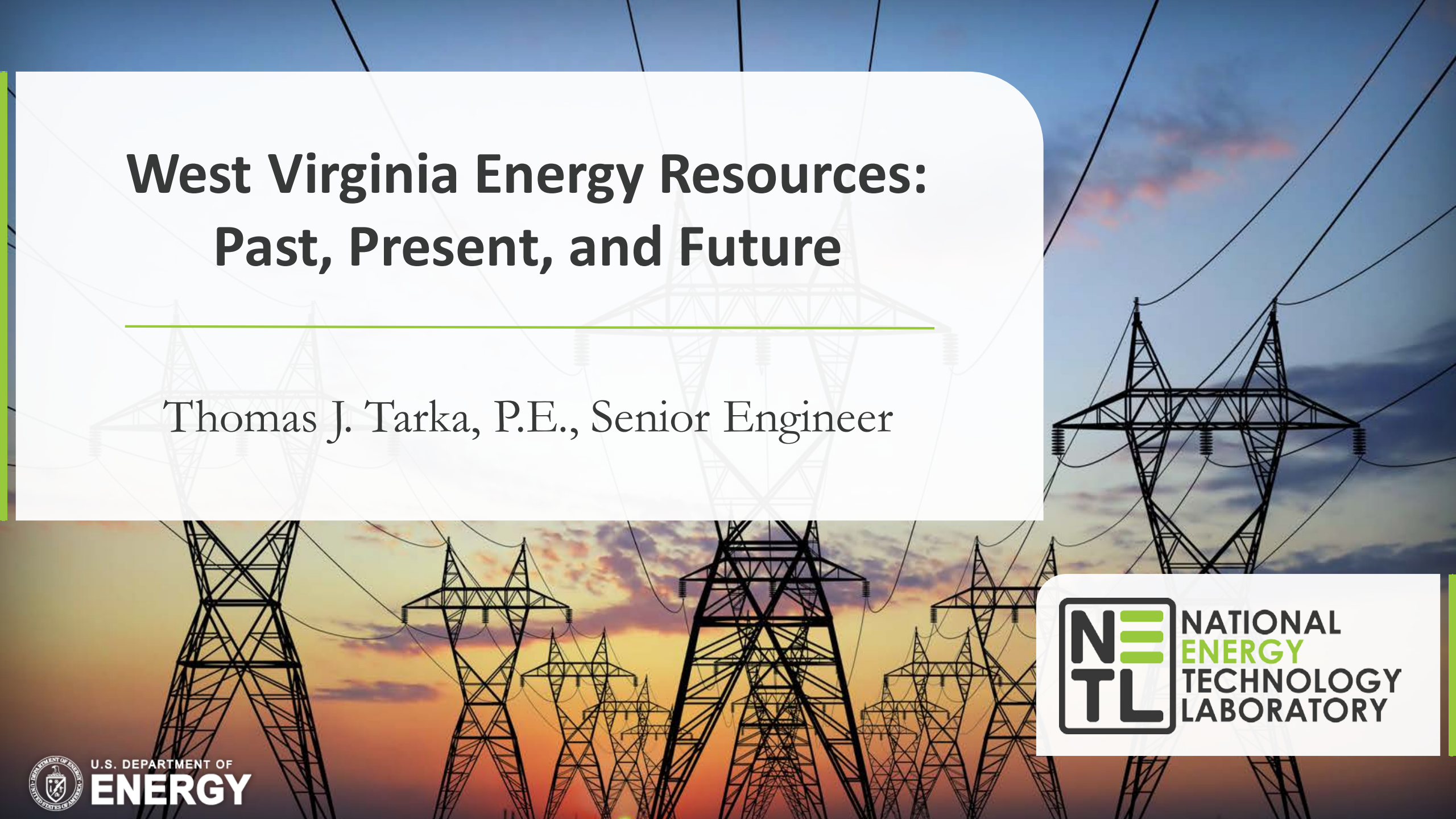
West Virginia Energy Resources: Past, Present, and Future

Thomas J. Tarka, P.E., Senior Engineer



U.S. DEPARTMENT OF ENERGY

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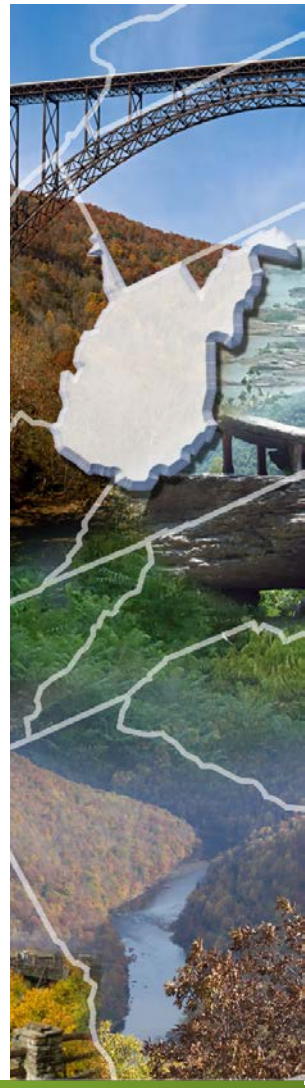
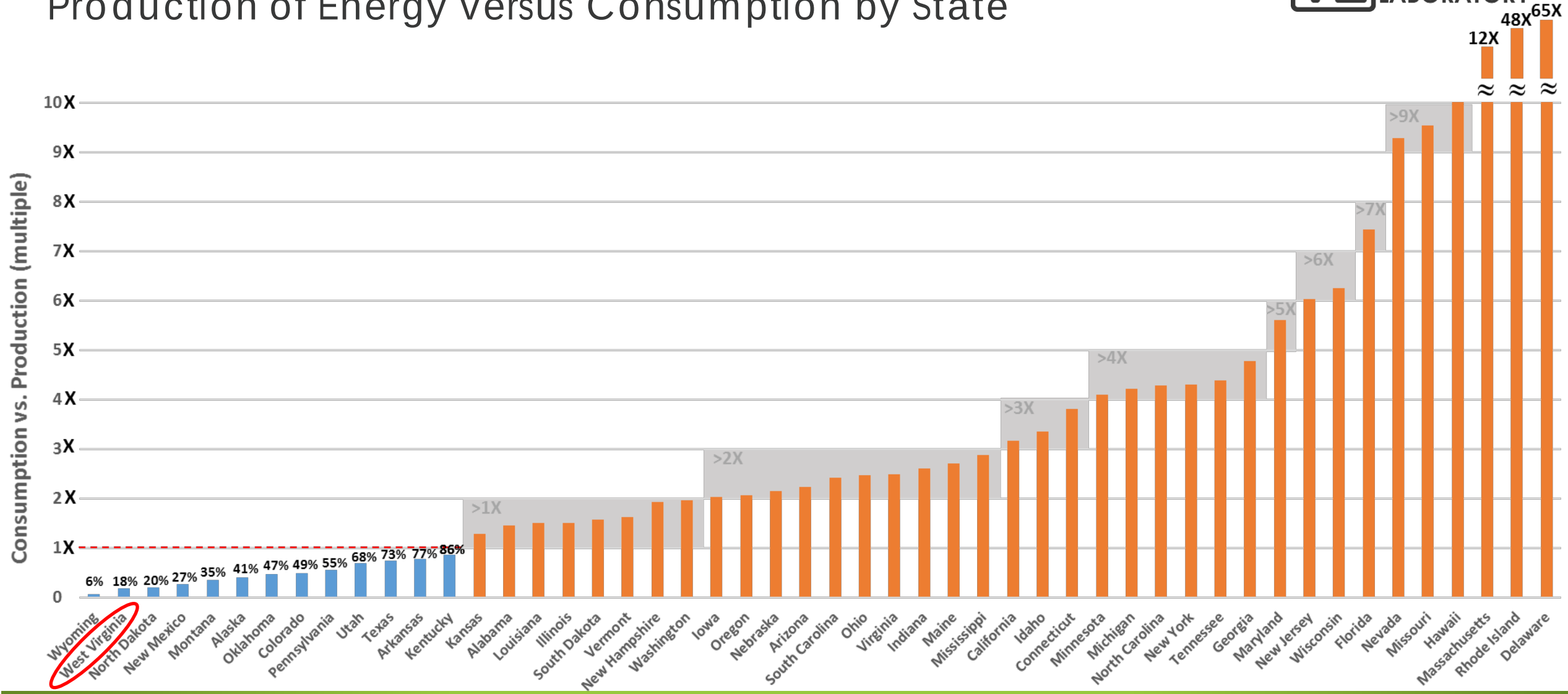
West Virginia Energy Facts

