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Powering Mexico's Future: An In-Depth Look at Long-Term Electricity Market Developments

Analysis Conducted by a Team of Analysts from:

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U.S. Department
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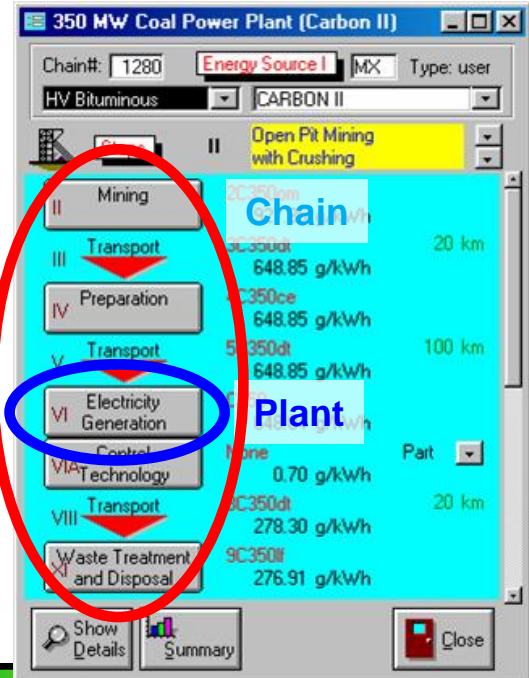
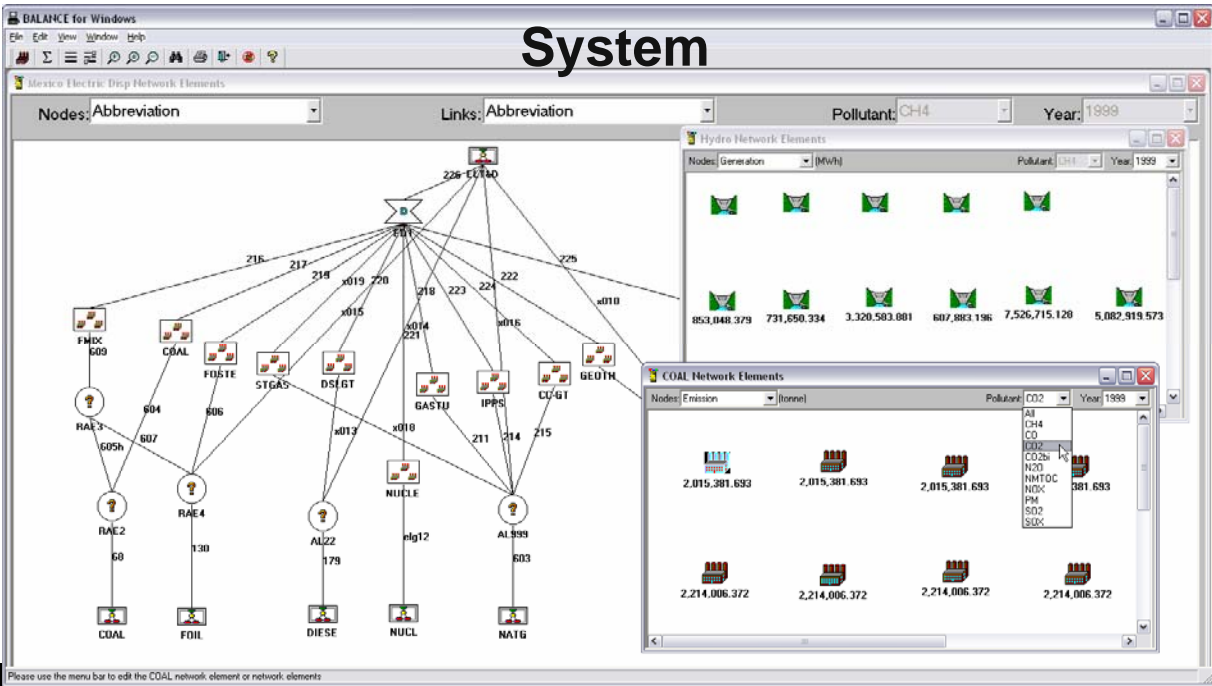
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The Team of Analysts Used the DECADES-WASP Tool Set to Conduct the Analysis

- Plant-level analysis for project evaluation
- Fuel chain-level analysis for comparative assessment of entire fuel chains
- System-level analysis for full-scale system expansion analysis up to 30 years using a dynamic optimization approach



The Team Analyzed a Total of 14 Scenarios

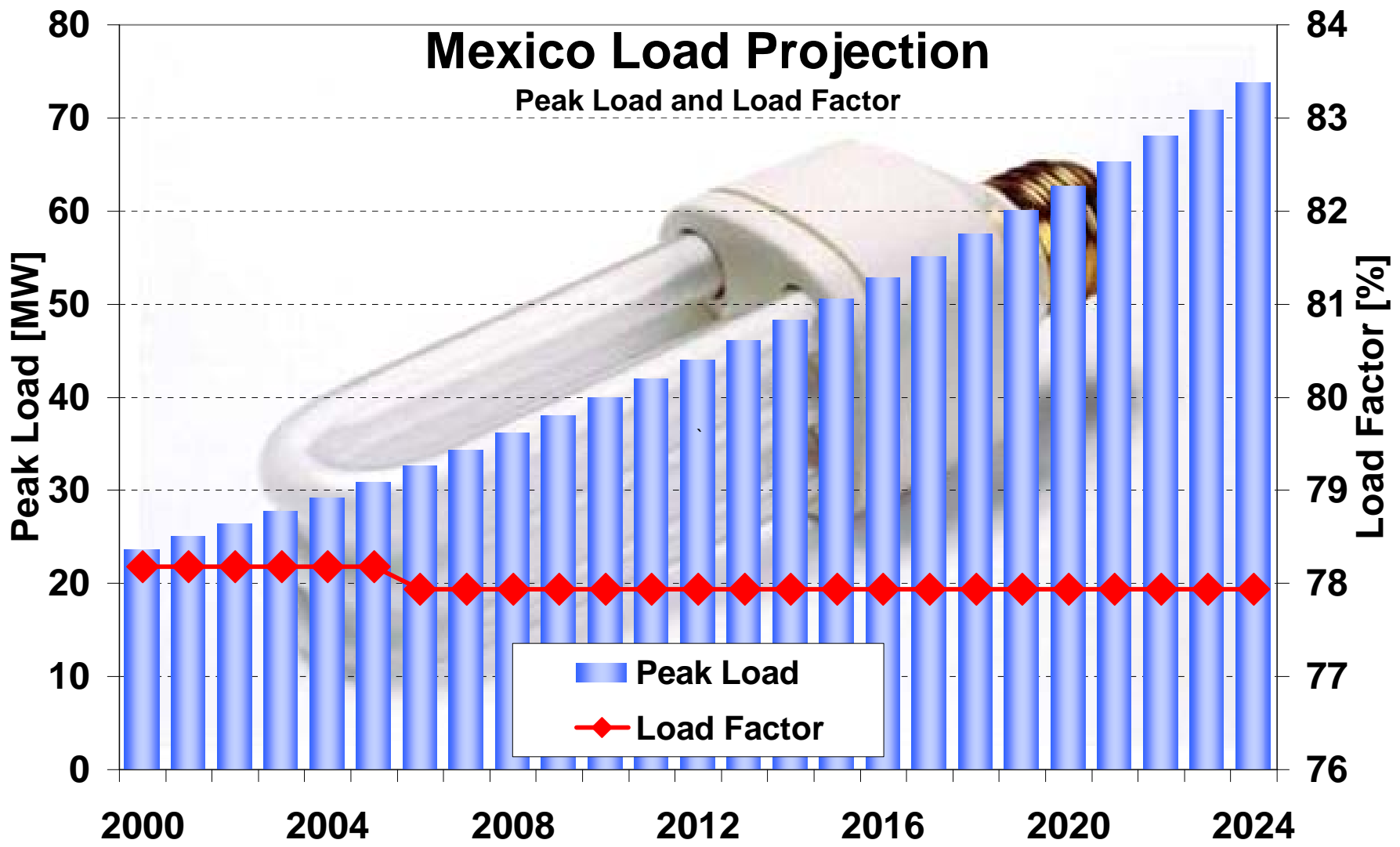
- Reference case
- High-load growth case (6.5% instead of 5.6% per year)
- Limitations on natural gas supply
 - Limit on annual additions of combined cycle units
 - Limit on power sector gas supply (supply constant after 2010)
- Variations on fossil fuel prices
 - Natural gas increases to 4.0 instead of 2.9 \$/mmbtu
 - Natural gas peaks at \$12.0/mmbtu and then declines to \$4.0/mmbtu by 2024
- Nuclear scenario
 - One forced nuclear unit
 - Reduction in nuclear capital costs to the point where nuclear enters the market
- Variations on discount rate (8% to 12%; 10% under Base Case)
- Variations on target system reliability
 - Increased reliability (loss of load probability of 1 day per year instead of 3 days)
 - Decreased reliability (LOLP of 5 days)
 - Decrease in system reserve margin

