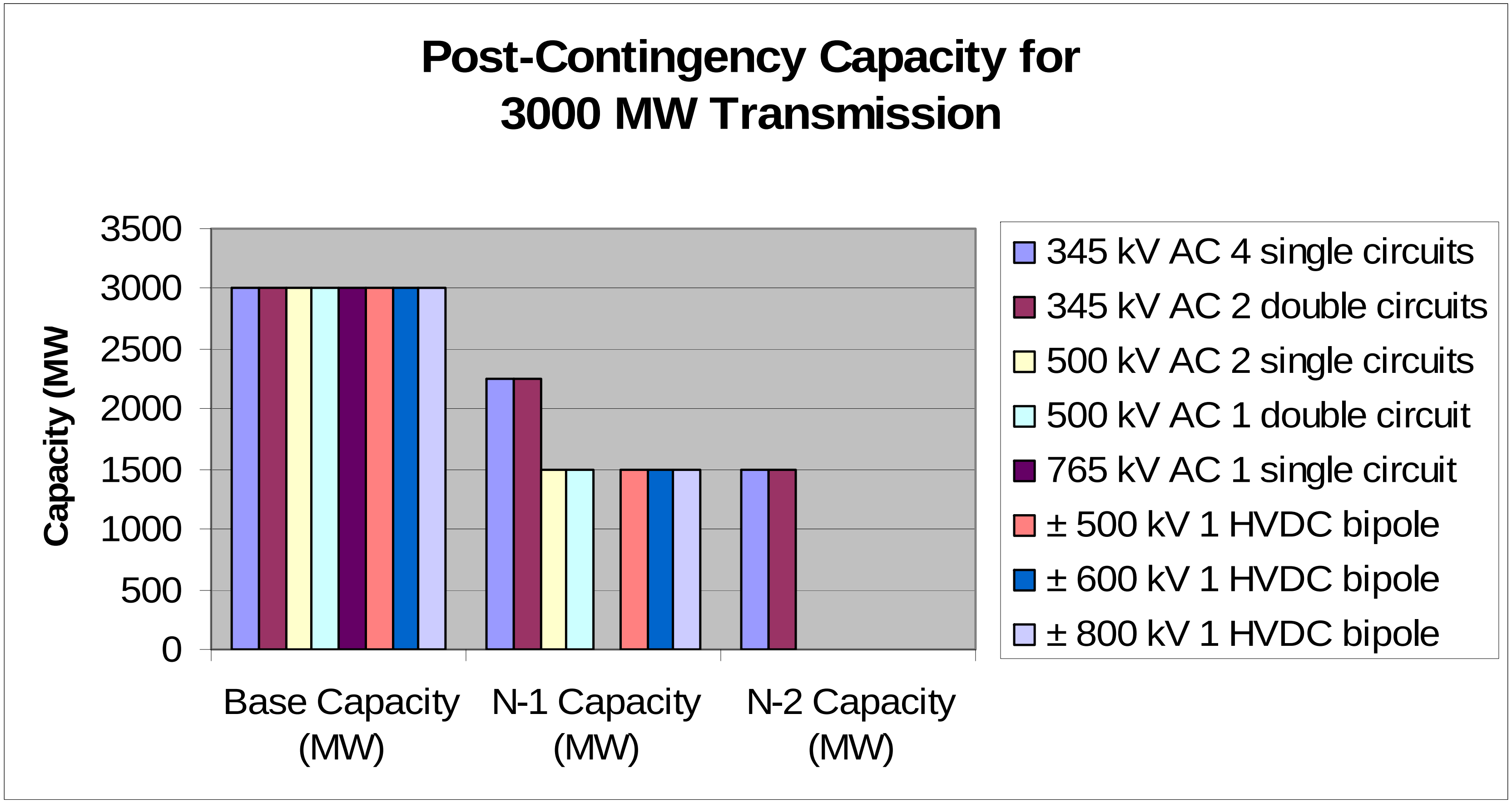


Note: Transmission line and substation costs based on Frontier Line transmission subcommittee and NTAC unit cost data.

