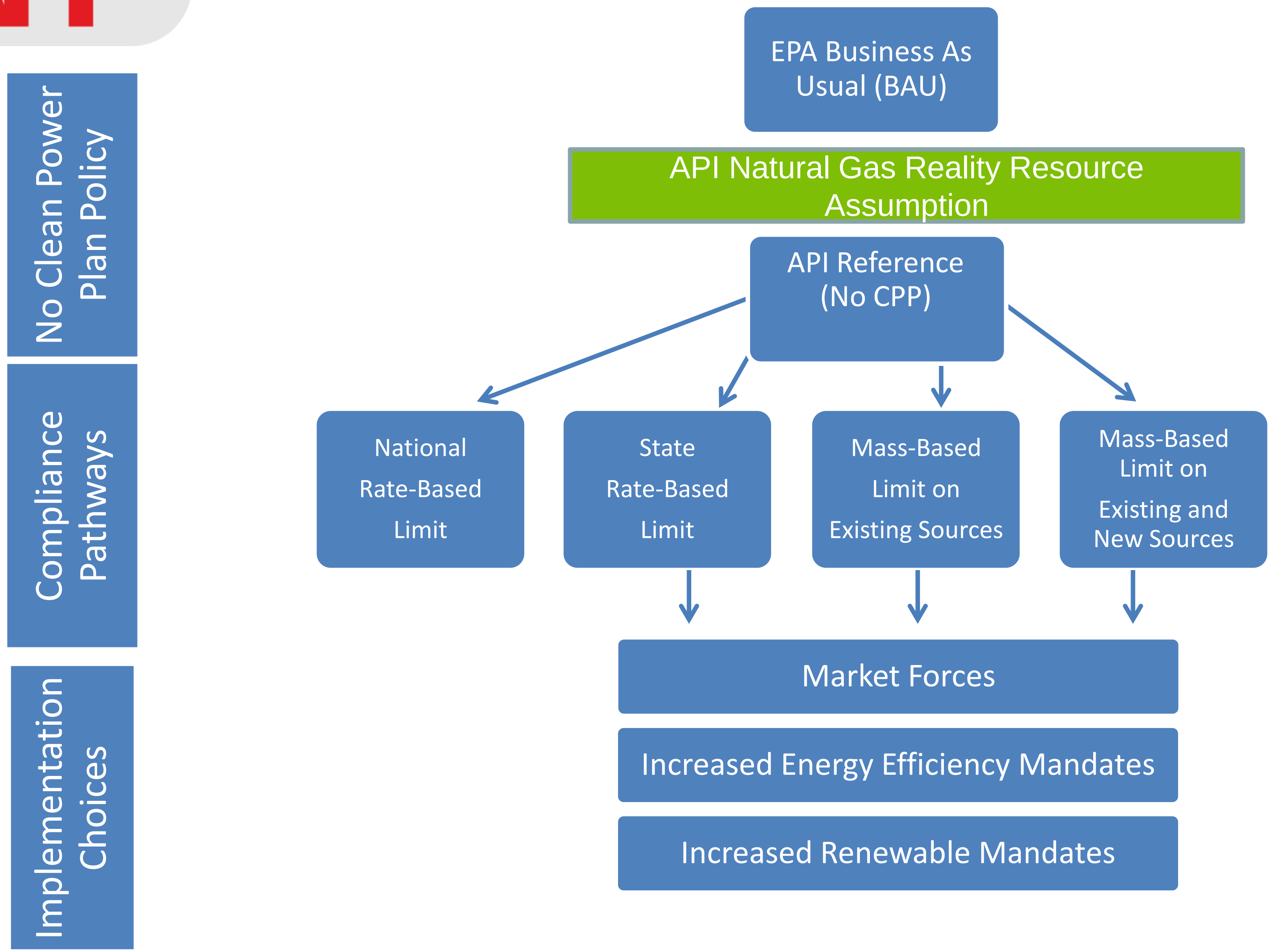
Natural Gas Solutions:
Power Generation

EPA Clean Power Plan Compliance Pathways --
Modeled Generation, Capacity and Costs

API Modeling of CPP

- Provides data driven analysis and an understanding of the role natural gas can play in a future generation mix, with or without CO_2 emission limits;
  - Demonstrates the importance of underlying assumptions about the size of the natural gas resource base.
  - Compares the compliance costs of relying on mandated energy efficiency or mandated renewables versus relying on market forces.
- Modeling represents four EPA-defined potential compliance pathways -- federal plan, state rate-based plan, mass based plan on existing sources, and mass-based plan on existing and new sources;
  - Uses the same assumptions and model as EPA with the following exceptions:
    - Considers realistic assumptions about the size of our nation's natural gas resource base;
    - Includes model version updates that reflect changes between the proposed and final CPP rules.

API Modeling Framework



energy API

API Methodology & Terminology

- On behalf of API, ICF International (ICF) ran their North American power production-cost model, which solves for the least-cost mix of generation to satisfy a given load while meeting certain constraints or requirements, e.g., emission limits.
- ICF created an API reference case and model runs that include assumptions as defined in EPA's v5.15 Power Sector Modeling Platform and the API-requested natural gas resource reflecting the EIA AEO 2015 High Natural Gas Resource assumption.
- **Compliance Pathways:** the EPA-defined options for states to comply with the CPP rule.
- **API-Defined Implementation Choices:**
  - **Market Forces:** Allows the model to solve for the least-cost compliance solution (i.e., generation mix and new capacity additions) to satisfy the constraints in the compliance pathway by not forcing additional mandates beyond those in existing policy.
  - **Increased Energy Efficiency (EE) Mandates:** Assumes reduced load, consistent with the 1% per year compounding load reduction EPA assumed in its Regulatory Impact Analysis and then applies EPA's assumed capital costs for EE to that load. Allows the model to solve for the lowest cost generation mix for remaining load.
  - **Increased Renewable Mandates:** Models a requirement that in-state renewable energy (RE) generation must at least be equal to the EPA-derived state level of renewables used in EPA Best System of Emission Reductions (BSER) standard calculation*.

* Although the EPA BSER calculation was based on renewable capacity operational after 2012, the model allowed any in-state RE generation to satisfy the requirement.

Understanding IPM Outputs

The **Integrated Planning Model (IPM)** iterates, shifting generation choices to satisfy the various constraints, while minimizing cost across a defined time horizon. Various outputs are created from the model including wholesale power prices and allowance prices as well as **production cost** components, including capital costs, fixed operating and maintenance (FOM) costs, fuel costs, and variable operating and maintenance (VOM) costs.

- **Marginal price**: cost to serve the next unit of demand.
- **Wholesale electricity price**: uses marginal price approach to determine the cost to serve one additional MW of load. In practice, due to bidding behavior, this often only captures a portion of capital and fixed costs.
- **Allowance price**: modeled "marginal abatement cost" created when environmental constraints are included. Reflects the cost to abate one additional ton of emissions. Like wholesale electricity prices, allowance prices often only capture a portion of capital and fixed costs, not the total cost.
- **Net import cost**: approximated costs* associated with electricity flowing from one region to another to meet load in the importing region.