Reference Case General Assumptions

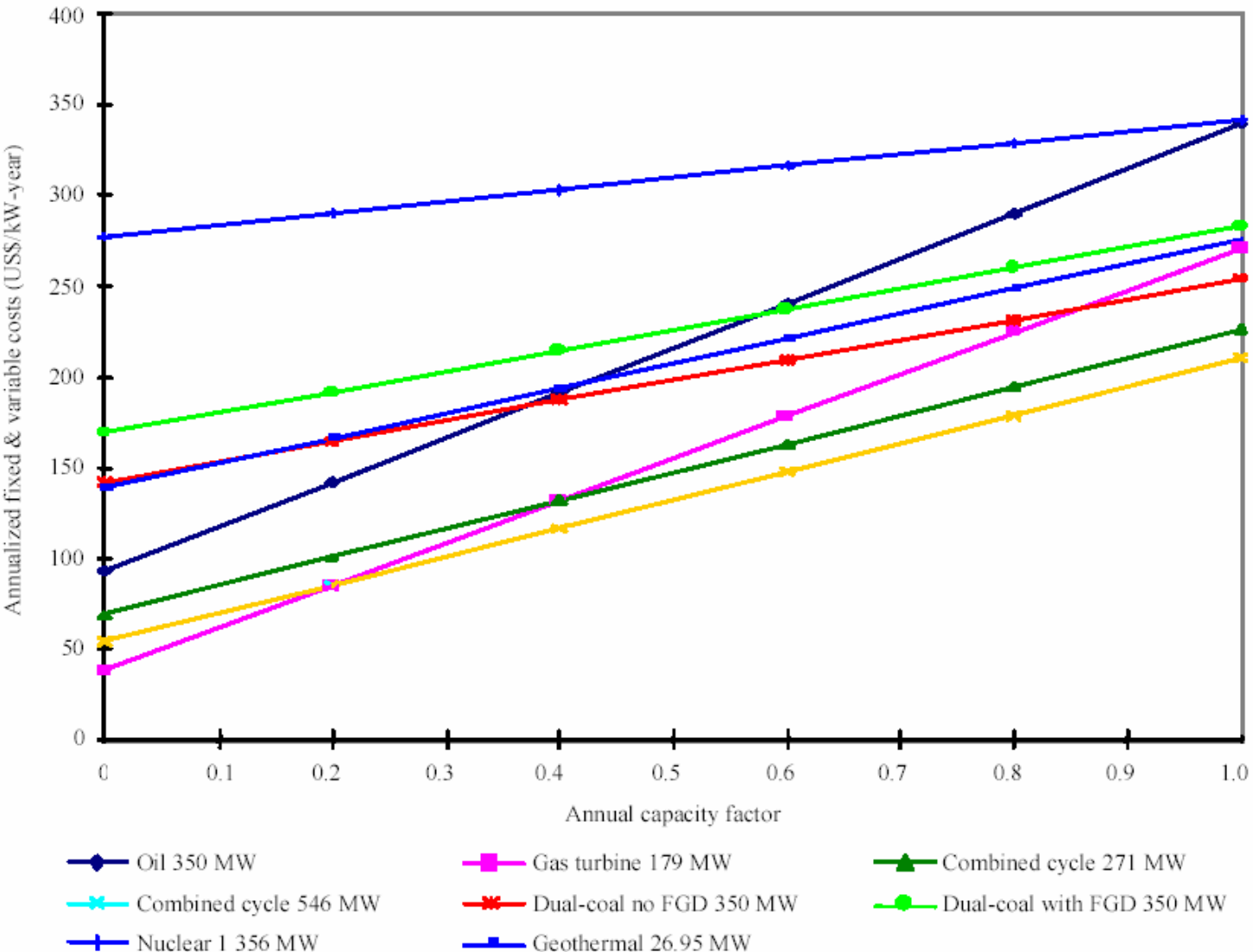
- Discount rate of 10%
- Cost of energy-not-served of 1.5 \$/kWh
- Target loss-of-load probability of 3 days/year or 0.82%
- Target range for system reserve margin of 10-30%
- Three seasons for inter-annual load variations (March-June, July-October, November-February)
- Three hydrological conditions and associated probabilities of occurrence
 - Dry: 19.0%
 - Medium: 58.7%
 - Wet: 22.3%
- Fuel prices according to the following table

Year	Fuel oil barrels	Natural gas 1000 cf	Imported coal 1000 kg (0.7% sulfur)	Enriched uranium g
1998	17.69	2.88	31.15	2.02
2027	20.70	2.95	25.99	2.34

Reference Case Assumption: Peak Load Grows from 23.5 GW (2000) to 73.7 GW (2024)



The List of Expansion Candidate Technologies Was Narrowed Down from a Larger Set by Using Screening Curves