- **4th largest energy producer in U.S. in 2013**, producing ~5% of nation's energy
- **2nd largest coal producer in 2014**, behind only Wyoming (largest east of the Mississippi)
- **8th largest producer of natural gas** and **biggest area of growth in reserves** (along with Pennsylvania)
- **Provides electricity to many mid-Atlantic & Appalachian neighbors**, keeping their lights on
- **Supplies coal to power plants and steel mills throughout Appalachia**, keeping energy prices low and steel mills running
- **Has almost 6% of the nation's natural gas storage capacity**, critical to keeping New York & New England homes heated and power plants running during winter



West Virginia In Context

Production of Energy versus Consumption by State



West Virginia Economy – Energy's Role

- Energy extraction ("Mining") 2nd largest contributor to GDP, 9th largest employer
- Power industry provides ~50% of WV utility jobs (0.3% of total jobs)
- Manufacturing 4th largest contributor to GDP
  - Sector driven in part by availability of cheap & reliable energy sources

Table 2 West Virginia GDP and Employment by Industry

Industry	GDP ($M) (2013)	Share of Total	Employment (2014)	Share of Total
Government	$11,691	16.7%	156,758	17.1%
Mining	$9,381	13.4%	45,458	5.0%
Finance, insurance, real estate, rental, and leasing	$8,990	12.8%	53,283	5.8%
Manufacturing	$7,306	10.4%	50,812	5.6%
Educational services, health care, and social assistance	$7,003	10.0%	137,132	15.0%
Professional and business services	$4,984	7.1%	90,570	9.9%
Retail trade	$4,972	7.1%	106,375	11.6%
Wholesale trade	$3,214	4.6%	24,645	2.7%
Construction	$3,107	4.4%	48,093	5.3%
Arts, entertainment, recreation, accommodation, and food services	$2,683	3.8%	85,219	9.3%
Transportation and warehousing	$2,165	3.1%	26,174	2.9%
Information	$1,589	2.3%	11,170	1.2%
Other services, except government	$1,499	2.1%	48,488	5.3%
Utilities	$1,165	1.7%	5,342	0.6%
Agriculture, forestry, fishing, and hunting	$328	0.5%	24,552	2.7%
Total	$70,077	100%	914,071	100%

Source: US Bureau of Economic Analysis. Percentages may not sum to 100 due to rounding.
Footnote 68 contains industry descriptions.

Presentation Overview

Past

- History of West Virginia's energy & electricity production

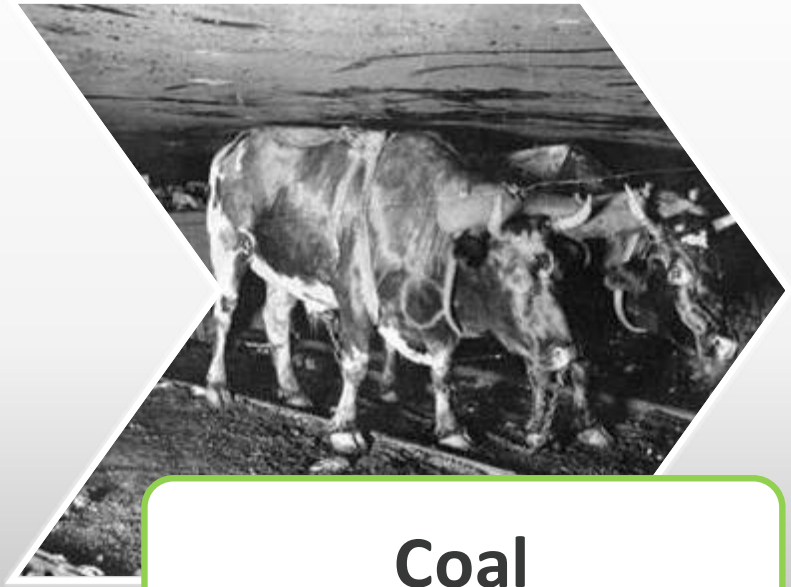
Present

- Energy today in West Virginia
  - Production
  - Consumption by sector
- Energy trends: coal, natural gas, renewables

Future

- Exciting new energy opportunities for West Virginia
- A look at the past to see the future

Energy Resources Development Timeline

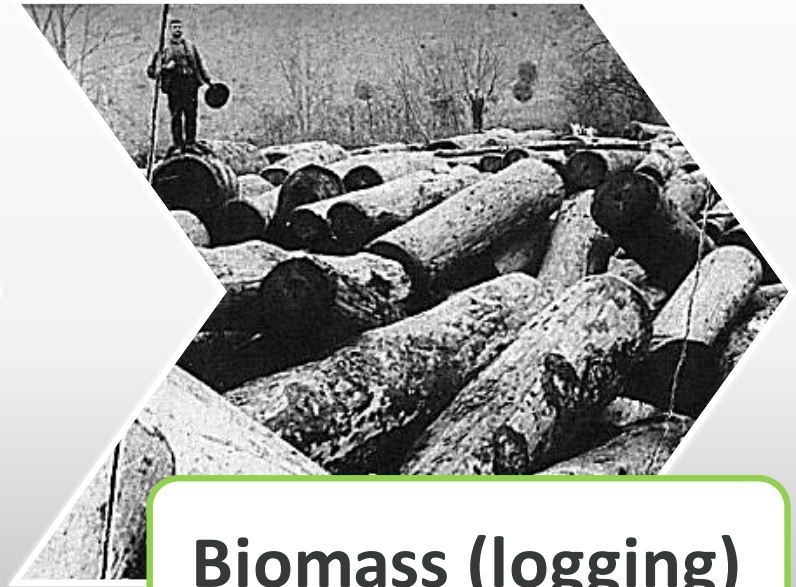


Coal

1810 – 1836

Oil & Gas

1859



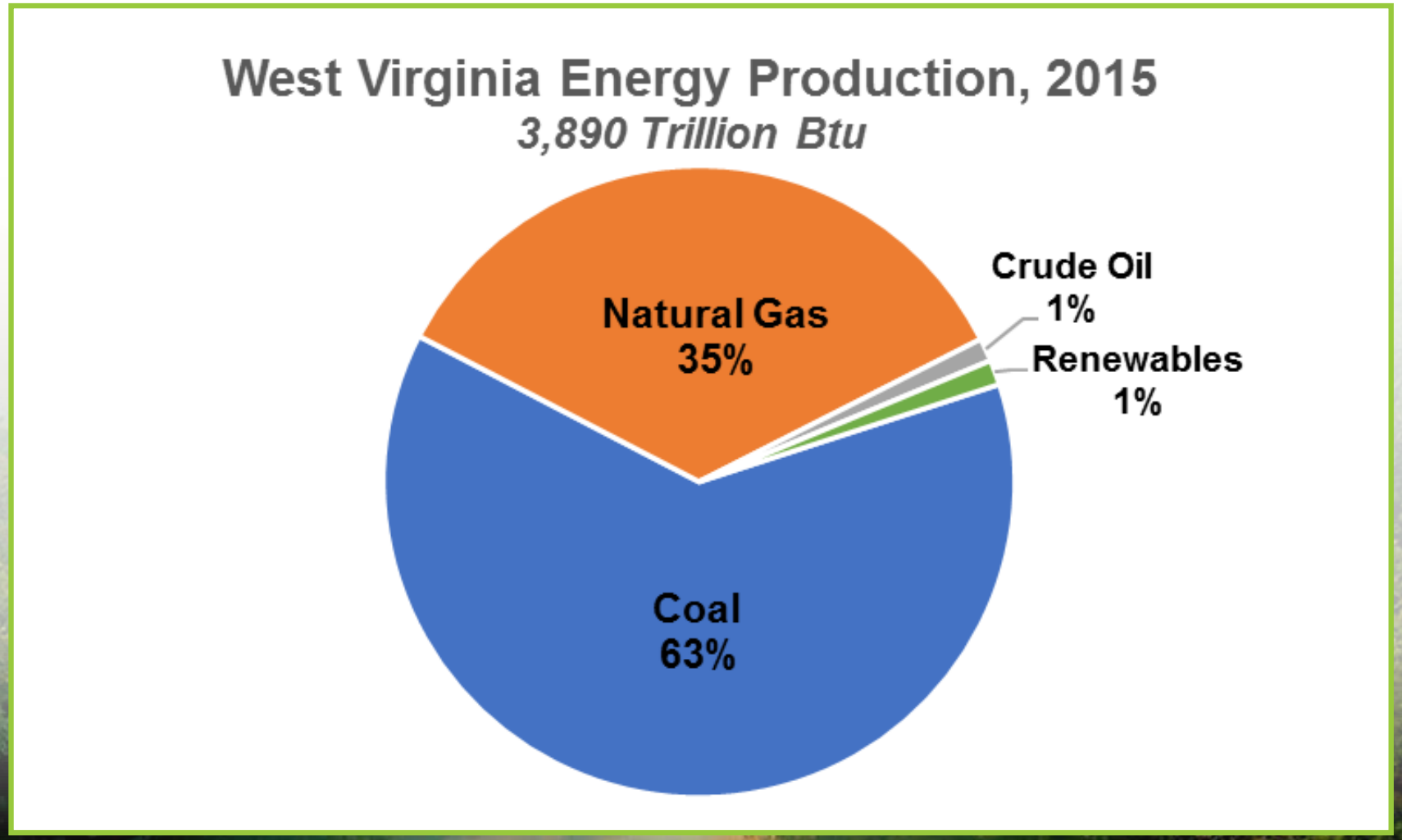
Biomass (logging)