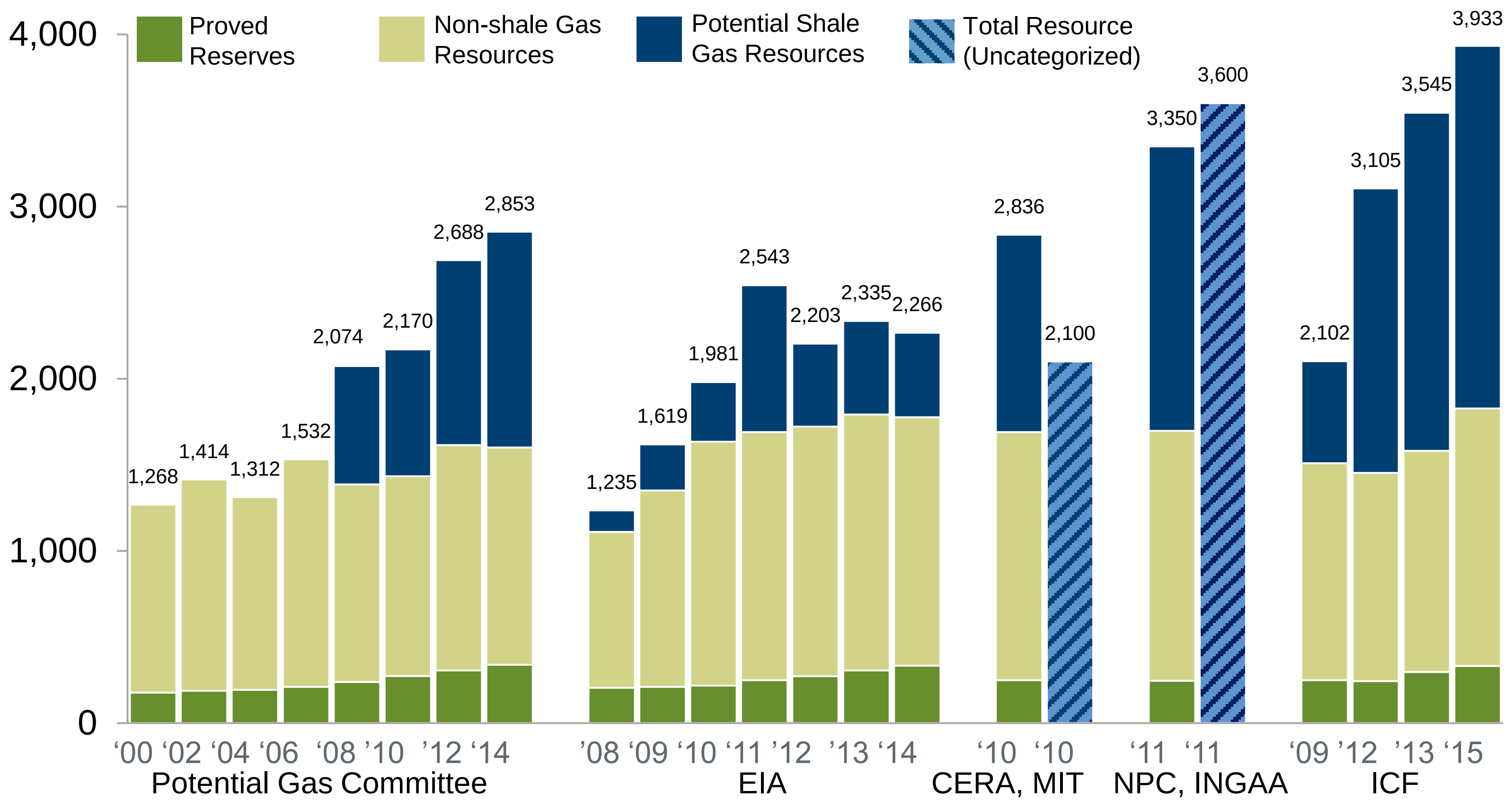
  *Note: Our net import cost does not precisely capture the capital and fixed costs associated with the imported electricity but is a reasonable approximation. In practice, a proportional amount of the capital and fixed costs is typically captured in contractual costs payed by the importing entity.

- **System costs**: At the state/regional level, the best approximation of system costs is **production costs** plus **net import costs**.

Abundant Gas Resource Base

Estimates of U.S. Recoverable Natural Gas

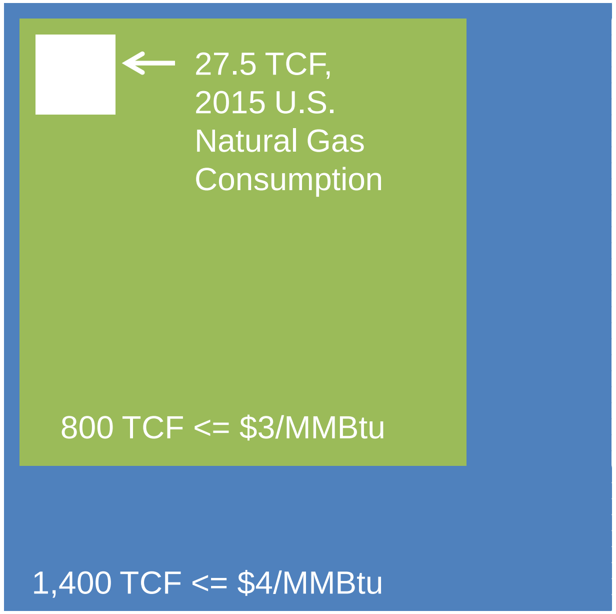
(trillion cubic feet)