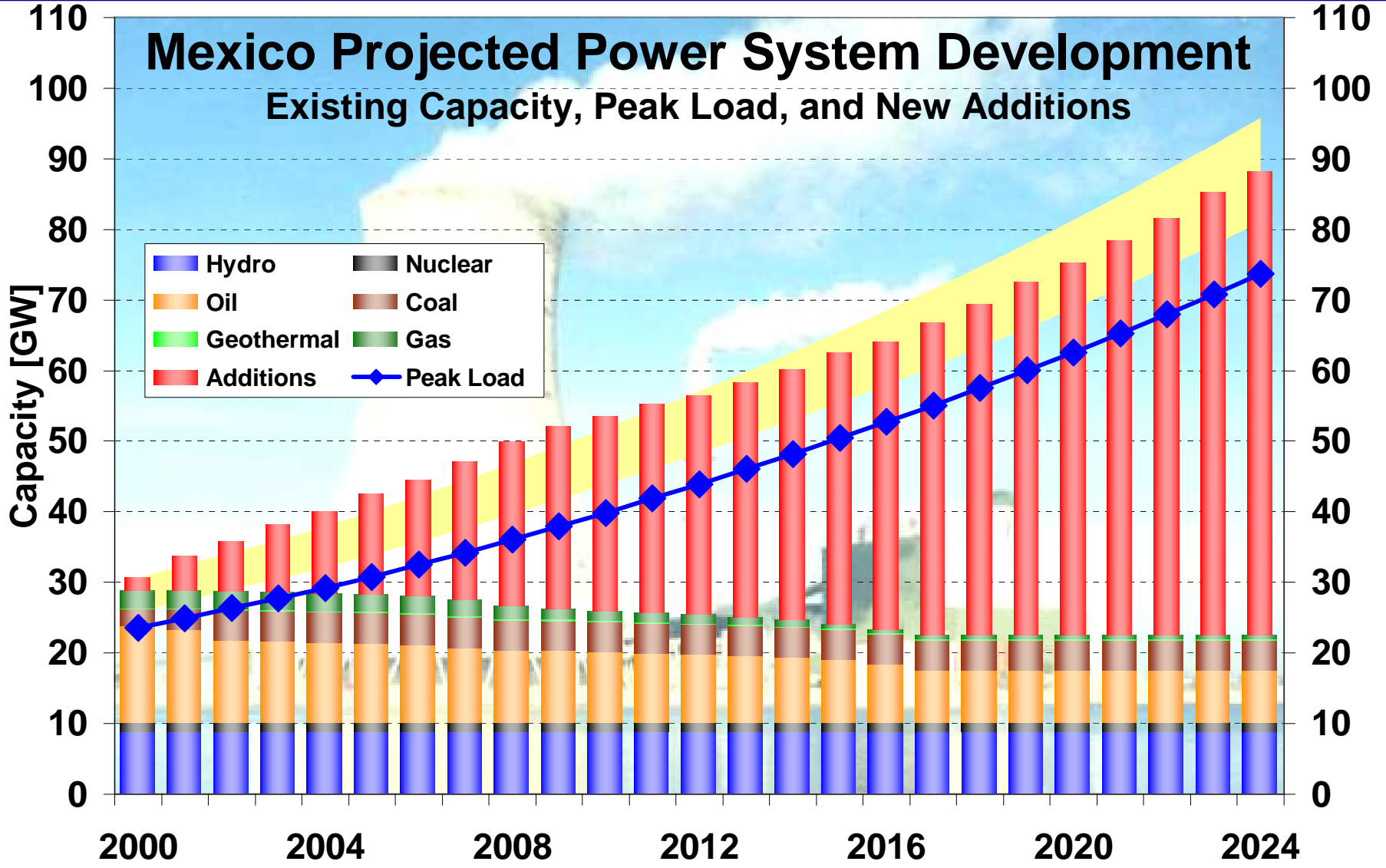


Final List of Candidate Technologies For System Expansion Includes the Following

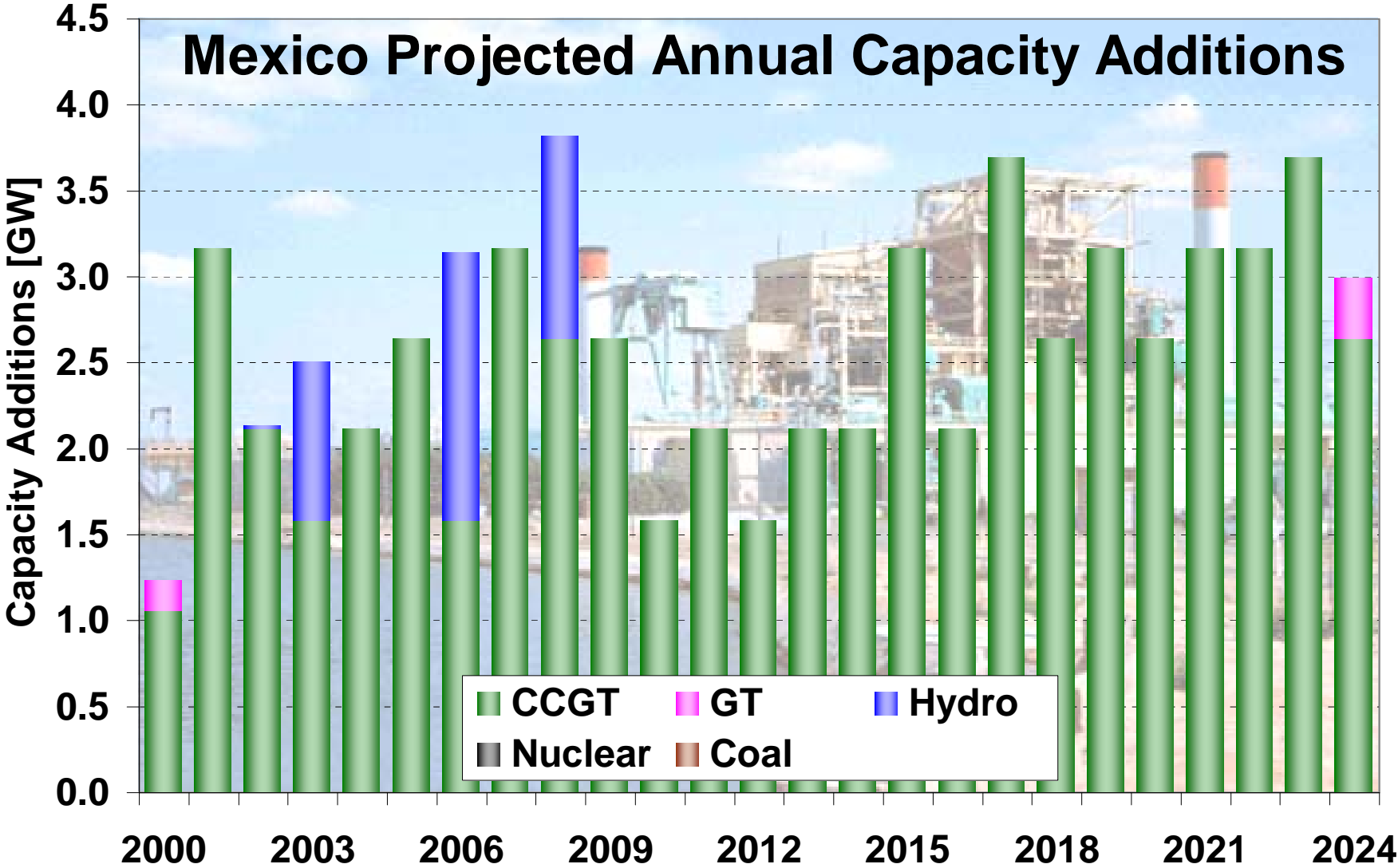
- Information comes from COPAR/CFE compiled from information on recently constructed plants, plants under construction, information from other countries, and information from plant manufacturers; costs are in US\$1998

Candidate	Capacity [MW]	Heat Rate [kcal/kWh]	Capital Cost incl. IDC [\$/kW]	Plant Life [years]	Construction Period [years]	IDC [%]
Gas Turbine	175	2,624	346	30	2	8.1
CCGT	527	1,763	427	30	2	8.1
Coal	310	2,597	1,468	30	4	15.6
Nuclear	1,314	2,570	2,485	40	8	29.2

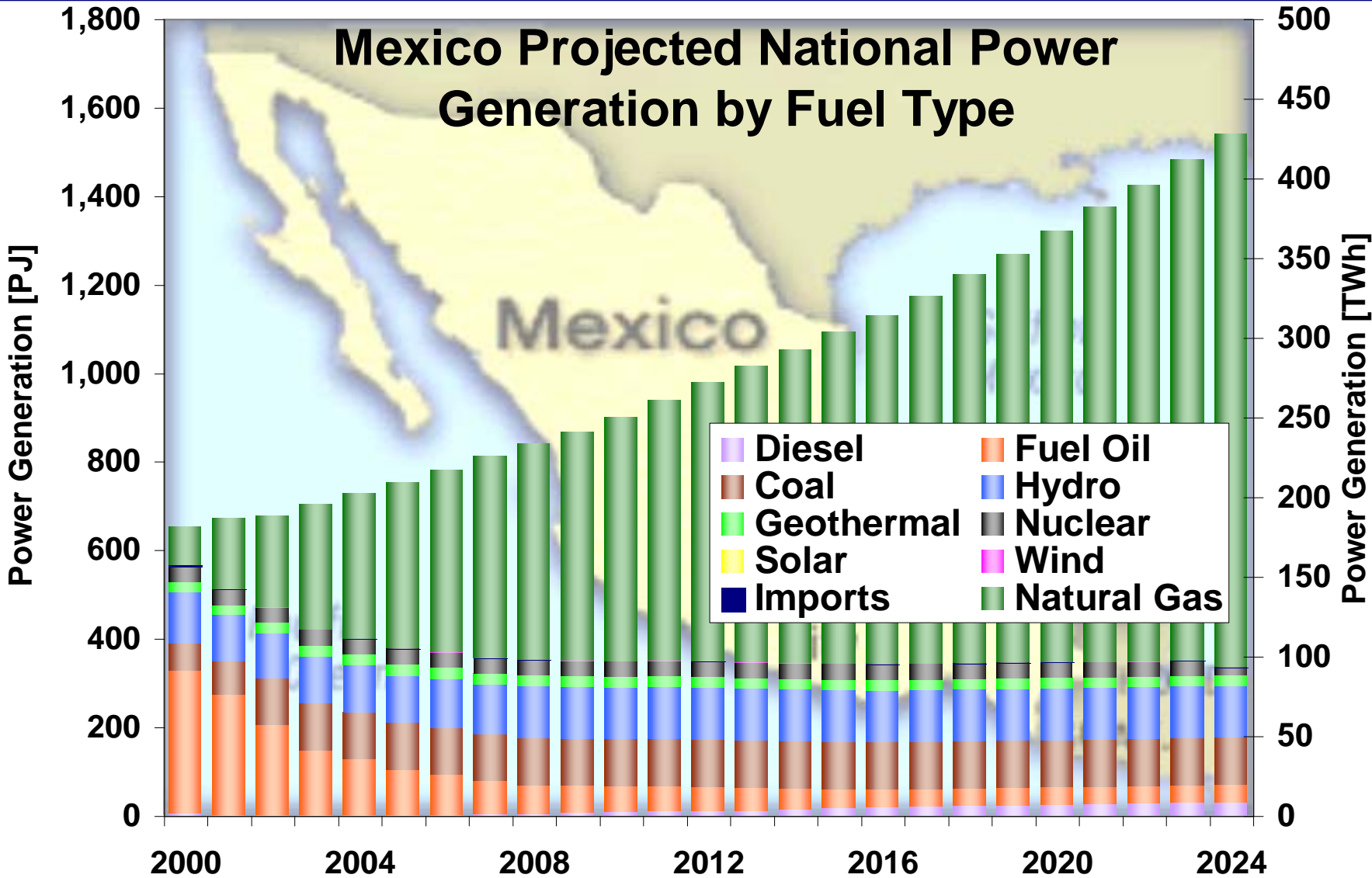
Capacity Additions 2000-2010: 26.9 GW
Capacity Additions 2000-2024: 65.2 GW



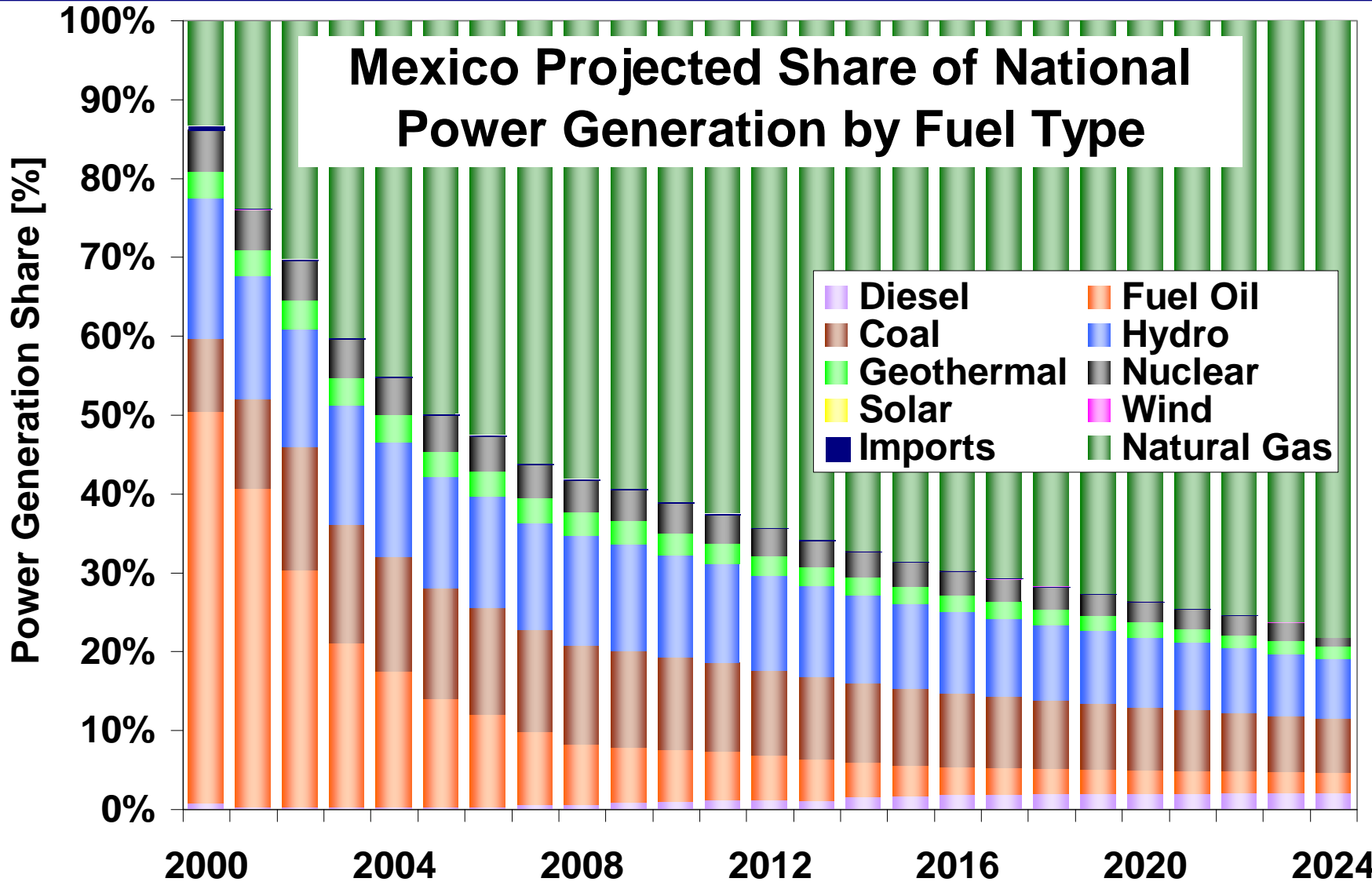
Reference Case Capacity Additions Are Dominated by Natural Gas