1870 – 1920

Electricity Development Timeline

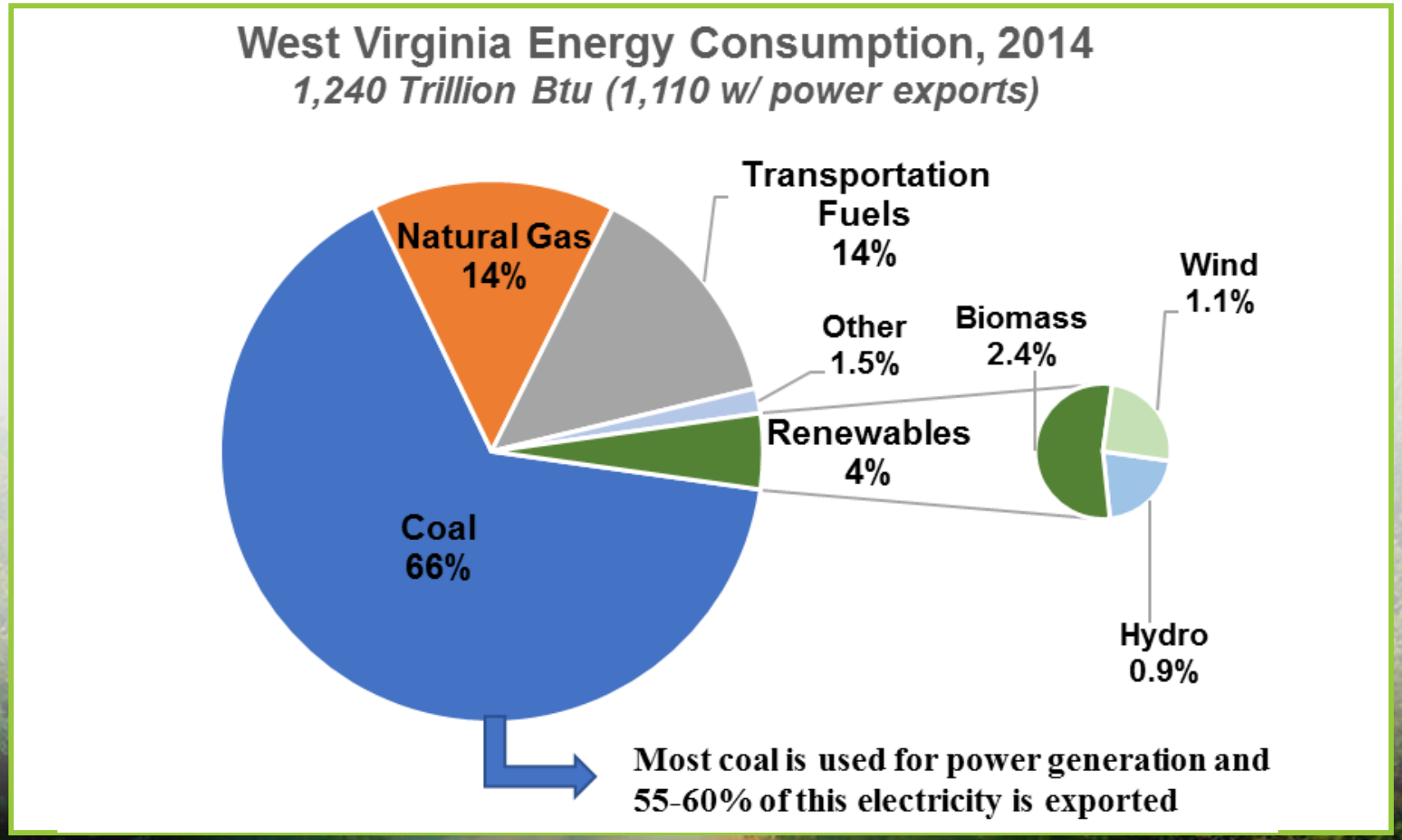
Hydropower	Coal	Wind	Solar
1899	1916	2002	2006

Energy Today – Production



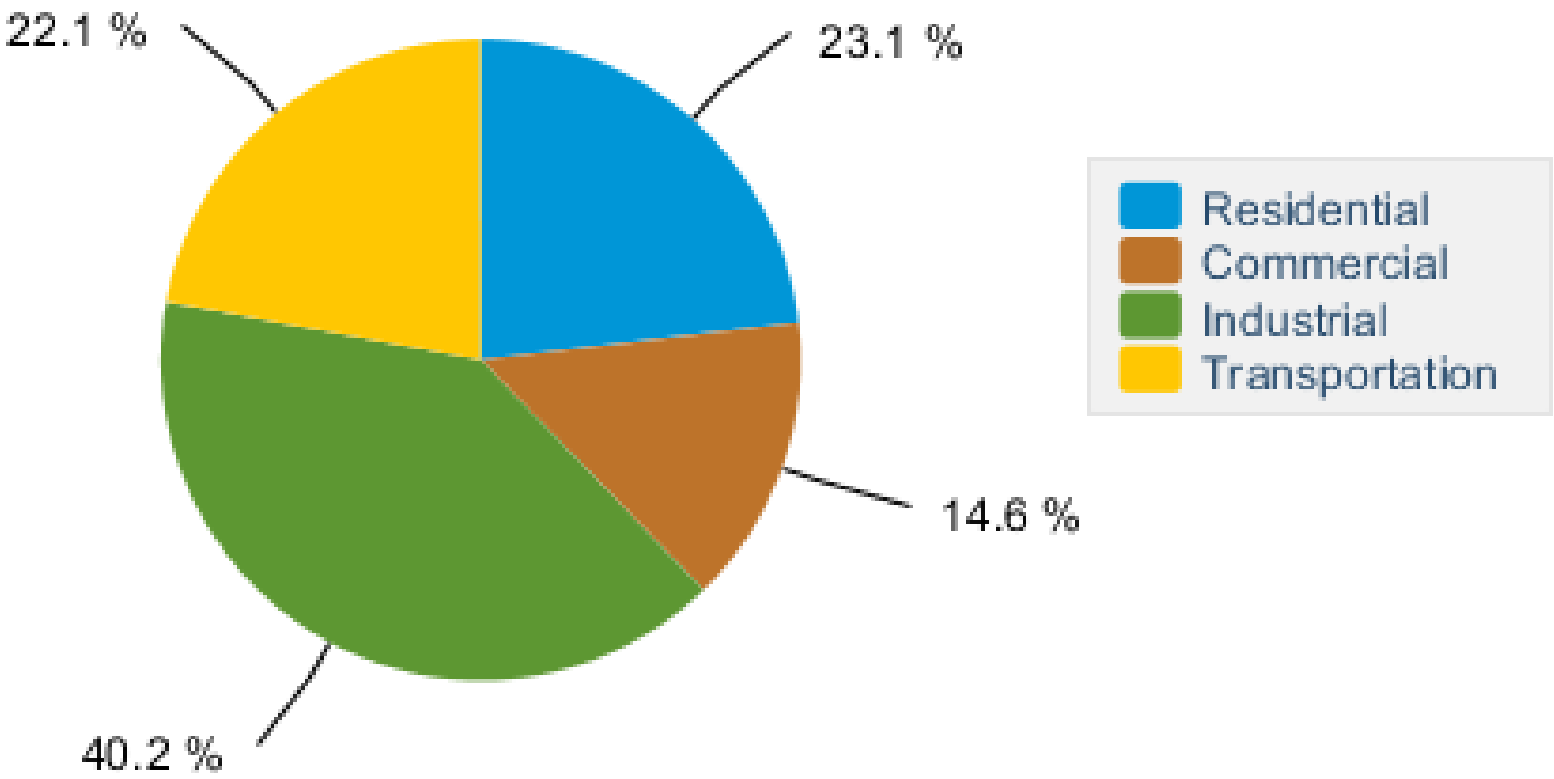
Source: Energy Information Administration, State Energy Data System