✓ *Estimated size of the resource base continues to grow.*

IHS Study Bolsters Resource Outlook

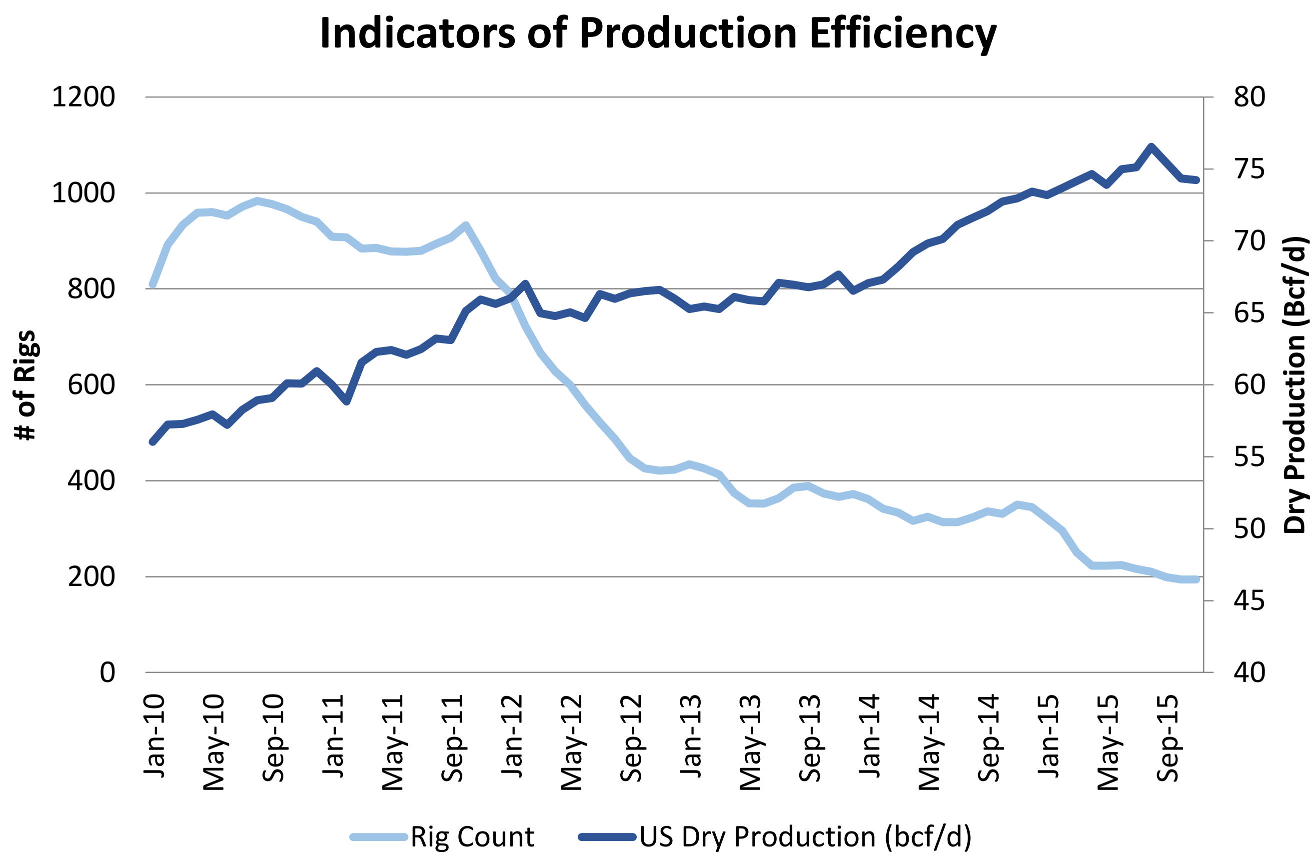
- The IHS supply study, ***Shale Gas Reloaded: The Evolving View of North American Natural Gas Resources and Costs***,* concludes that in the U.S. Lower 48 and Canada:
  - Approximately 1,400 TCF of natural gas is recoverable at a current Henry Hub break-even price of $4/MMBtu or less (in real terms), a 66 percent increase over 2010 estimates.
  - More than 800 TCF can be produced at a current break-even price of $3/MMBtu or less.



✓ *North America has enough supply to meet increased natural gas demand for generations.*

*http://press.ihs.com/press-release/north-americas-unconventional-natural-gas-resource-base-continues-expand-volume-and-de