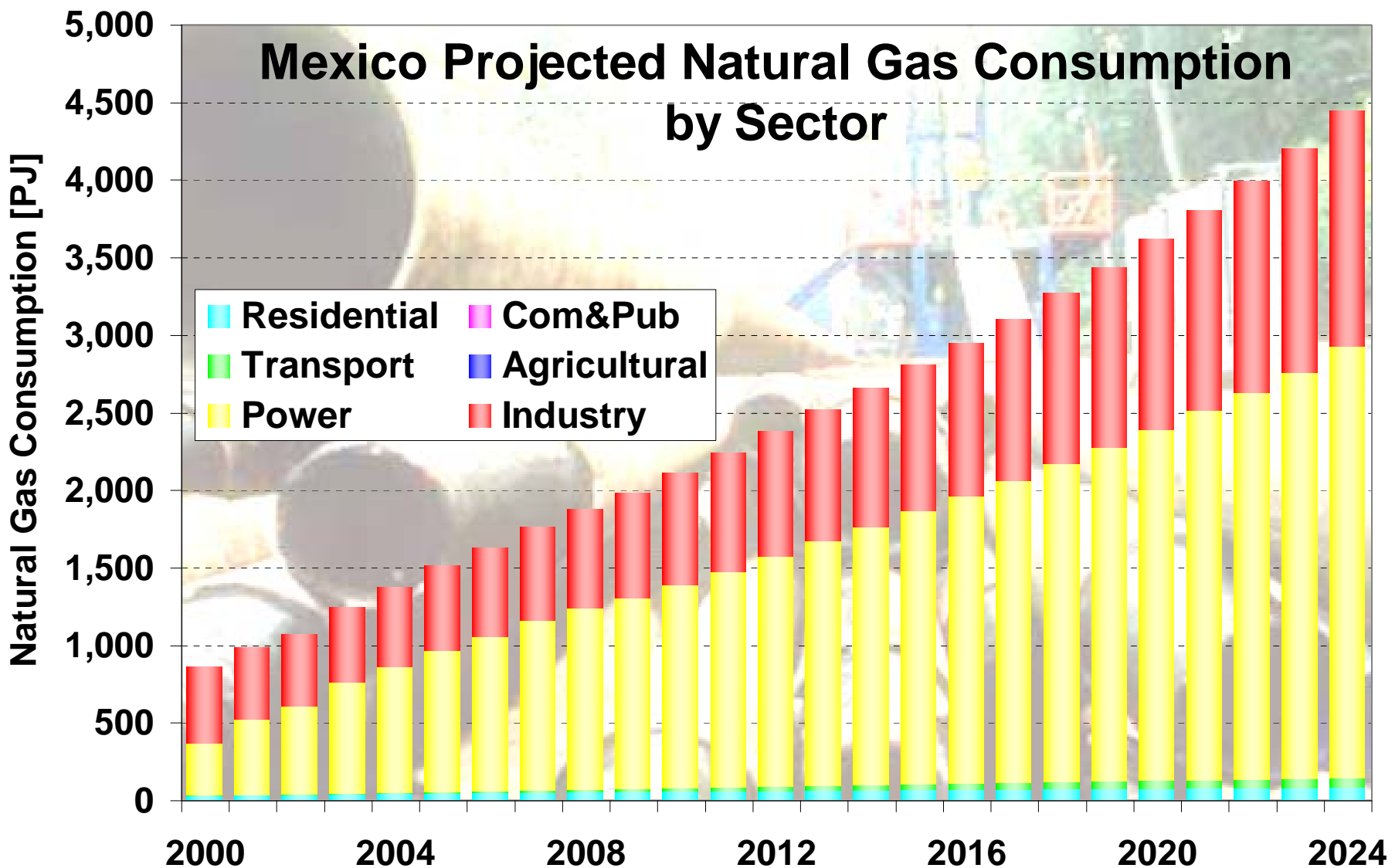
Gas-Fired Power Generation Grows at 11.6% per Year from 24 TWh (2000) to 335 TWh (2024)



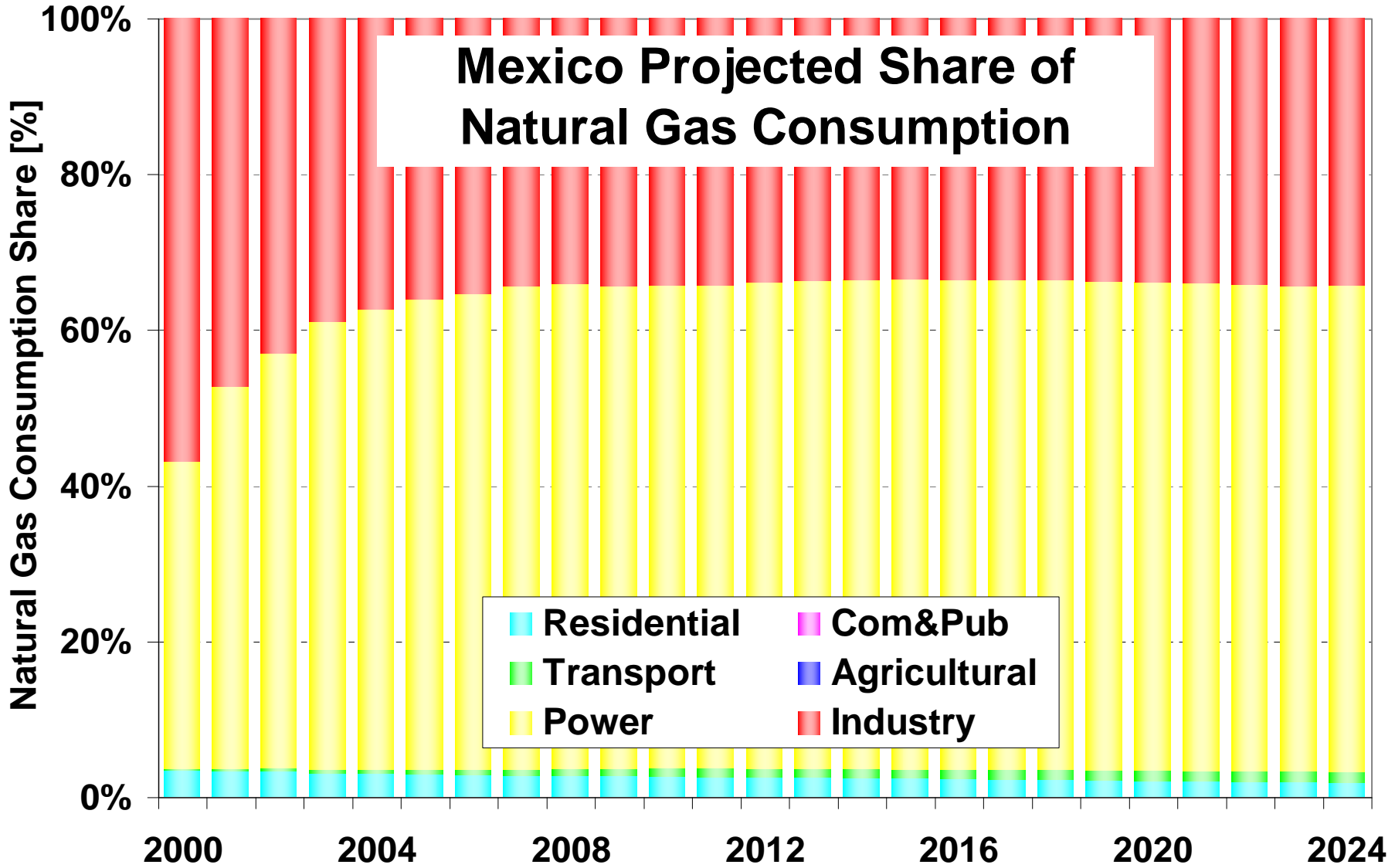
Natural Gas-Fired Generation Will Account for 78% of Total Generation by 2024, up from 13% in 2000



Power Sector Gas is Projected to Grow at 9.2%/yr from 339 PJ (2000) to 2,780 PJ (2024); Overall Gas Demand Grows at 7.1%/yr from 858 PJ (2000) to 4,447 PJ (2024)