Transmission Alternatives Loss Comparison

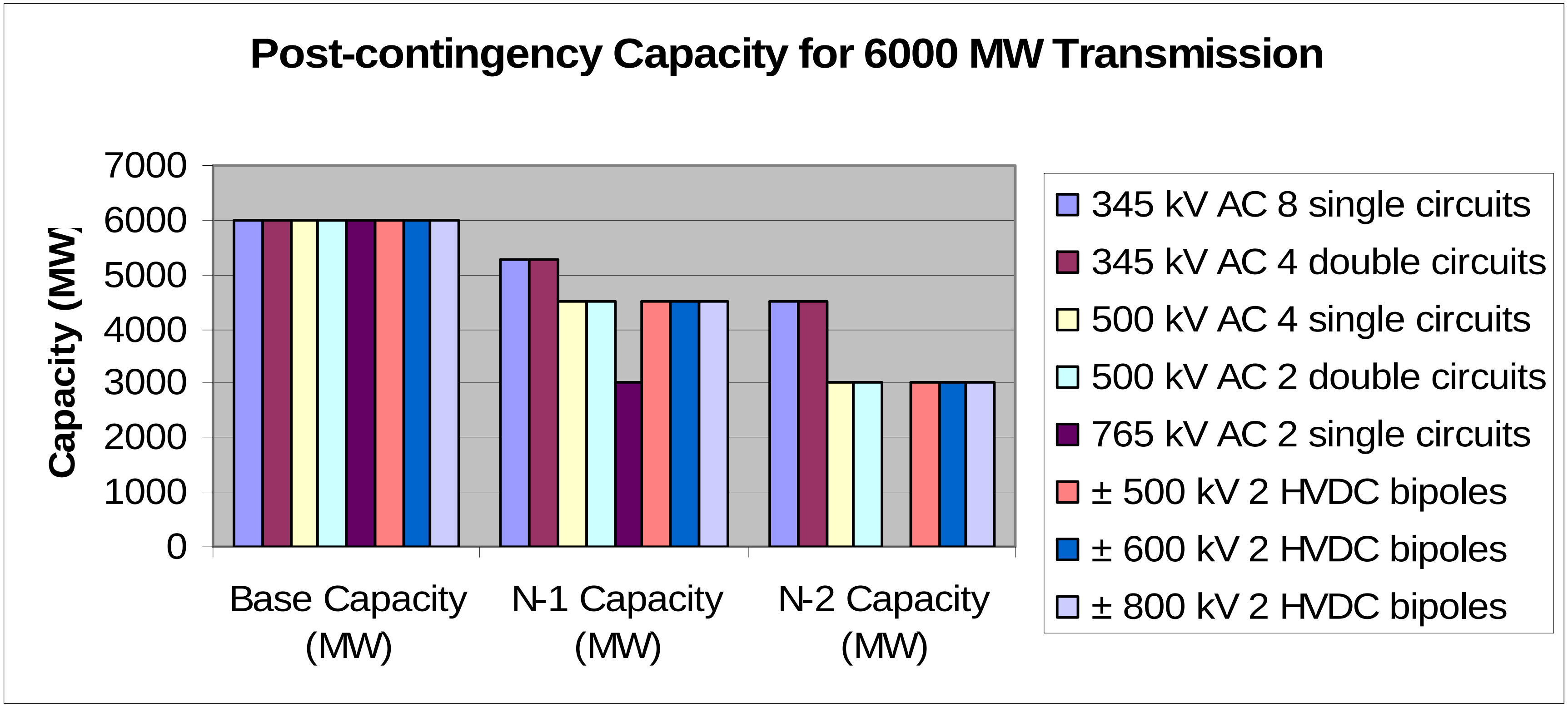


Post-Contingency Capacity – 3000 MW Base



N-1 = Loss of one circuit or pole, excluding loss of tower
N-2 = Loss of two circuits, one double circuit or bipolar line