Energy Today – Consumption

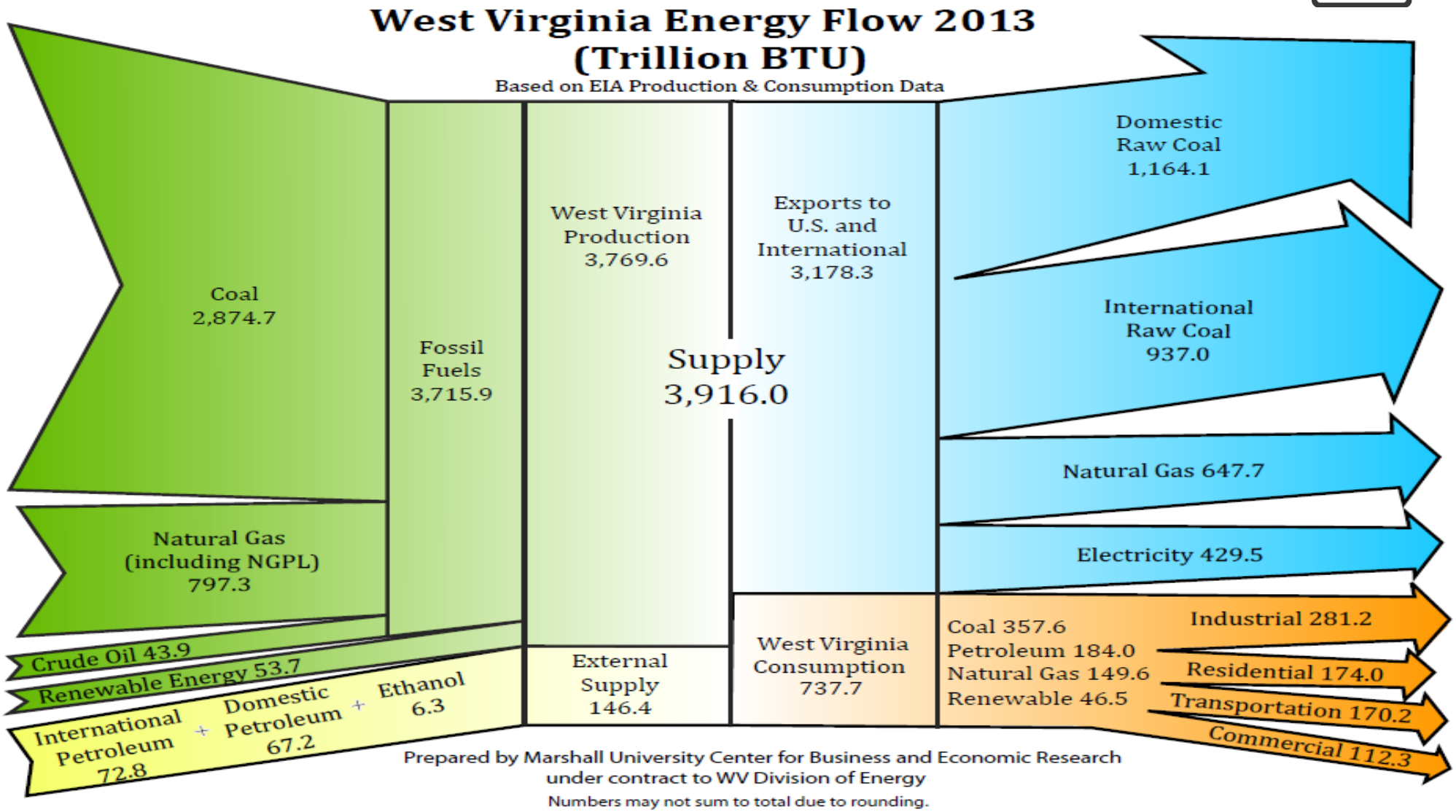


Energy Today – Consumption by Sector

West Virginia Energy Consumption by End-Use Sector, 2014



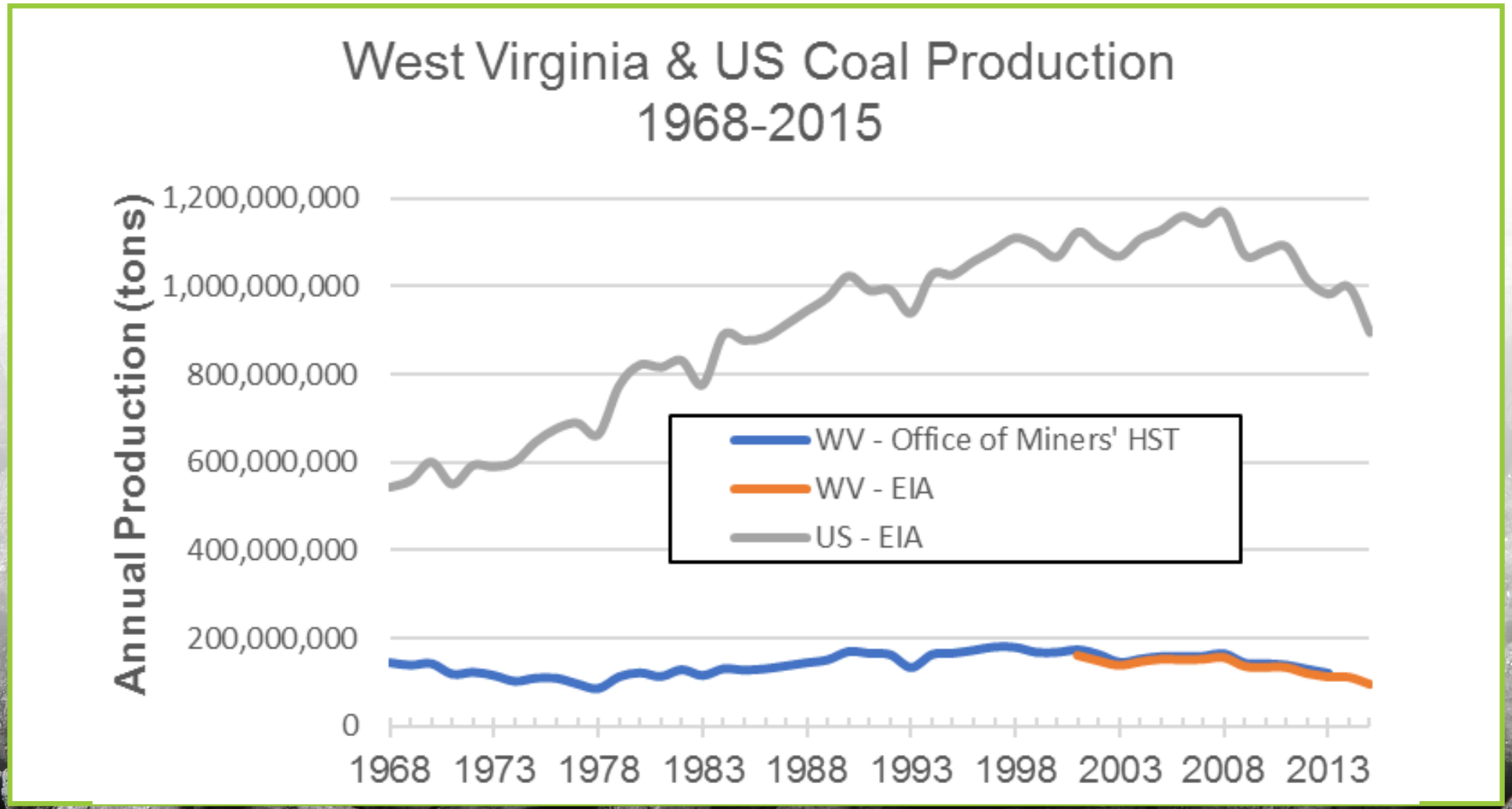
Energy Today – Detailed Overview (2013)