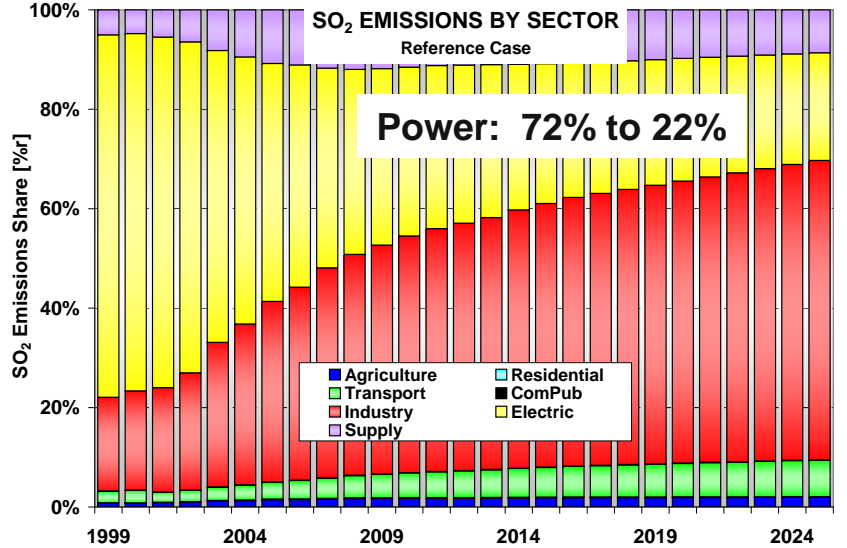
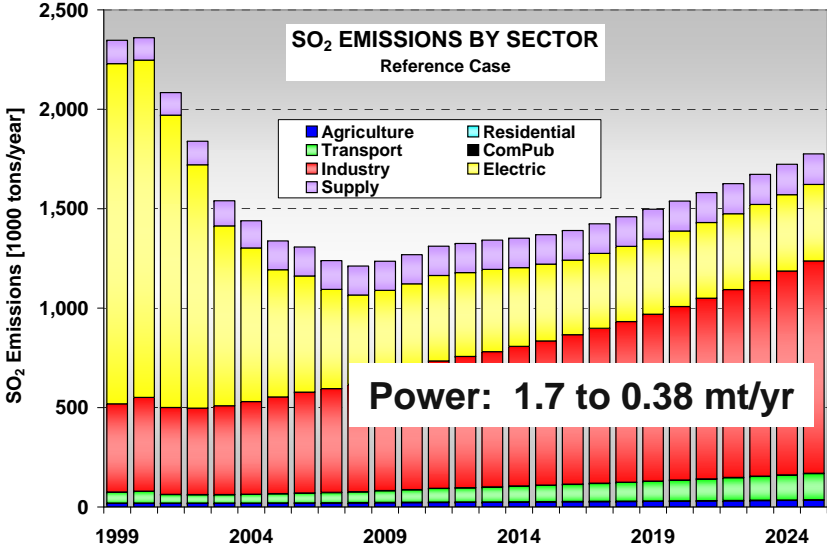
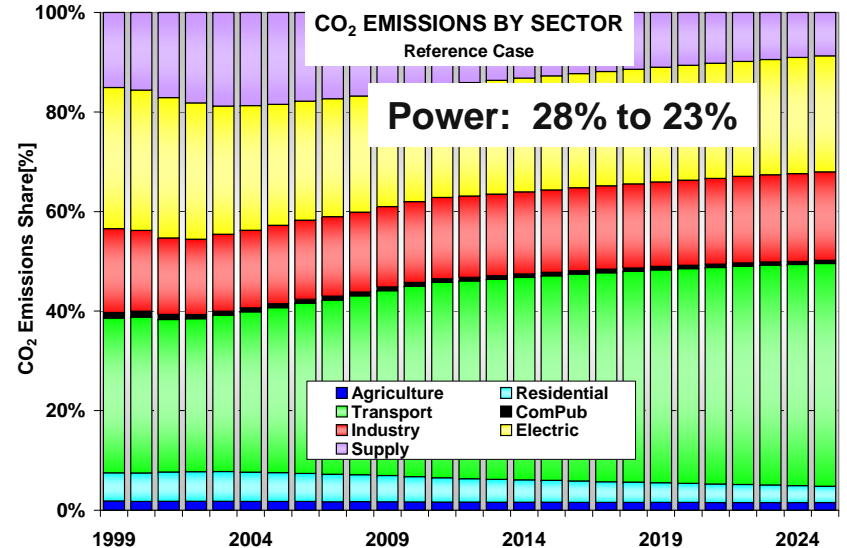
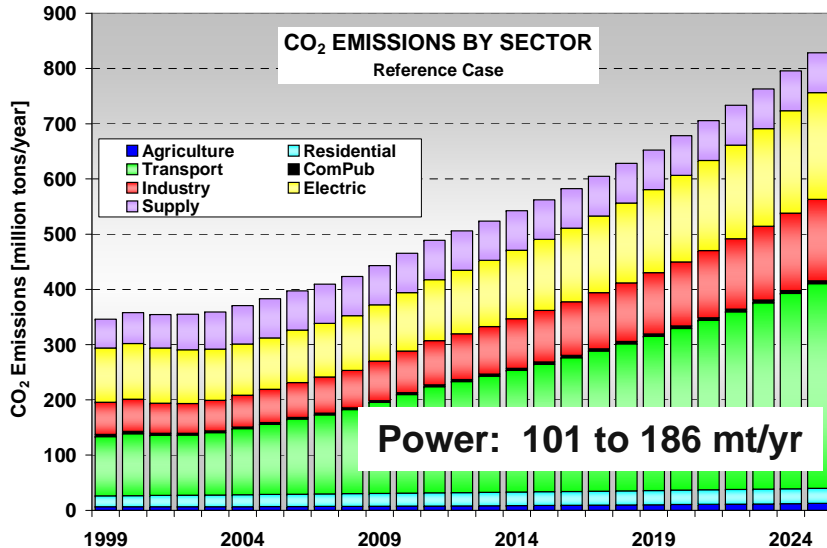


Power Sector Will Account for 63% of Total Gas Demand by 2024, up from 39% in 2000



Reference Case Emissions by Sector:

CO₂ will Increase from 346 to 828 million tons/year
SO₂ will Decrease from 2.3 to 1.8 million tons/year