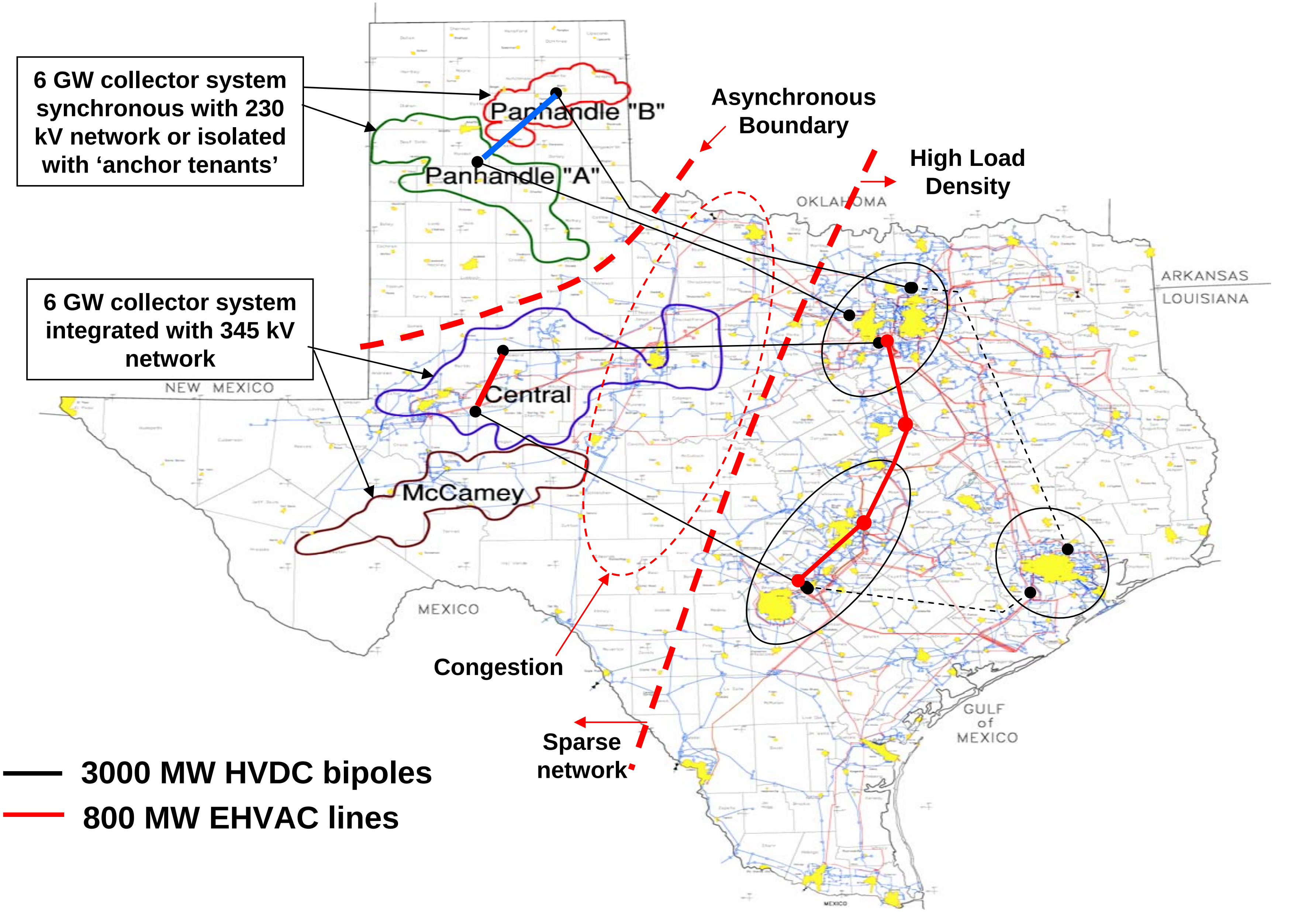
Post-Contingency Capacity – 6000 MW Base