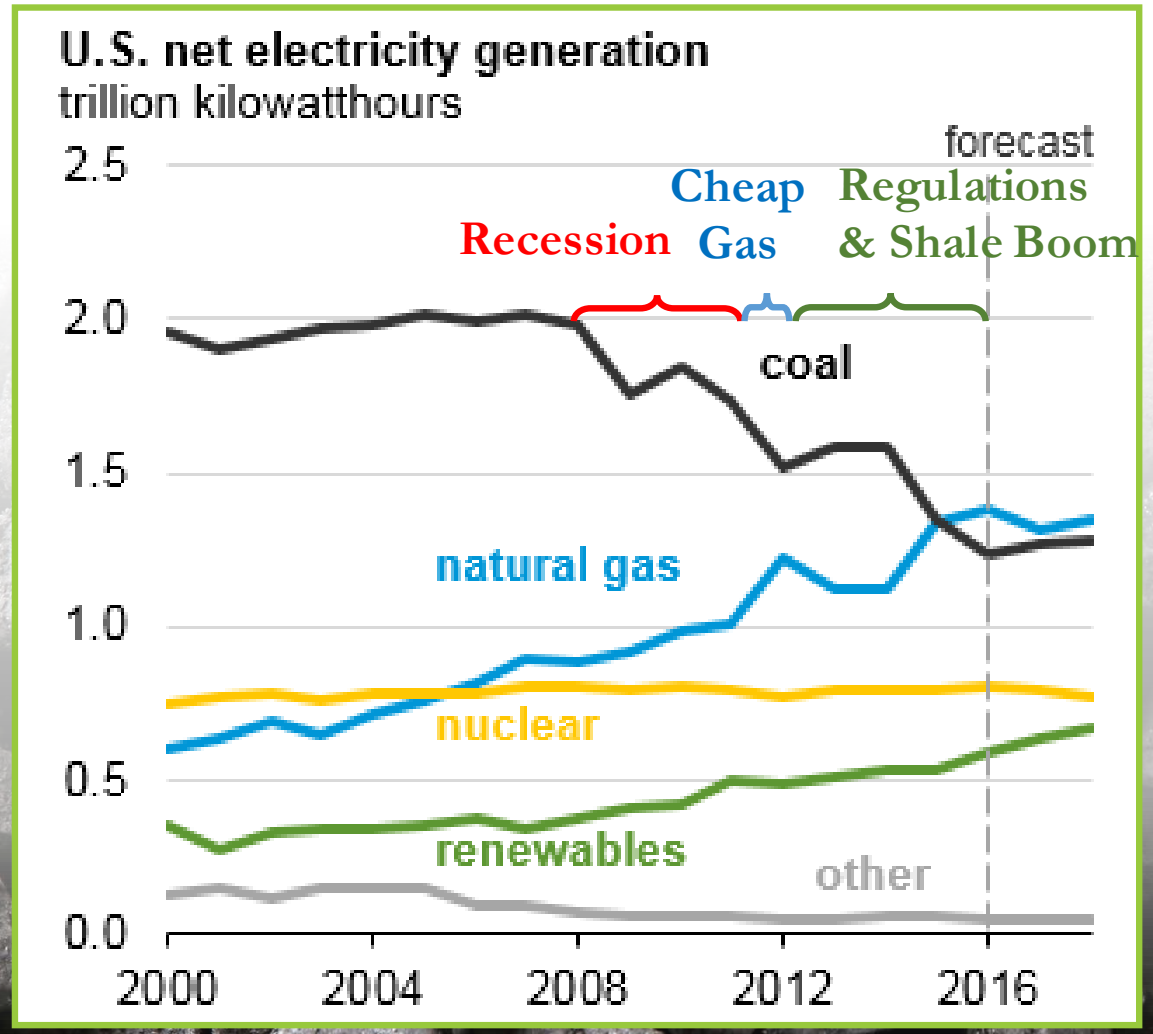
Energy Today – Summary

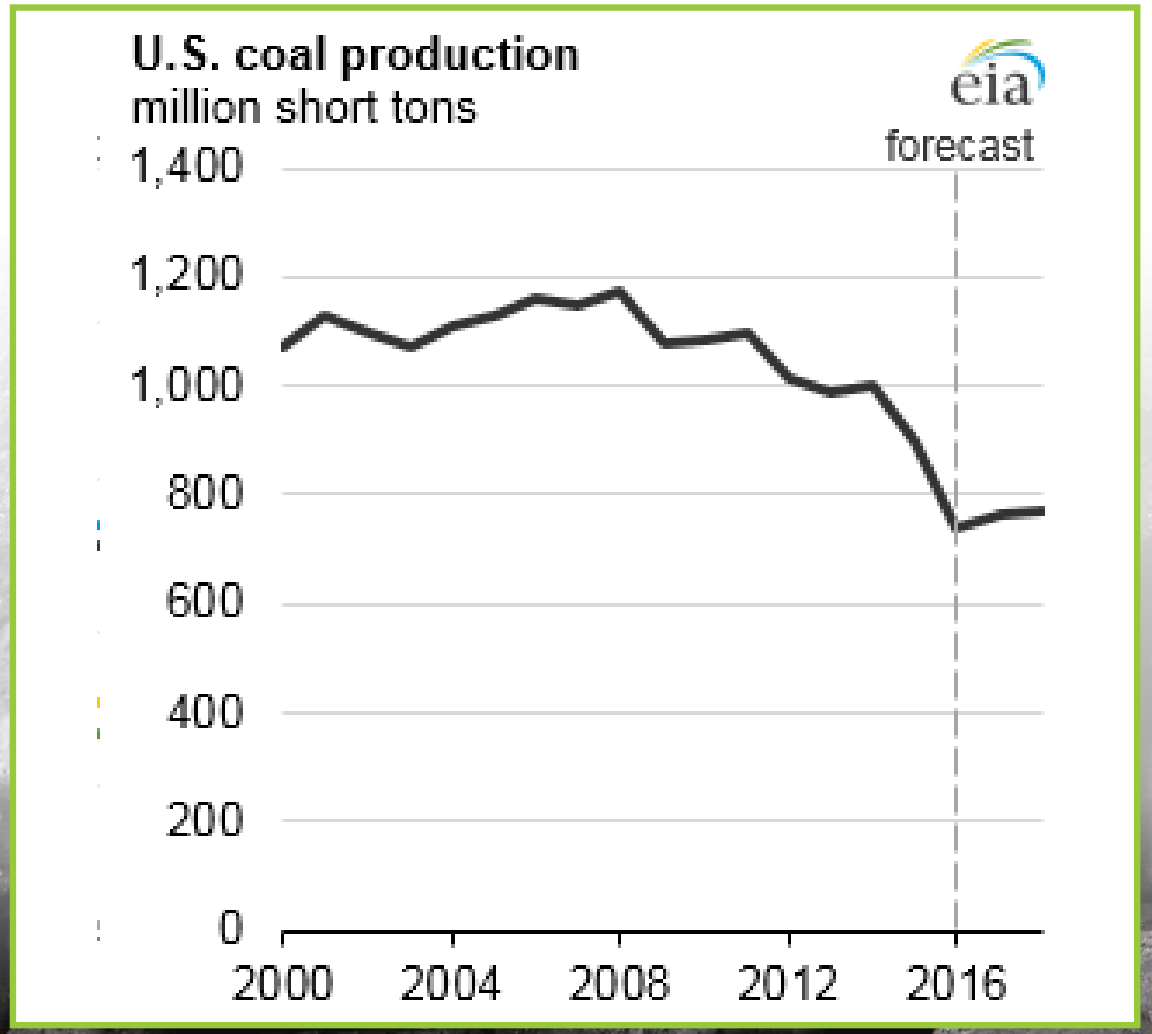
- **~70% of energy or energy products (electricity) produced is exported**
  - 55–60% of electricity generated
  - ~80% of coal produced, to both domestic (~50%) and international (~30%) markets
  - >85% of natural gas and associated products (NGLs)
- **Some limited imports occur, ~15% of total energy supplied**
  - Petroleum products and ethanol
  - Almost 50% of coal used in WV power plants, particularly in those near state borders
- **Renewable & other energy sources are growing but are small compared to coal**
- **Natural gas production increased 5 fold in the last 6 years, from 7% to 35%**
  - Production has currently flattened due to low prices but will rebound
  - Substantial opportunity to use natural gas or natural gas liquids to produce higher value products