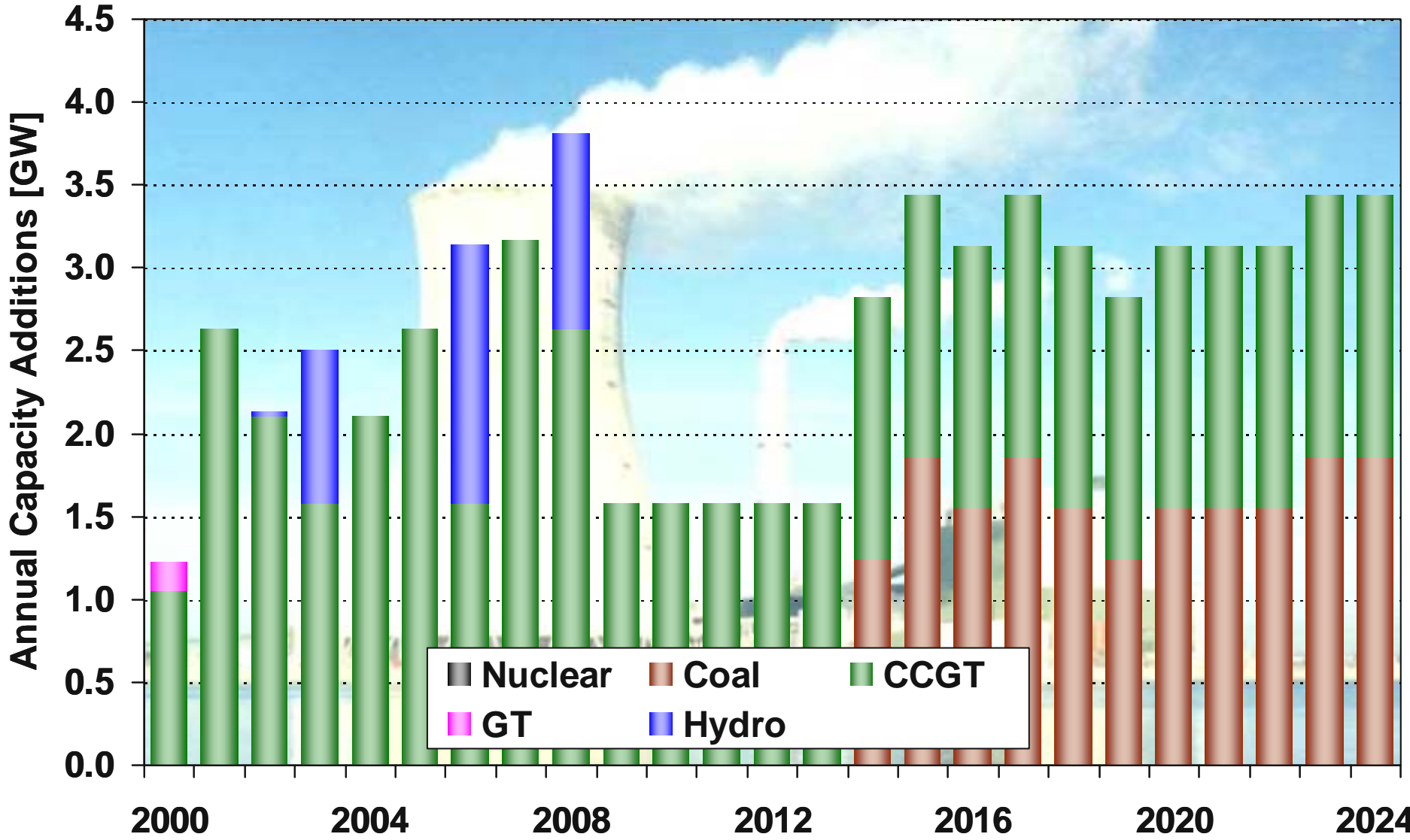




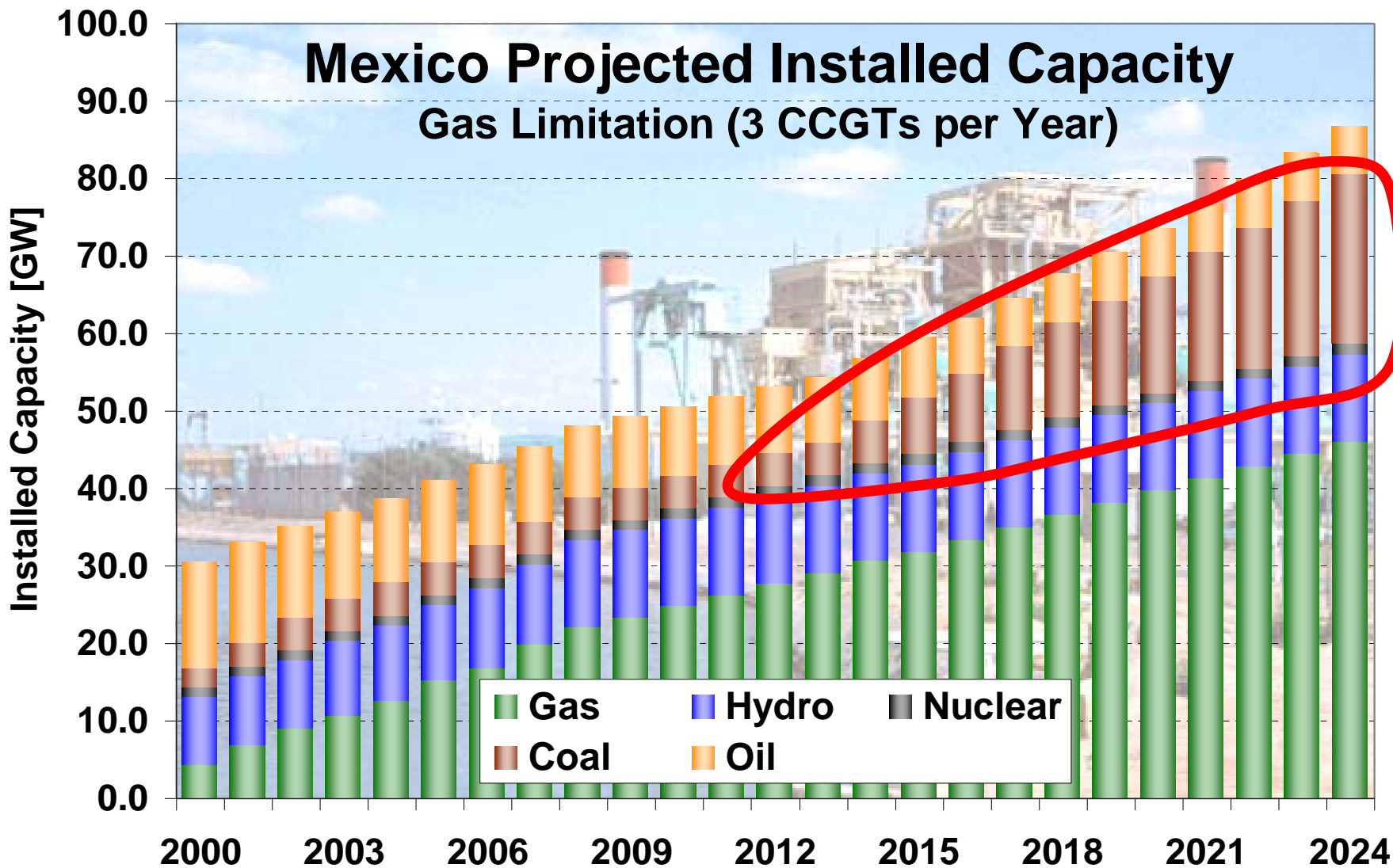
Results for Limited Gas Supply Scenario

Maximum of 3 CCGT Units per Year

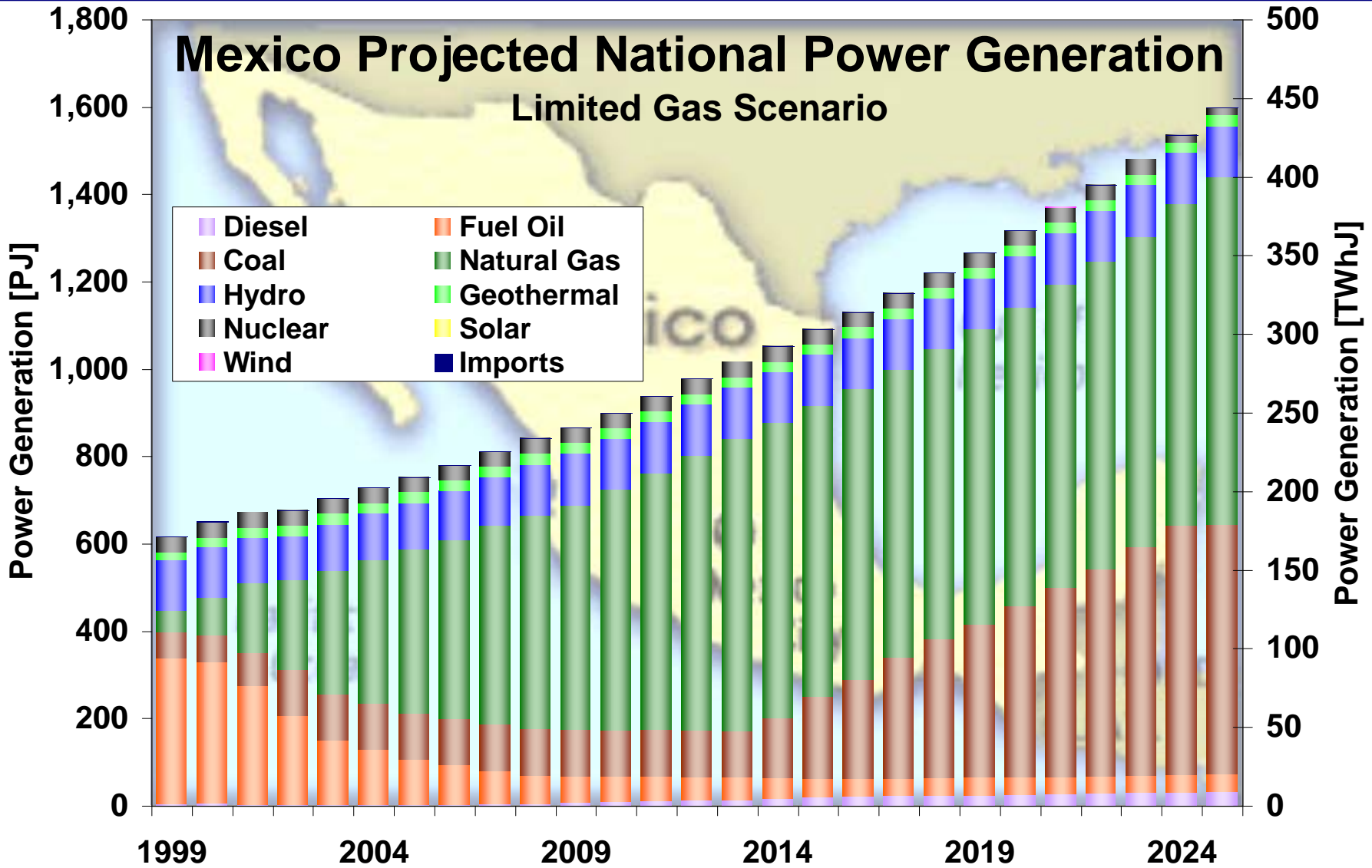
With CCGT Limitation, A Total of 57 Coal Units Enter the Market and Replace Mostly 33 CCGT Units Starting in 2014



By 2024, CCGT Limitation Results in 17.7 GW of Coal Capacity Replacing 17.7 GW of CCGT Capacity



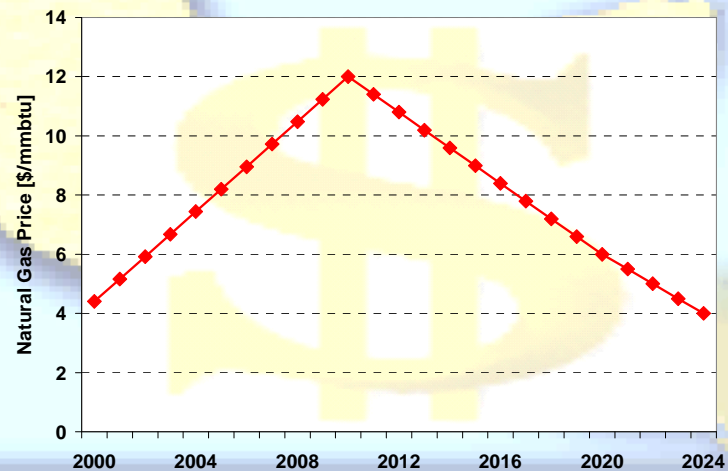
By 2024, Coal Replaces about 37% of Gas Generation but Still Accounts for 48% of Total Generation; Reduces Power Sector Gas Demand by 35% and Overall Gas Demand by 22% (2024)