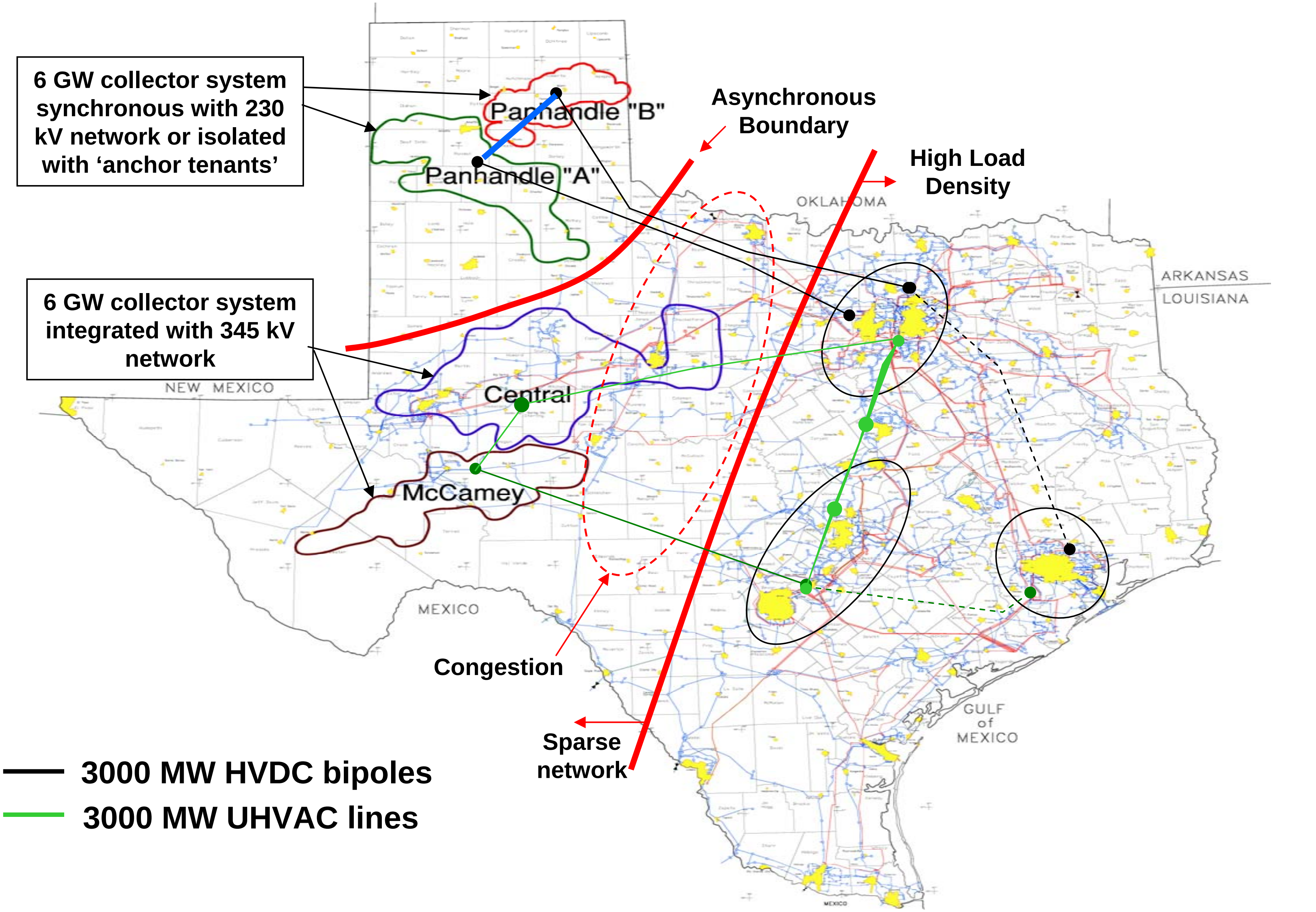
N-1 = Loss of one circuit or pole, excluding loss of tower