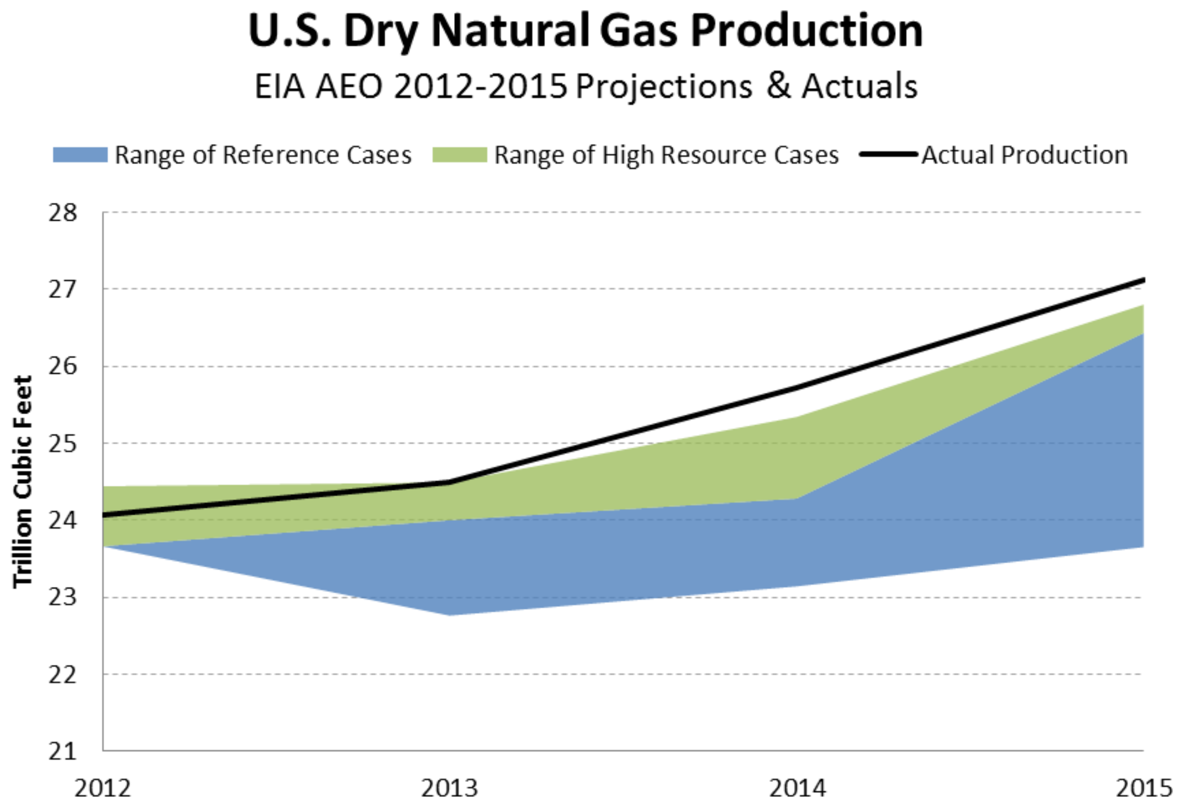
NG Production Efficiency Growing



Source: EIA, Baker Hughes

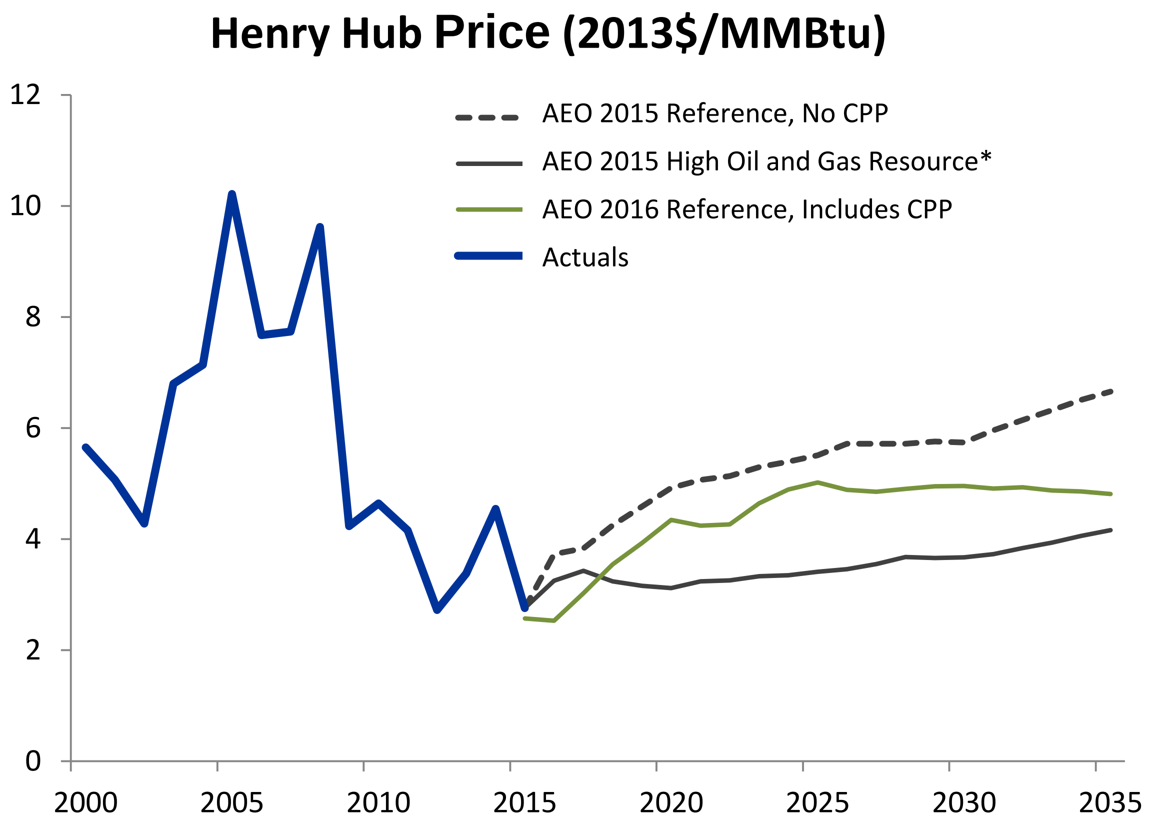
✓ *Continued efficiency and technology improvements are unlocking shale gas potential, delivering more gas with fewer rigs and enabling fast supply response to changing demand signals.*

Production Exceeds Expectations: Demonstrates High Resource Reality



- ✓ *North America is in a high resource reality.*
- ✓ *Even though production projections increased in each subsequent AEO, actual production continues to exceed even EIA high oil and gas resource projections.*

Natural Gas Price Outlook



Source: Energy Information Administration, NYMEX

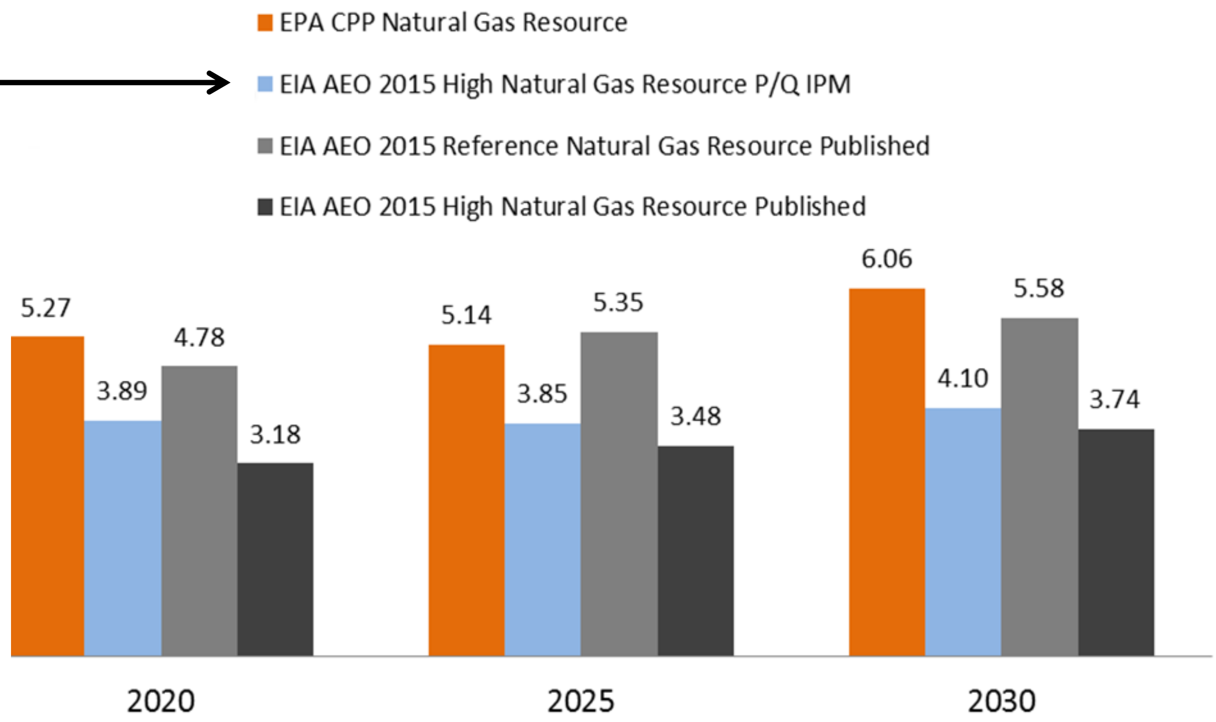
*** ICF used the price-quantity (P/Q) relationship from this case to create the natural gas supply curve in API's modeling**.

✓ *Supply abundance translates into long term affordable and stable gas prices.*

API Assumption Uses EIA Resource Base

API natural gas resource assumption used in our Reference case and policy scenarios is based on the Price/Quantity relationships found in the AEO 2015 High Natural Gas Resource Case.