Energy Trends – Coal Production



Energy Trends – Coal Production



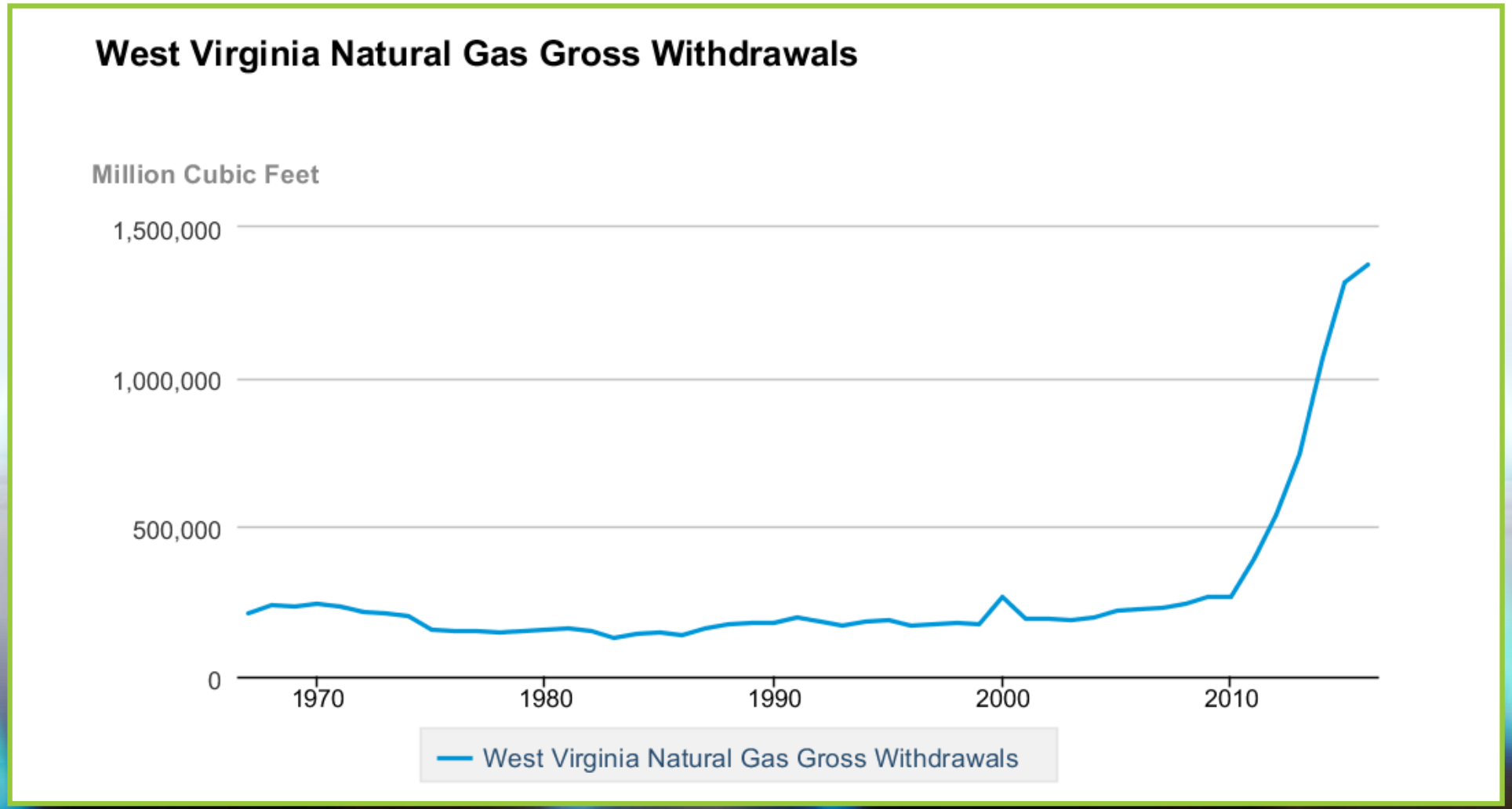


Source: U.S. Energy Information Administration, Short-Term Energy Outlook, February 2017

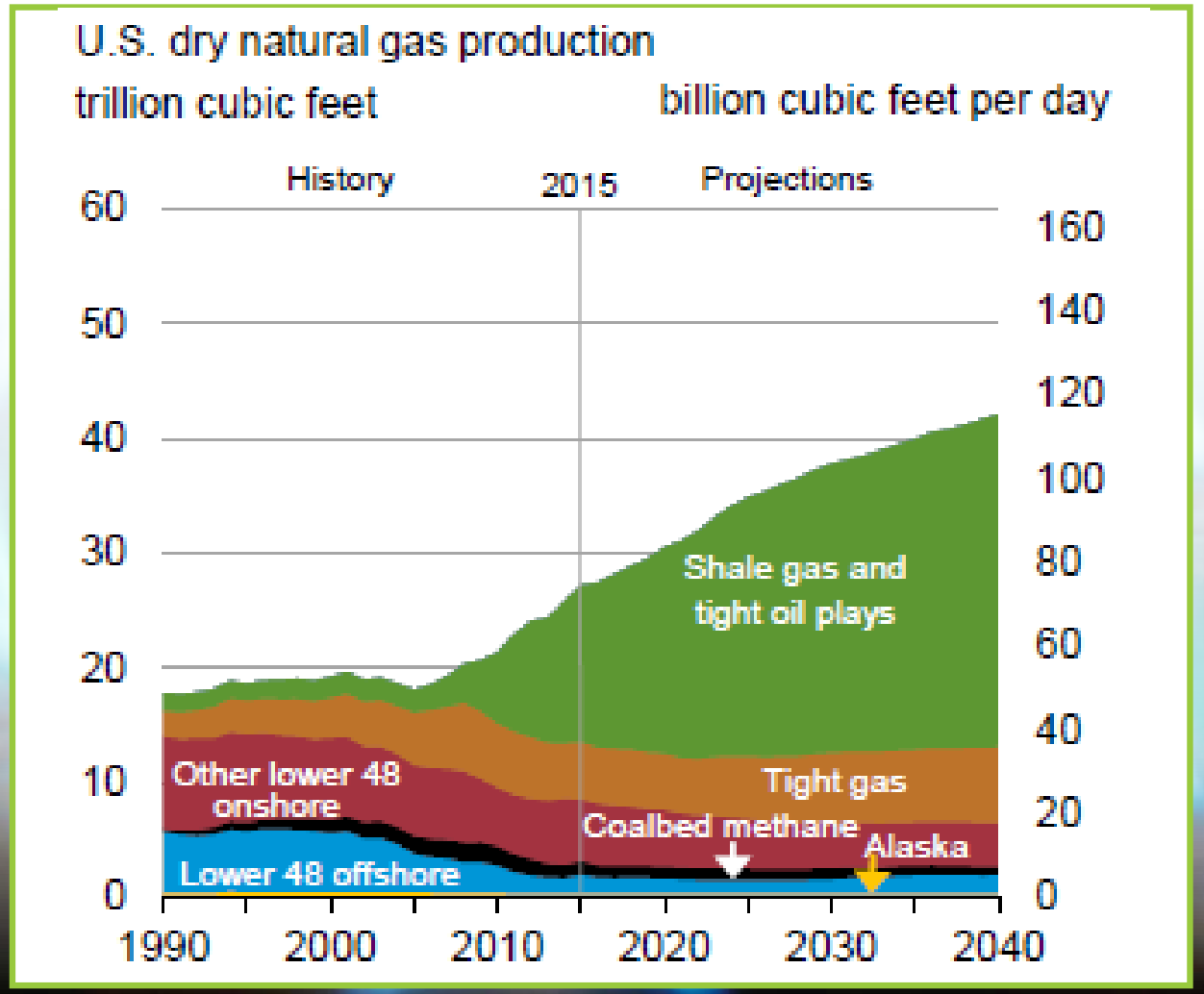
Energy Trends – Coal Take-Aways

- **WV and U.S. coal production are at ~40- and ~25-year lows, respectively**
- **Northern WV mines generally more cost competitive than those in south**
- **Coal consumption driven by electricity sales & cost competitiveness with natural gas**
  - WV coal is competitive with natural gas in certain markets at certain times
  - Price and levels of local natural gas storage determine current level of competitiveness
- **Any of the following conditions could drive increased coal consumption**
  - Increased economic growth and associated increase in electricity consumption
  - Growth in energy-intensive sectors, such as manufacturing
  - Higher natural gas prices