N-2 = Loss of two circuits, one double circuit or bipolar line

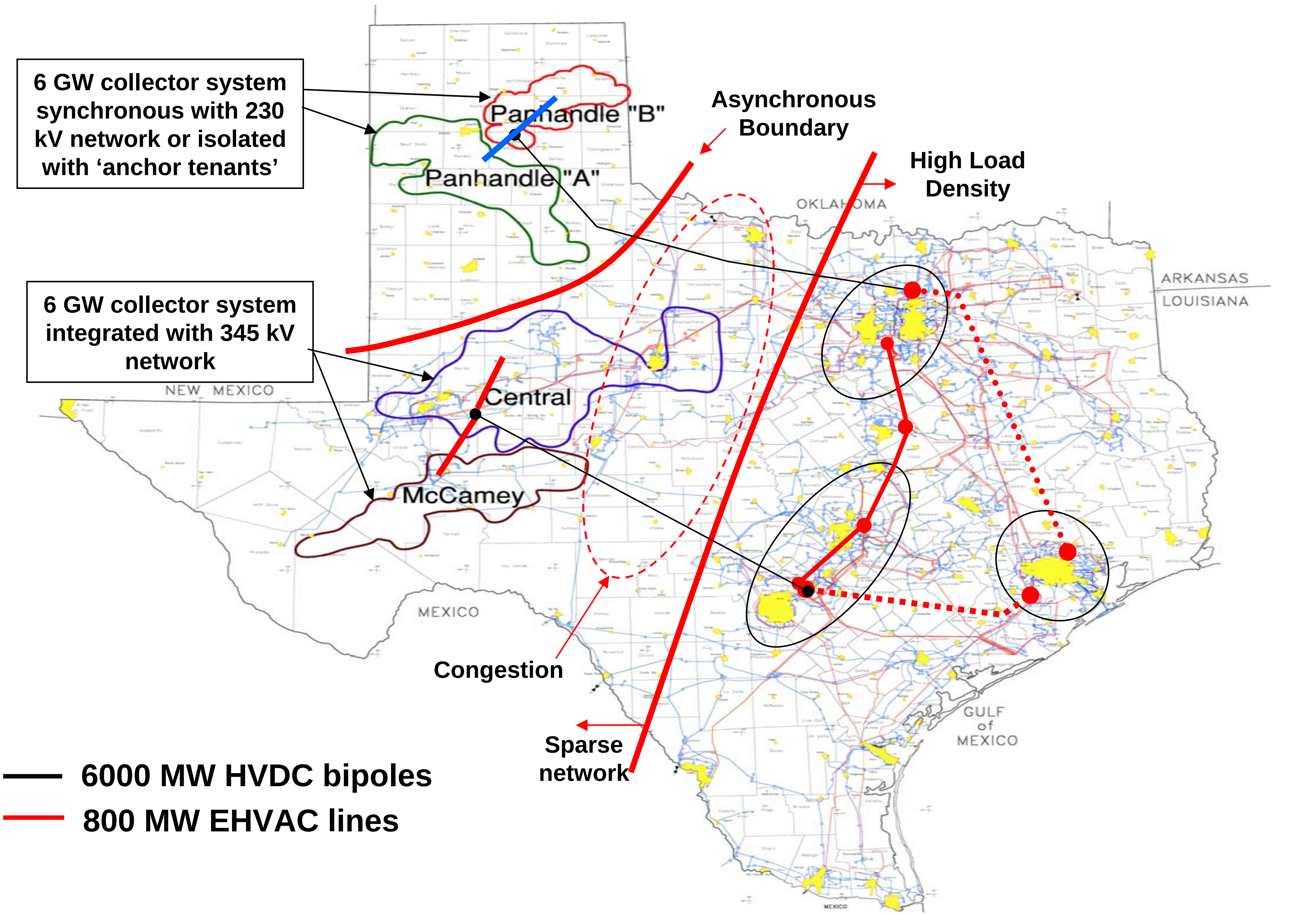
Generator Outlet HVDC, Sink-Link EHVAC



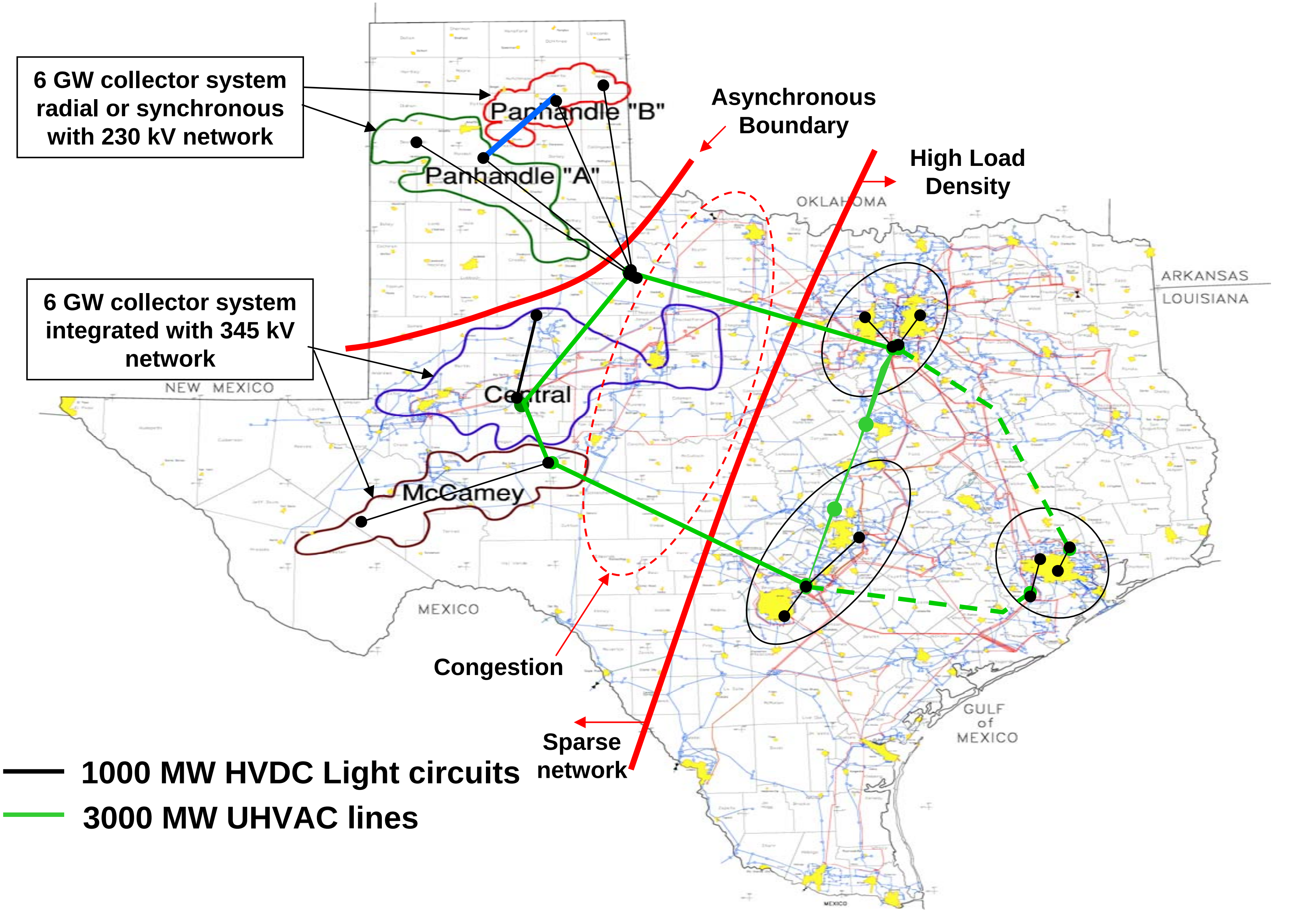
Panhandle Outlet HVDC, Central Outlet UHV AC