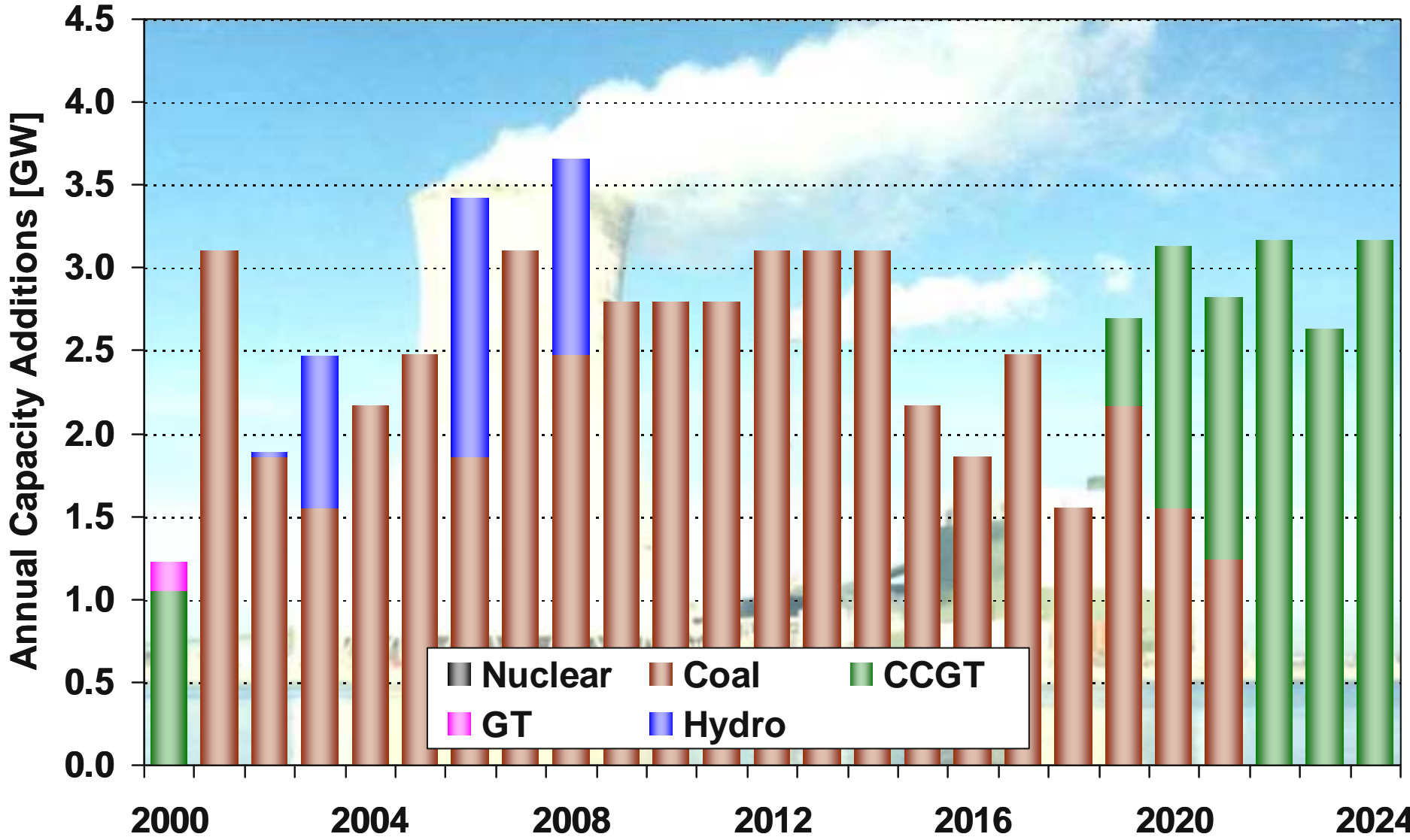
Results for Natural Gas Price Scenario

**Gas Price Peaks at
\$12.0/mmbtu (2010)**

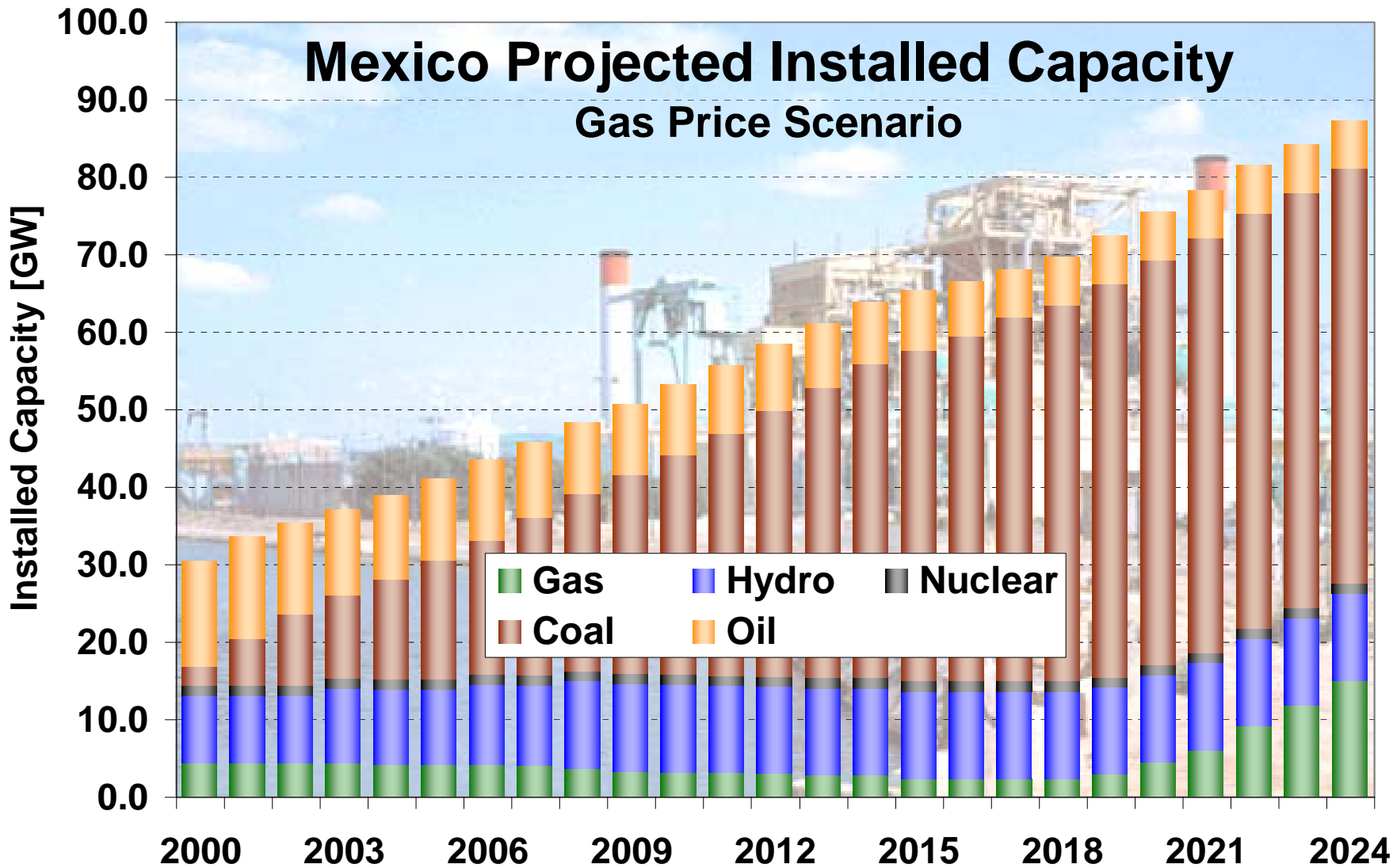
**Then Declines to
\$4.0/mmbtu (2024)**



At a High-Gas Price, A Total of 159 Coal Units Enter the Market and Replace Mostly 92 CCGT Units Starting in 2001



Under High-Gas-Price Scenario, Coal Dominates the Expansion with a Total of 53 GW of Coal Capacity Added by 2024