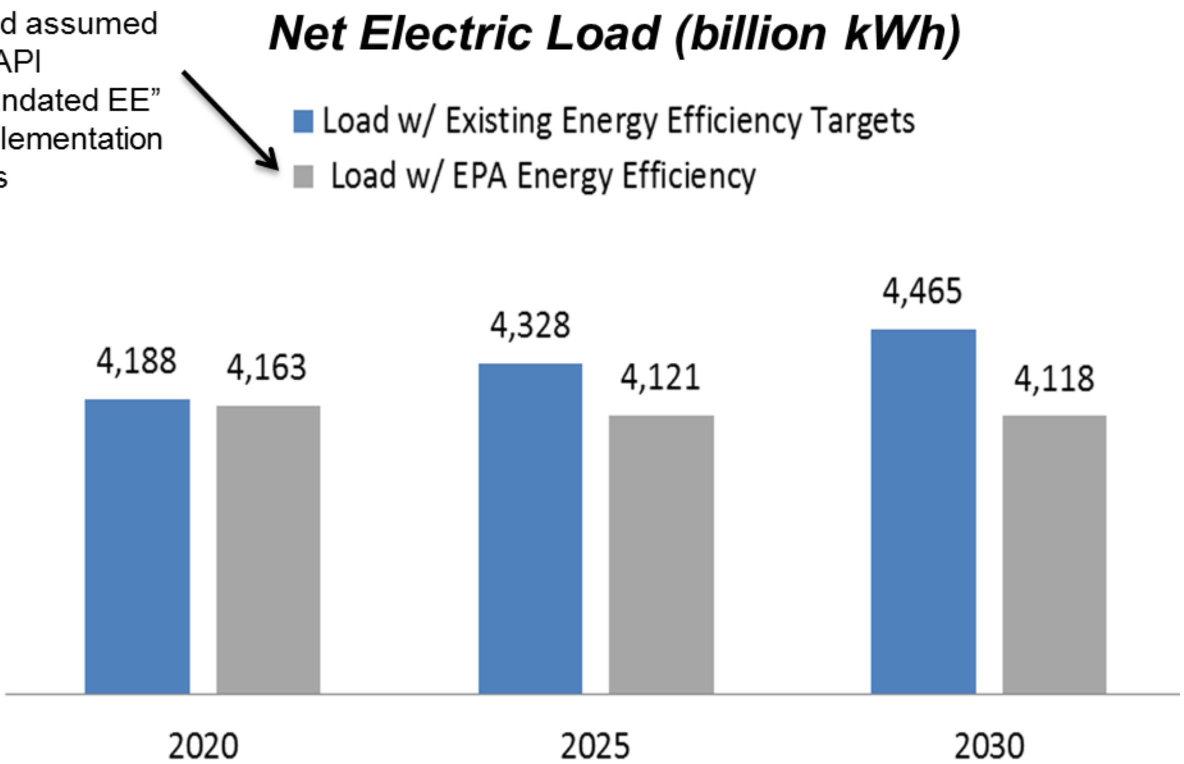
Henry Hub Prices ($/MMBtu)



- ✓ *Natural gas resource assumptions affect future natural gas prices and impact the modeled relative cost-effectiveness of natural gas generation.*
- ✓ *API natural gas resource assumptions reflect the high natural gas resource reality in which we live.*

API Assumption for Energy Efficiency Mandate Scenarios

Load assumed for API "Mandated EE" implementation runs

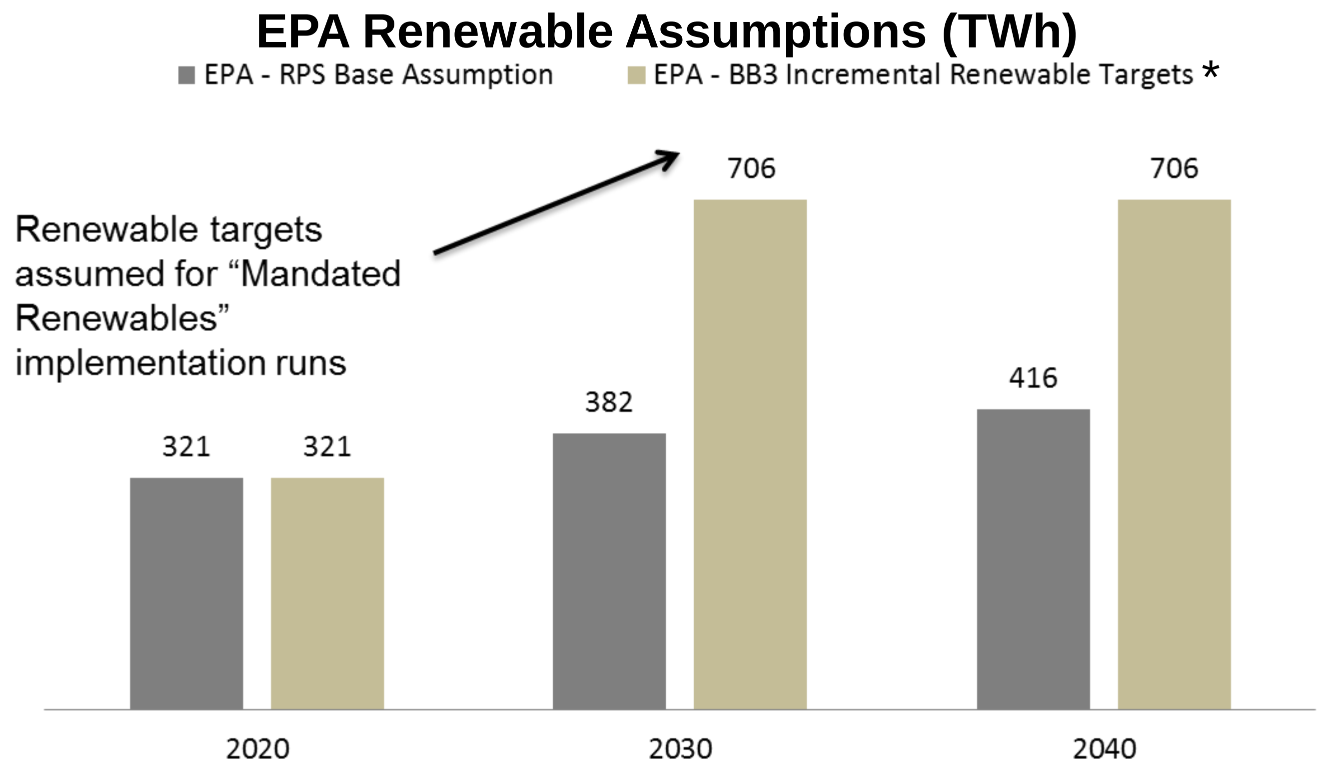


EPA assumes 1% per year compounding load reduction from 2020 to 2030 on top of existing state and federal EE targets resulting in a **7.8% load reduction** from BAU **by 2030.**

Fact: From 2004 to 2014, **U.S. electric load grew by 5% despite** many new state and federal EE policies, the warmest winter on record (2012) and the Great Recession.