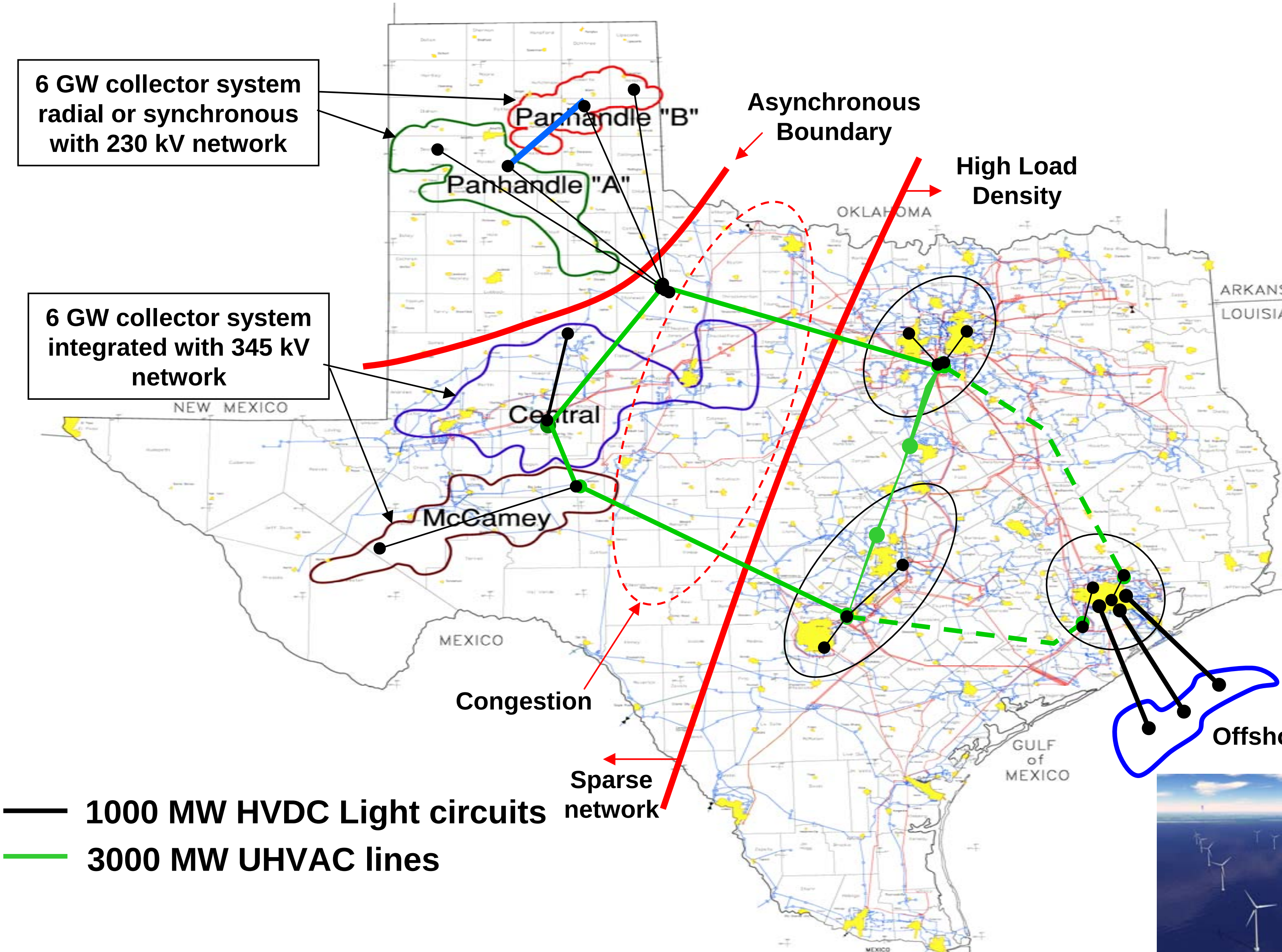
Generator Outlet HVDC, Sink-Link EHVAC

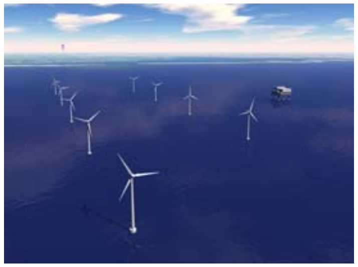


HVDC Light On/Off Ramps to UHV AC



HVDC Light – Add Offshore CREZ





Cost Benefit Screening Analysis Example

TOTAL SYSTEM

Trans Option No.	T4	Installed Cost ($Million)	1,302
		Capacity (MW)	3,000
Description	Panhandle - DFW 500 kV DC bipole		
Line Utilization	41%		

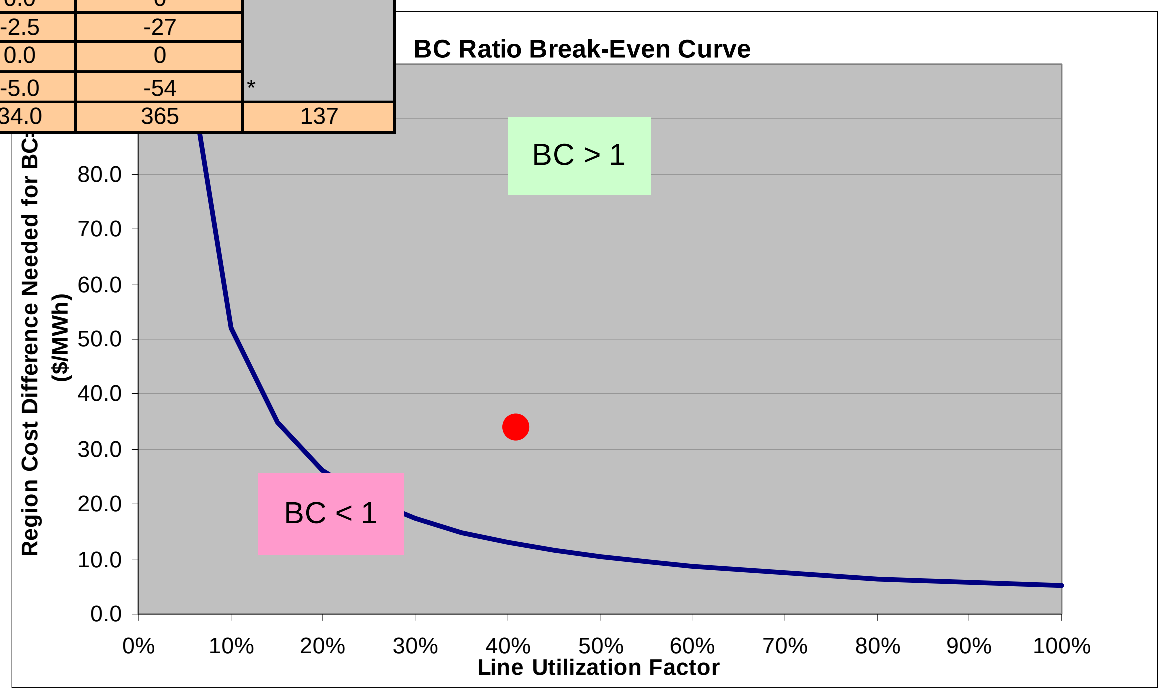
		Regional Difference			Annual	Annual
		Source	Sink	Diff	Benefits	Cost
	($/MWh)	($/MWh)	($/MWh)	($/MWh)	($Million)	($Million)
Line Cost	12.8					137
Power Cost		52.5	73.9	21.3	229	
GHG Adder		0.0	23.2	23.2	249	
CO2 for EOR		0.0	0.0	0.0	0	
Renewable Credit		0.0	0.0	0.0	0	
System Integration		3.0	0.0	-3.0	-32	
Prod Tax Credit		0.0	0.0	0.0	0	
Losses		2.5		-2.5	-27	
Grid Eff		0.0		0.0	0	
Dependable Cap Value			-5.0	-5.0	-54	*
TOTAL		58.0	92.0	34.0	365	137
Benefit to Cost Ratio	**2.66**					