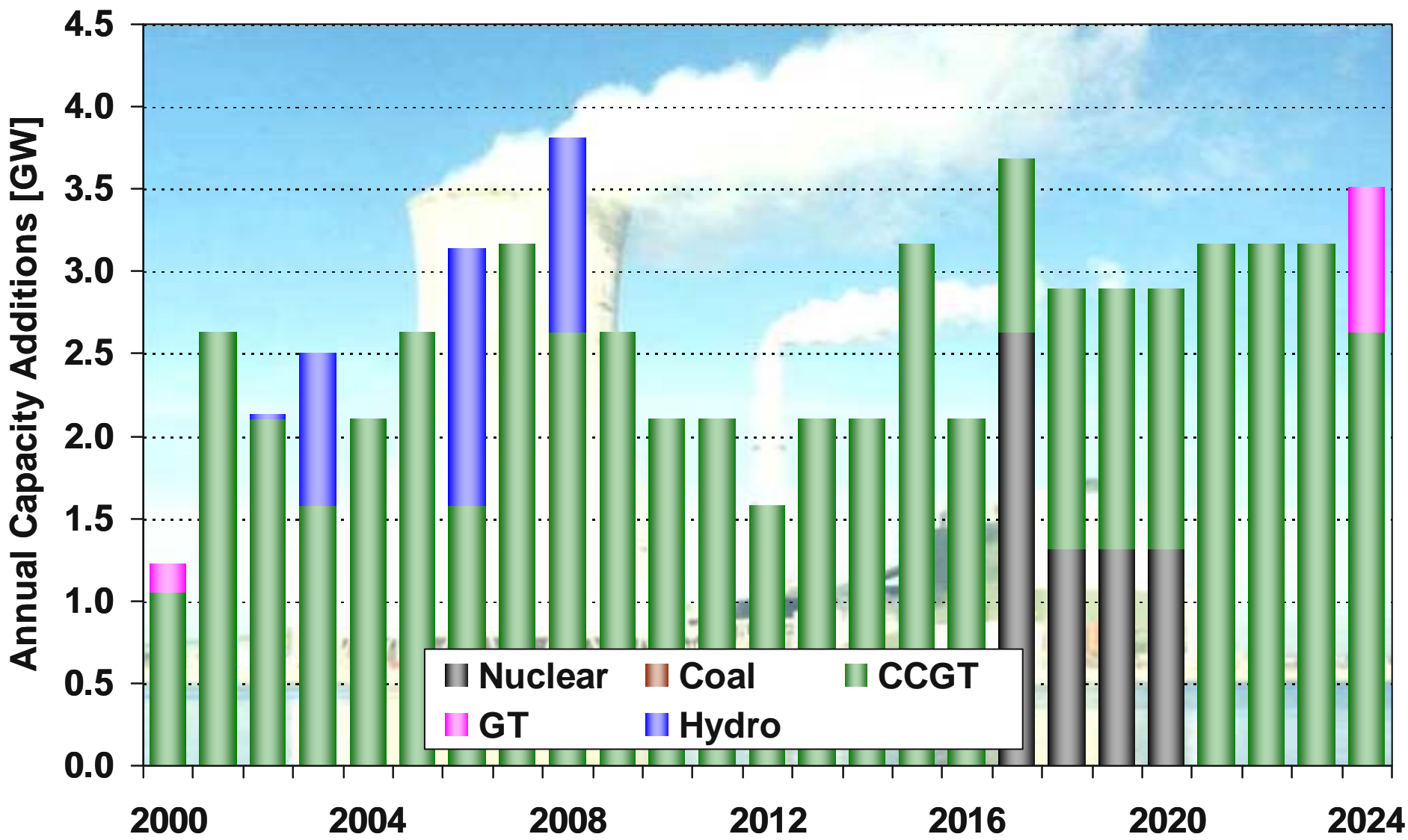




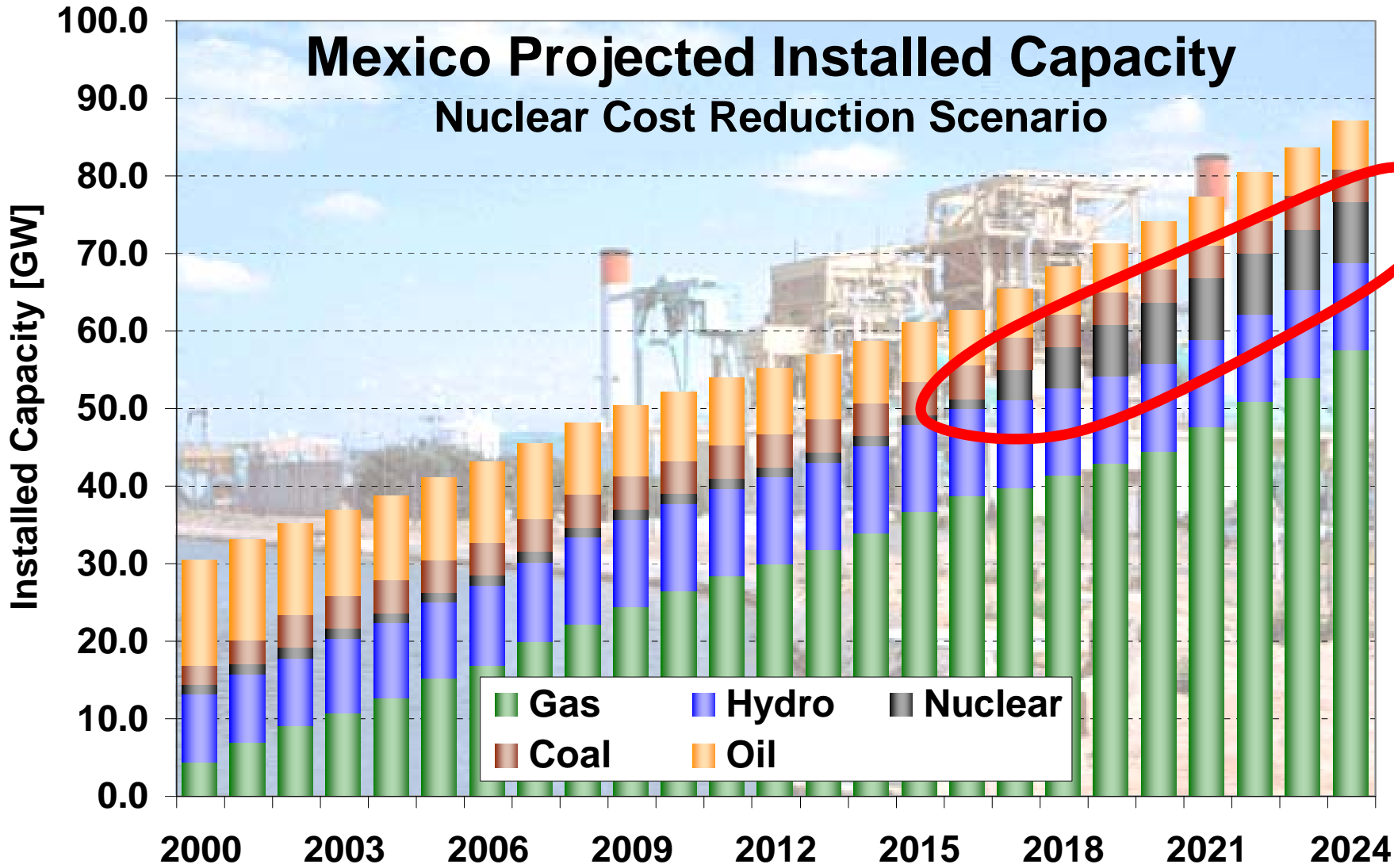
Results for Nuclear Scenario

Cost Reduction To Test Market Entry Barrier

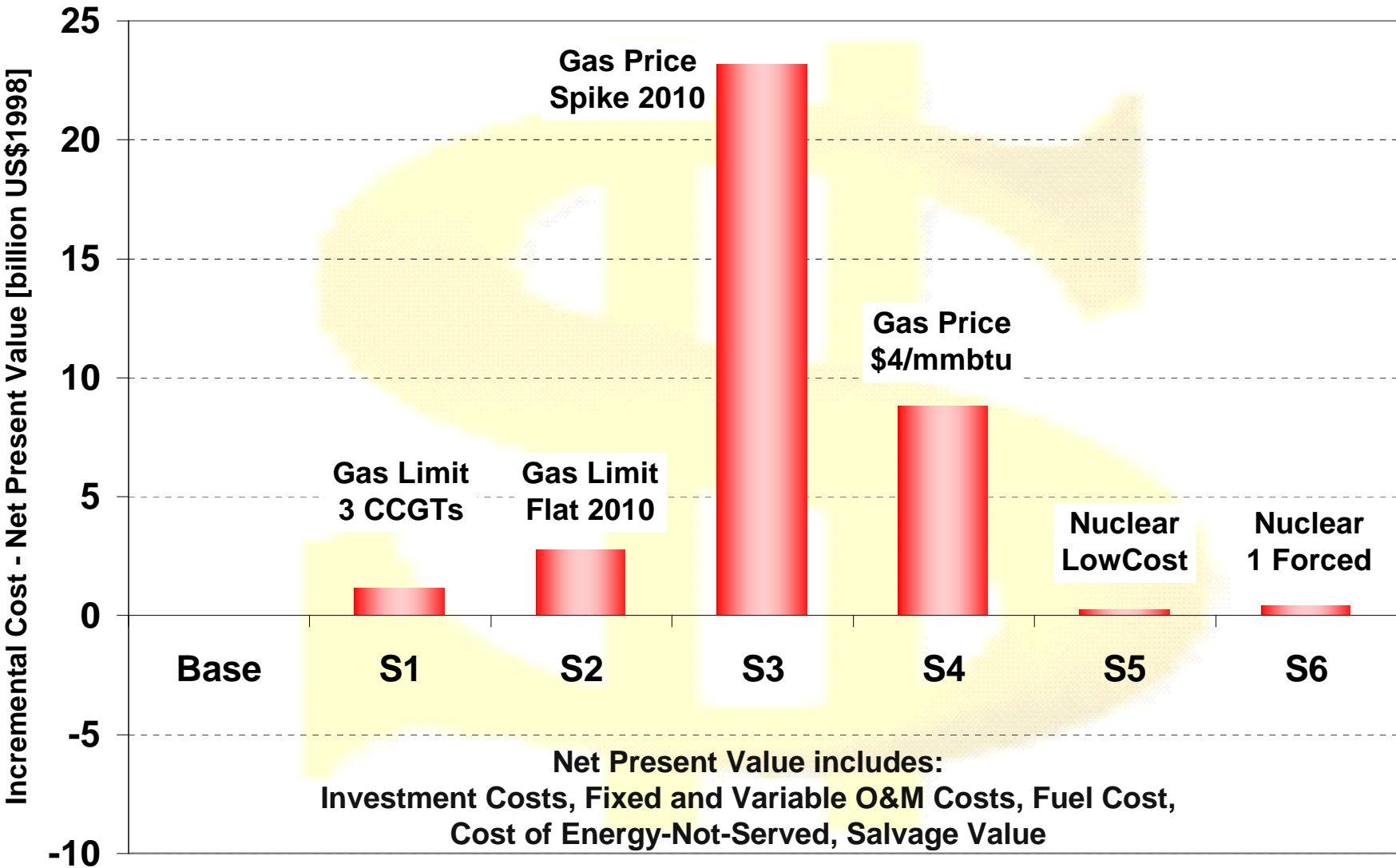
A Total of 5 Nuclear Units Enter the Market and Replace Mostly CCGT Units Starting in 2017 if Costs are Reduced from \$2,485/kW to \$1,292/kW (48% Reduction)



By 2024, 6.5 GW of Nuclear Capacity Replaces about 6.8 GW of CCGT Capacity



Summary Economic Comparison of Various Scenarios



Concluding Remarks

■ Reference Case

- Natural gas will be the primary fuel of choice for power generation accounting for up to 63% of total gas demand
- The strong growth in gas will put substantial strain on the natural gas supply system
- Growth of CO₂ emissions in the power sector is below national average; SO₂ emissions are reduced substantially (78%)

■ Gas Limitations

- If gas is limited, the alternative technology of choice is coal
- Substantial coal can be expected to come on-line
- Comes at economic and environmental cost

■ Gas Price

- If gas prices remain at high levels, coal becomes competitive

■ Nuclear

- For nuclear to compete, investment costs have to be substantially lower (48%)