Energy Trends – Natural Gas Production



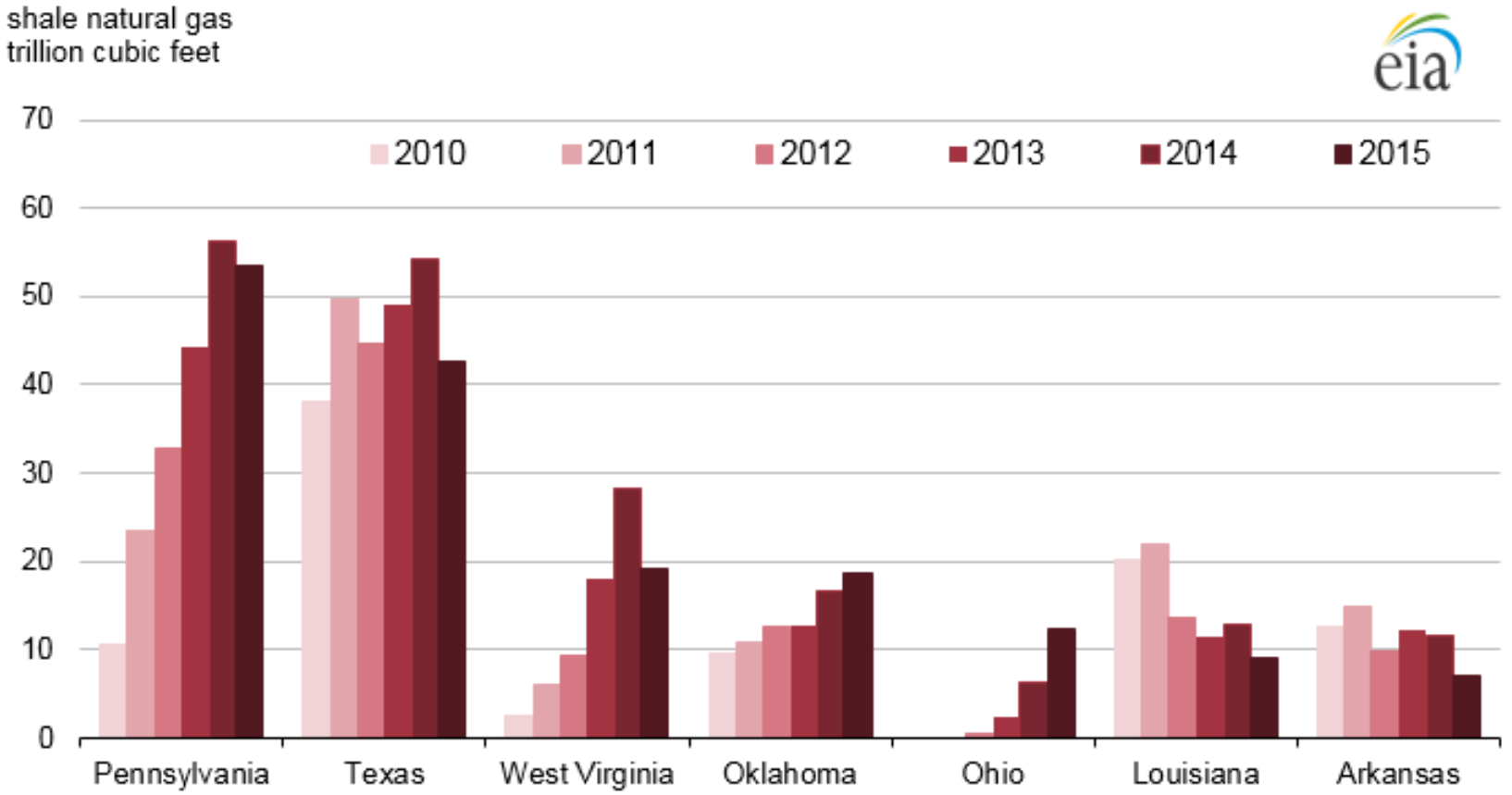
Energy Trends – Natural Gas Production



Source: EIA, Annual Energy Outlook 2016

Energy Trends – Natural Gas Reserves

Figure 13. Proved shale gas reserves of the top seven U.S. shale gas reserves states, 2010-15



Source: U.S. Energy Information Administration, Form EIA-23L, Annual Report of Domestic Oil and Gas Reserves 2010–15

Energy Trends – Natural Gas Take-Aways

- **West Virginia has substantial reserves of natural gas in shale plays**
  - 8th largest gas producer in nation
  - 2nd largest shale gas proven reserves in nation
  - Additional promising plays exist beyond Marcellus and Utica, including substantial volumes of "wet" gas
- **Natural gas prices are predicted to increase due to:**
  - Liquefied natural gas (LNG) export terminals coming on-line in the Gulf of Mexico
  - Recent and announced coal power plant retirements and potential nuclear retirements
- **Increased prices likely to re-invigorate production**
  - Production grew substantially from 2010 to 2015, from 265 Bcf to 1,320 Bcf before flattening in 2016
  - Challenges still exist with getting gas to market
- **Opportunities exist for in-state utilization if action is taken soon**
  - Utilization of "wet" gas (predominantly ethane) to produce plastic feedstocks for local manufacturing
  - Natural gas for transportation, either directly or via conversion to conventional fuels
  - Production of other chemicals or high-value products

Energy Trends – Renewable Energy

- **West Virginia has long history of hydro power**
  - 460 MW of existing capacity at 13 dams, ranging from 1 MW to 110 MW
  - Preliminary permits have been issued for an additional 6 facilities, totaling ~110 MW of capacity
- **Wind power is currently biggest source of renewable electricity**
  - 580 MW of operating capacity at 5 wind farms, ranging from 55 MW to 264 MW
  - Generates slightly more electricity than hydro power
  - Only one additional project on the books, and that has been stalled since 2012
- **Biomass, particularly wood, is the biggest source of renewable energy in West Virginia**
  - 300,000 tons/year of wood pellet production capacity
  - 135,000 cords of wood used for residential heating (96%) and industrial boilers (4%)
  - 150,000 acres of forest harvested annually, or 1.25% of the 12 million forested acres
- **Solar energy is growing, but small: 4 MW of capacity, all installed in the last 10 years**
- **Geothermal is an existing, but as-of-yet untapped resource**
  - Numerous geothermal "hot spots" in state provide an opportunity going forward

Future Opportunities

Exciting New Prospects for Energy in West Virginia

- **New markets for coal and coal by-products**
  - Rare earth elements
  - Carbon-based materials: nano-circuits, carbon fiber, carbon black
- **The potential of natural gas liquids (NGLs)**
  - Plastics production via ethane "cracker," producing low-cost feedstocks for local manufacturing
  - Ethane storage, boosting value and creating opportunities for longer-term NGL-based businesses
- **Renewable energy and hybrid renewable/fossil systems**
  - Re-use of mined lands for solar, wind, or biomass production (the latter used alone or with coal)
  - Pumped hydro electricity storage in abandoned mines
  - Geothermal via hot-spots or using mine-pool water (also has potential for hybrid fossil systems)
  - Integration of solar or wind into conventional power plants: low risk, high potential impact