- ✓ *API used EPA's EE assumptions to model implications of implementation choices that include increased energy efficiency mandates.*
- ✓ *However, given historic load growth even in decades with circumstances that would contribute to decline, it is not realistic to assume the level of load reduction that is "taken off the top" in EPA's modeling of the Clean Power Plan.*

API Assumption for Increased Renewable Mandate Scenarios



Source: EPA, "Final Clean Power Plan, TSD File: GHG Mitigation Measures Appendix", August 2015

✓ *API modeled implications of increased renewable generation mandates by modeling in-state renewable generation requirements equivalent to the derived state level of renewables in EPA's BSER calculation.*

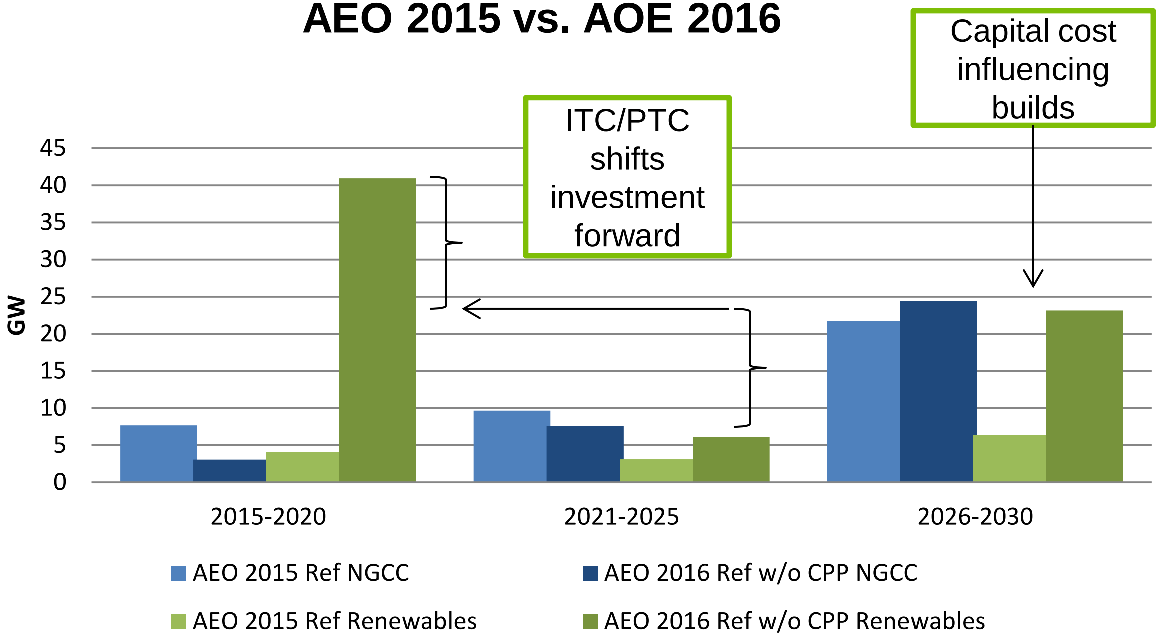
* Although EPA's BSER is based on renewable capacity builds that commenced operation after 2012, our modeled increased renewable mandate cases allow any in-state renewable generation to satisfy the requirement.

API Treatment of ITC/ PTC

- API Modeling was initiated before Congress extended the investment tax credit (ITC) and production tax credit (PTC) for renewables so it is not captured in our modeling.
- Key AEO 2015 vs. AEO 2016 assumption differences driving capacity investment include: capital costs for renewables, natural gas resource/costs, ITC/PTC.

- Extension of the renewable tax credits boosts projected additions of wind and solar capacity prior to 2022, but does not affect total capacity in 2030.
- API modeling relies on EPA's more aggressive (lower cost) renewable assumptions and a more realistic (larger) natural gas resource base assumption, which would further mute any 2030 impact of the early-years ITC/PTC driven renewable additions.

Electric Generating Capacity: Unplanned Additions AEO 2015 vs. AOE 2016



✓ *API 2030 modeling results are not impacted by the model's lack of an ITC/PTC extension.*

Key Findings

(1) Natural gas generation in the power sector will drive emission reductions even without the CPP. In fact, modeled 2030 CO_2 emissions under API's reference case[1] are 30% lower than 2005 CO_2 emission levels;

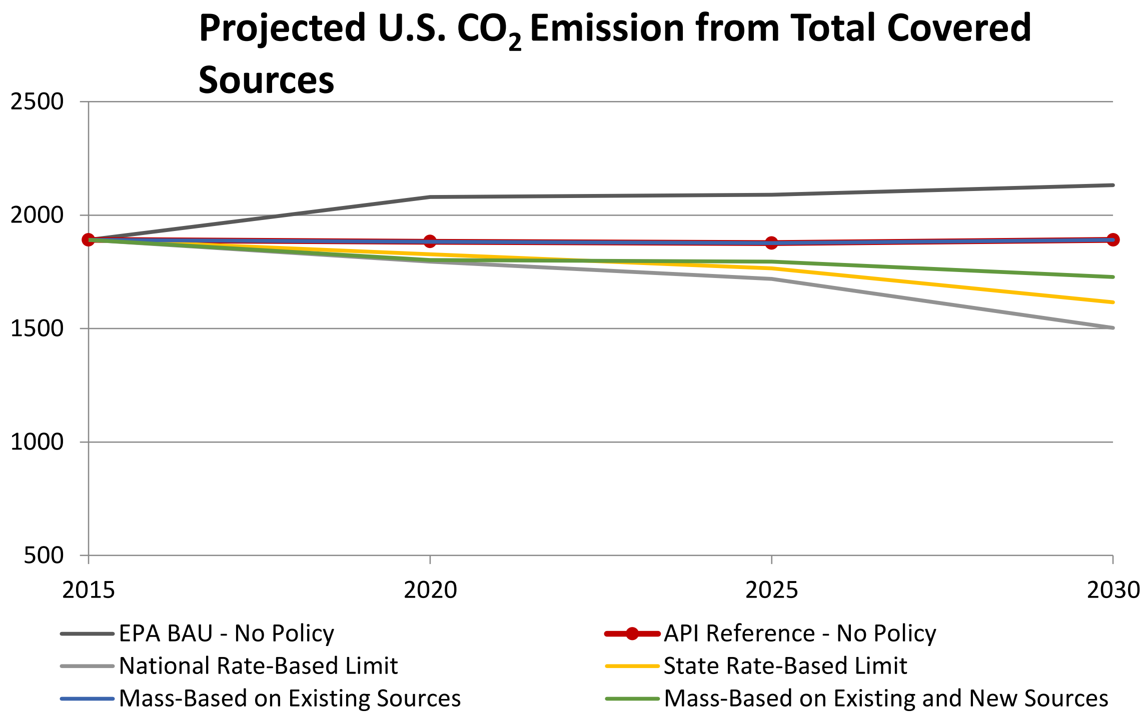
(2) Total production costs[2] are lowest when market forces drive the future resource mix to achieve compliance rather than relying on government mandates for energy efficiency or renewables;

(3) Within each of the EPA-defined compliance pathways, the lowest cost solution to meeting compliance also has the most natural gas generation.

[1] API reference case assumes: No CPP, Business-as-usual load, API natural gas resource assumptions.
[2] IPM production costs include costs associated with the production of electricity including capital, fixed operating and maintenance, fuel, and variable operating and maintenance costs.