*Accounting for dependable capacity difference?	Yes

Note: Example makes use of Frontier Economic Analysis Screening Tool

Source: 3500 MW Wind @35% CF
Sink: 2400 MW fossil mix

- Export transmission and S/S costs only – does not include collector system costs or receiving system reinforcements.
- Transmission distance of 400 miles to account for practical line route
- Transmission capacity deemed firm, i.e., no congestion
- Screening tool only – not production cost simulation



Cost Benefit Screening Analysis Comparison

		exas Panhandle to Dallas-Ft Worth 3000 MW Transmission Alternative			
Scenario		T1	T2	T3	T4
Source	Coal - PC				
	Coal - CCS				
	Wind	3,500	3,500	3,500	3,500
Sink	Gas CC	900	900	900	900
	Gas CT	1,000	1,000	1,000	1,000
	Coal - PC	500	500	500	500
Net Line Capacity	MW	3,000	3,000	3,000	3,000
Line Segments		2 x 345 KV (AC) dbl ckt	1 x 500 KV (AC) dbl ckt	1 x 765 KV (AC) single ckt	1 x 500 KV (DC) bipole
Line + S/S Costs	$ Million	$2,081	$1,717	$1,802	$1,302
Line + S/S Losses		10.2%	7.4%	5.6%	4.8%
Financing		Utility	Utility	Utility	Utility
GHG Adder		$40	$40	$40	$40
Dependable Capacity		Yes	Yes	Yes	Yes
GWH		10,731	10,731	10,731	10,731
		T1	T2	T3	T4
Results					
B/C Ratio		1.58	1.98	1.95	2.66
Benefits ($MM)		$334	$350	$360	$365
Costs ($MM)		$212	$177	$185	$137
Savings ($MM)		$122	$173	$175	$228
Value ($/MWh)		$11.37	$16.12	$16.31	$21.25

- Export transmission costs only – does not include collector system costs or receiving system reinforcements.
- Transmission distance of 400 miles to account for practical line route
- Transmission capacity deemed firm, i.e., no congestion
- Screening tool only – not production cost simulation

Line Loading Capability

Line Type	Voltage kV	Conductor kcmil	Thermal Limit of Line GW	Thermal Limit of Terminal Equipment GW	SIL GW	1.5 x SIL GW	Req'd no. of lines - EHVAC at 1.5 x SIL 8 GW	12 GW	Charging per 100 mi MVAr
EHVAC - UHVAC	345	2 x 954	1.2	2.4	0.4	0.6	14	21	80
	500	2 x 2312	2.9	3.5	0.8	1.3	7	10	180
	765	5 x 795	6.0	4.0	2.3	3.5	3	4	460
	1000	8 x 795	12.5	5.2	3.9	5.9	2	3	800
HVDC	±500	3 x 2515	5.3	4.0	n.a.	n.a.	2	3	n.a
	±600	3 x 2515	6.3	4.8	n.a.	n.a.	2	3	n.a
	±800	5 x 795	7.6	6.4	n.a.	n.a.	2	2	n.a

- More lines are needed with lower transmission voltage. Loadability increases and number of ac lines can be reduced by series compensation.
- Potential issues with induction generation and series compensation.
- Fewer lines and less need for series compensation with UHV. More shunt compensation is needed at light load to absorb excess charging.
- Larger contingency impact with fewer lines or circuits – savings v SPS
- Conventional HVDC converters are subject to minimum short circuit capacities relative to transmitted power – ac voltage stability issue
- Reactive power compensation issues: AC – distributed, DC - local
- Interconnection issues are similar – the collector and receiving networks must be able to handle the power