API Model Results

EPA Presumptively Equivalent Compliance Pathways Actually Vary in Stringency of Emissions Reductions

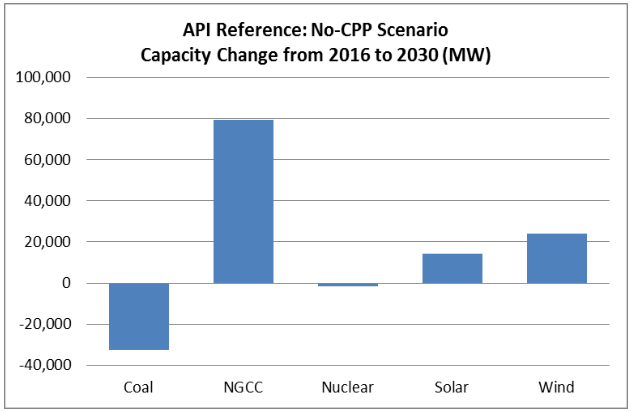


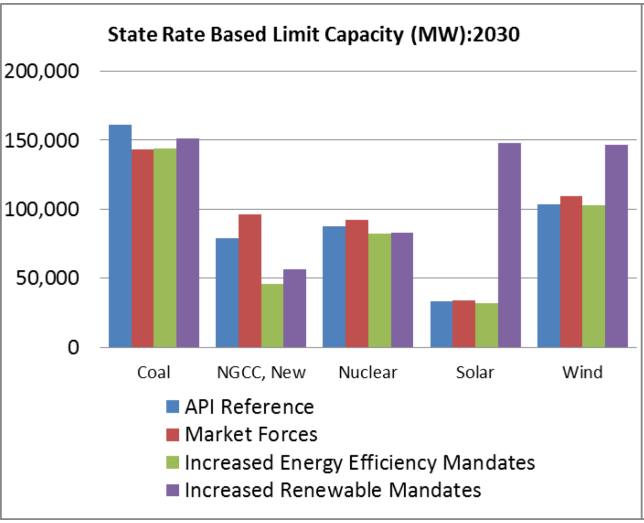
Required reductions (million short tons) in projected CO_2 Emissions Relative to EPA BAU Case in 2030 vary by pathway: the National Rate-Based Limit is most stringent (840 million) followed by State Rate-Based Limit (678 million), then Mass on Existing and New Sources (405 million). Finally because it is non-binding, Mass on Existing Sources is on par with No CPP policy (358 million).

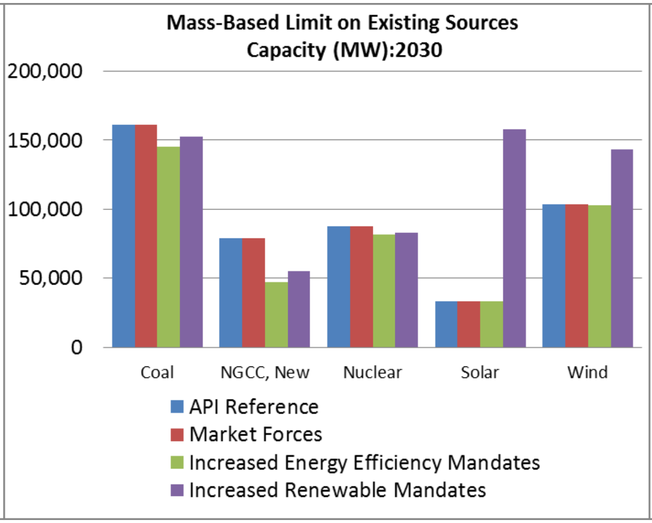
- ✓ *Using more realistic natural gas resource assumptions demonstrates that natural gas enables significant emission reductions. Under API's reference case, fuel economics drive capacity investment and generation shifts that result in enough emission reductions to satisfy reduction requirements under the Mass on Existing Sources policy case.*
- ✓ *Differences in stringency make comparisons of implementation choices across compliance pathways challenging, however API modeling reveals consistent patterns in relative cost-effectiveness when comparing implementation choices within each pathway.*

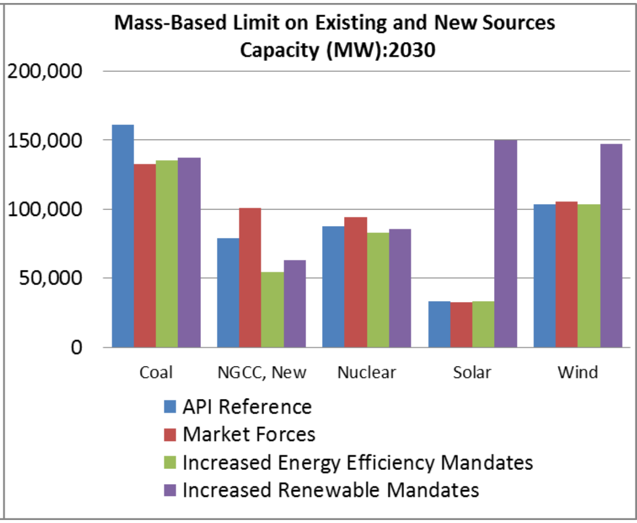
API Results: U.S. Generation Capacity

In the API no-CPP Reference case, an additional 33 GW of existing coal is retired and almost 80 GW of new NGCC capacity is built by 2030, driven by availability of affordable natural gas.



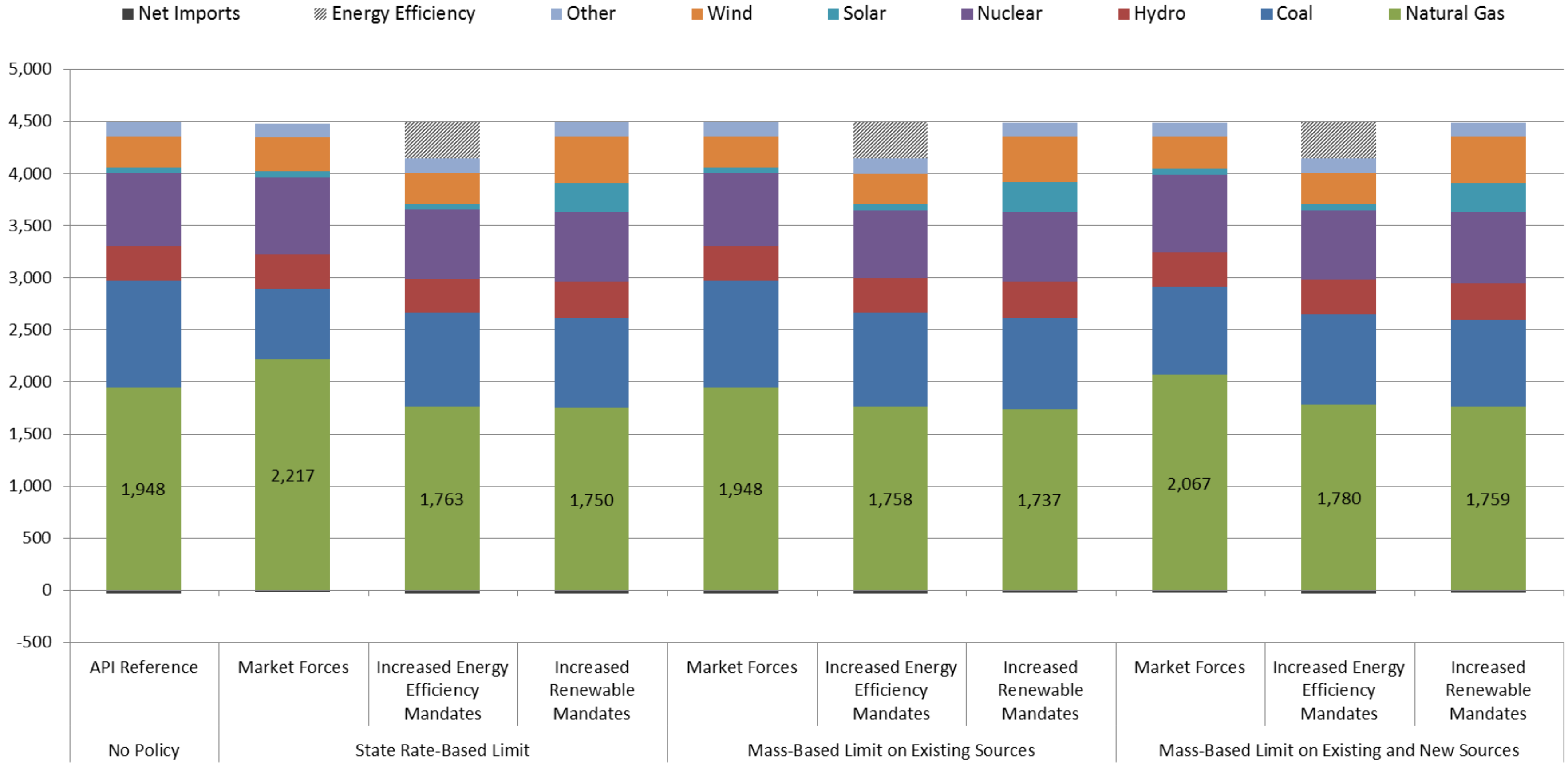






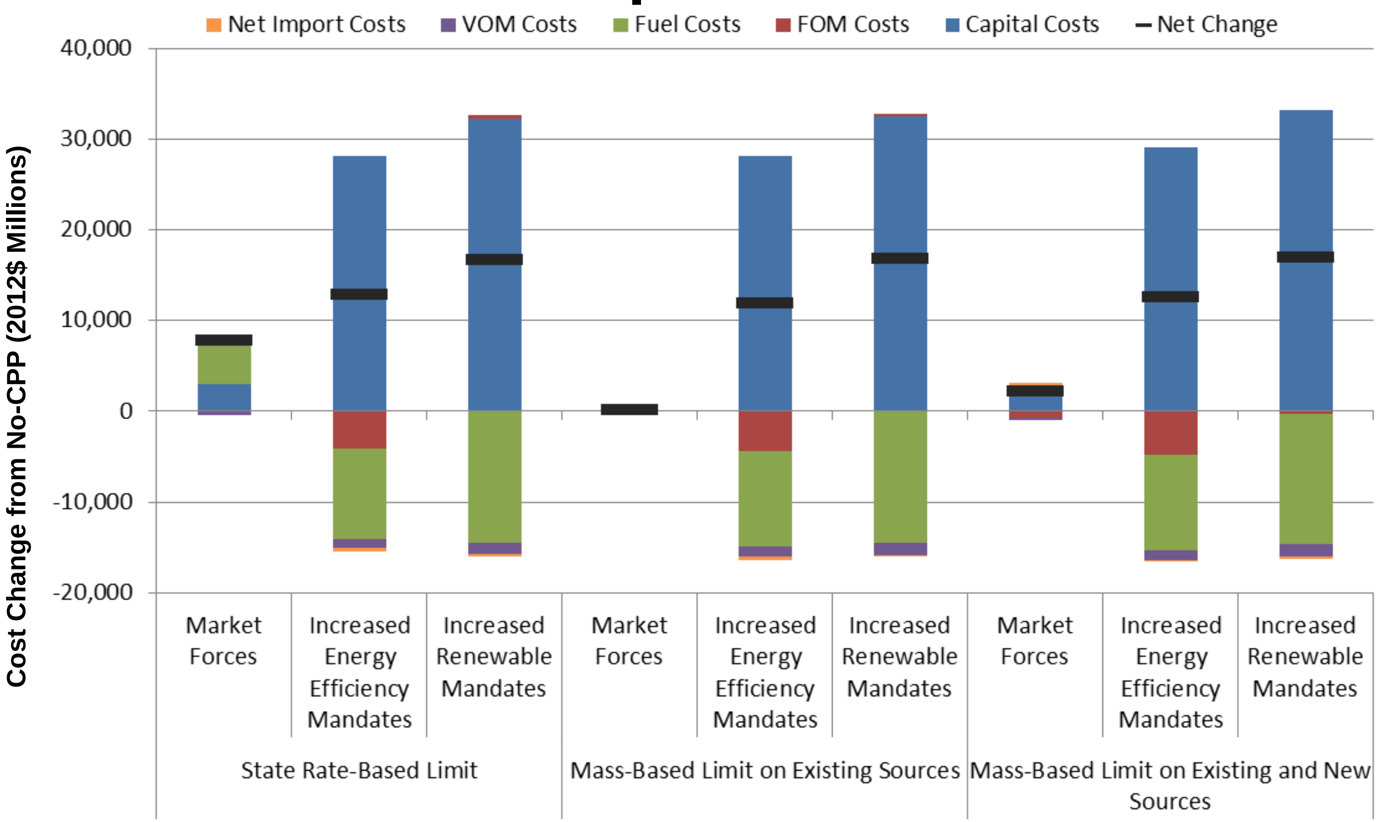
- ✓ *Natural gas capacity is added under all pathways and increases most where market forces are allowed to drive the lowest cost compliance solutions. Wind and solar are not generally selected by the model as the least-cost compliance option unless mandated, and neither is high LCOE new nuclear.*
- ✓ *The significant wind and solar capacity investments in the mandated renewables case are offset by more modest reductions in coal and NGCC capacity, reflecting the fact that only a fraction of renewable capacity can be counted toward reliability requirements.*

API Results: U.S. Generation (TWh): 2030



- ✓ *Under every API compliance pathway, the lowest-cost Market Forces Implementation Choice has the highest natural gas generation.*
- ✓ *The increased renewable mandates, which force 161 GW of additional renewable capacity, result in an additional 373 TWh of renewable generation. Only 50 GW of additional NGCC capacity could produce that same level of incremental generation.*

API Results: U.S. Net Cost Change and Cost Change by Production Cost Component in 2030



Because natural gas is so affordable:

- Reductions in fuel costs in the mandated EE and RE cases are more than offset by increased EE & RE capital costs.
- Capacity investments and generation shifts in the API reference scenario result in greater emission reductions than required by the CPP Mass-Based Limit on Existing Sources, therefore the market forces implementation case shows no cost change.

✓ *Market forces, not mandates, lead to lowest cost compliance: Costs are higher for implementation choices that mandate RE or EE.*