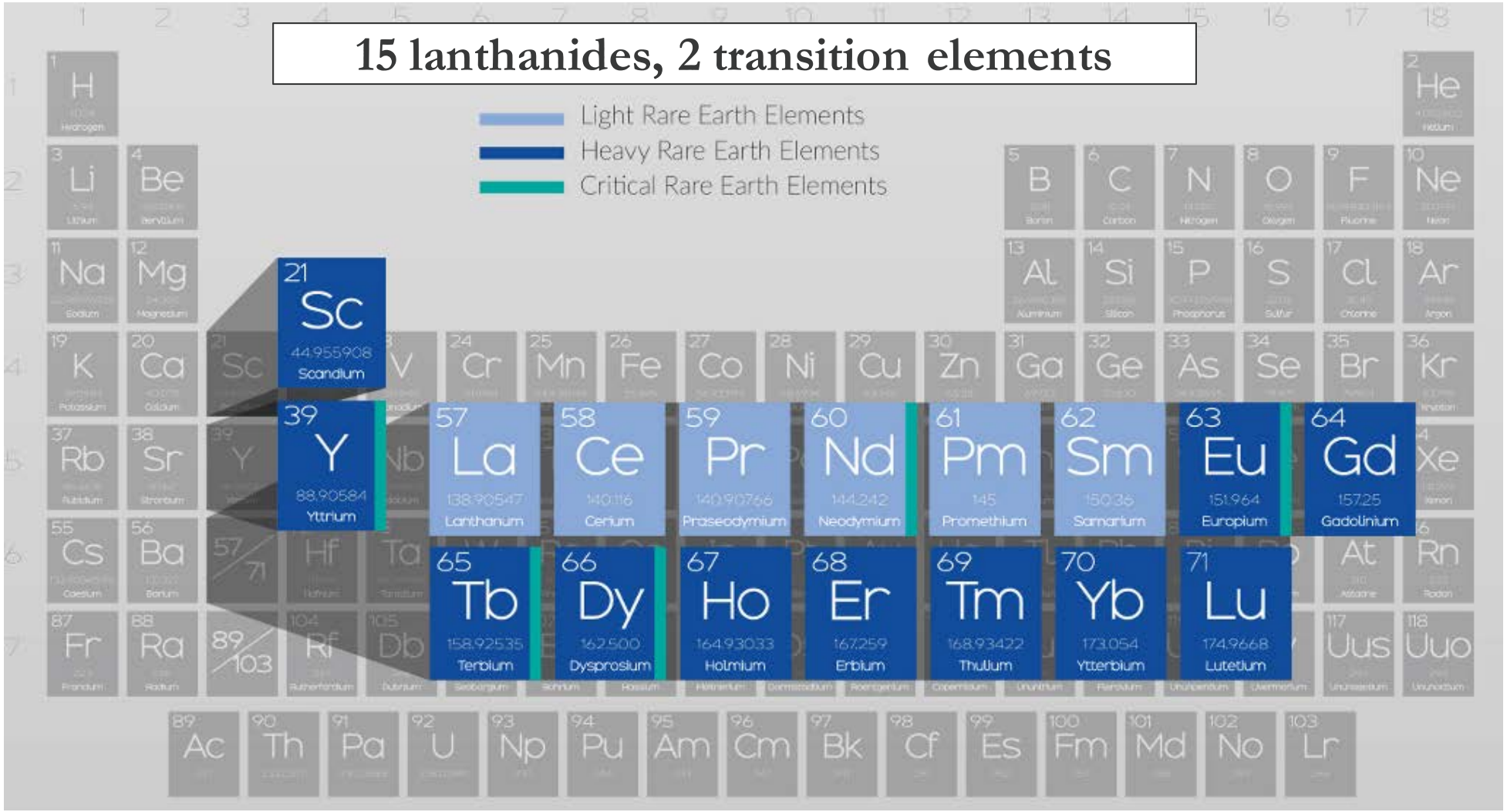
Future Opportunities (Continued)

Exciting New Prospects for Energy in West Virginia

- **Next generation of coal and natural gas energy**
  - High efficiency fuel cells
  - Modular systems which can be rapidly deployed to produce electricity, heat, or high value products
  - Transportation fuel production from coal and/or natural gas in conjunction with biomass
  - Next generation, high-efficiency power plants
  - Carbon capture, utilization, and storage (CCUS)
- **Enhancing oil & gas production while storing CO_2**
- **Safe resource development**

Future Opportunities – Rare Earth Elements

New Markets for Coal and Coal By-Products

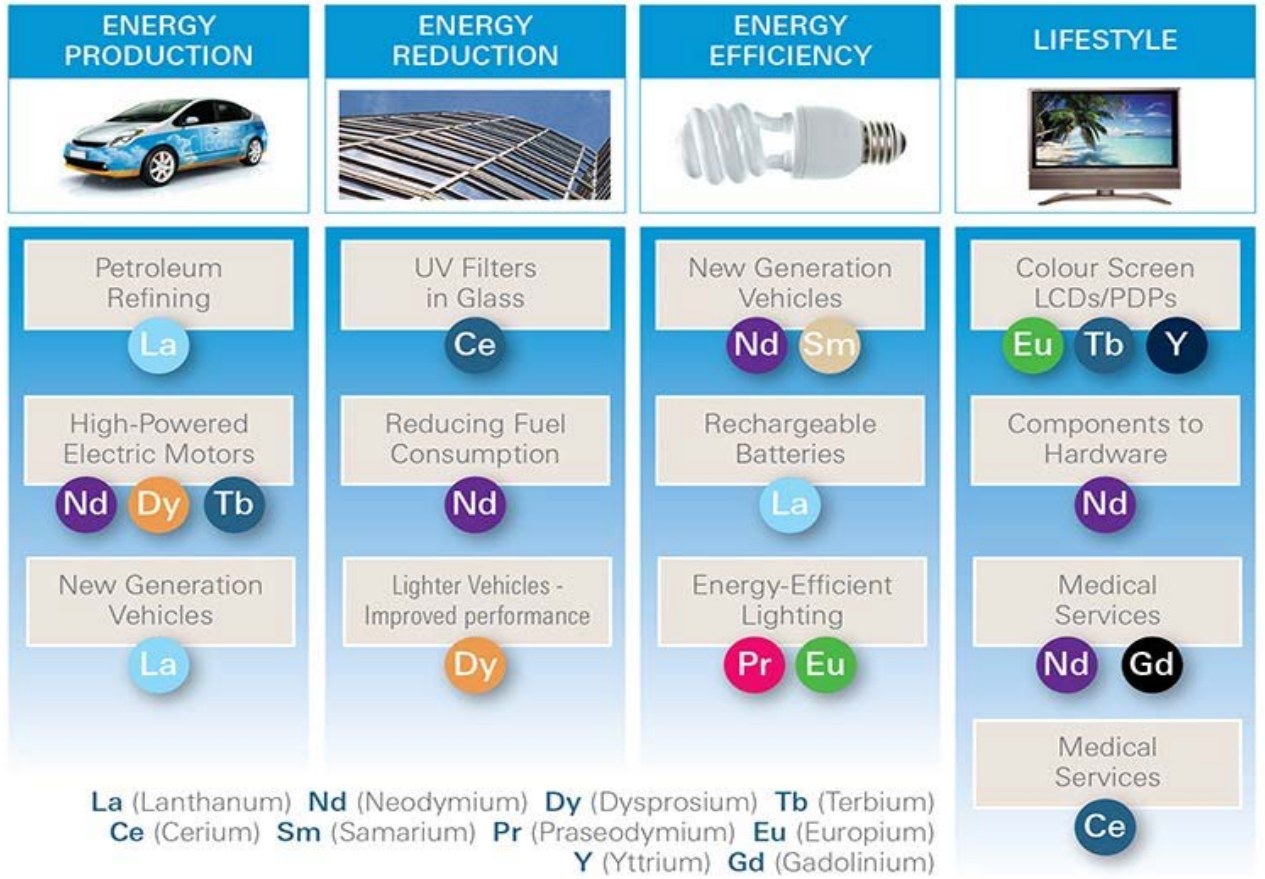


Future Opportunities – Rare Earth Elements

Applications Overview

- **Primary application sectors**
  - Magnetics
  - Phosphors
  - Ceramics
  - Metal alloys
  - Catalysts
  - Polishing powders
  - Glass additives
- **Defense applications**
  - Satellite communications
  - Guidance systems
  - Aircraft structures
  - Fly-by-wire
  - Smart missiles

Examples of REE Applications



Future Opportunities – Rare Earth Elements

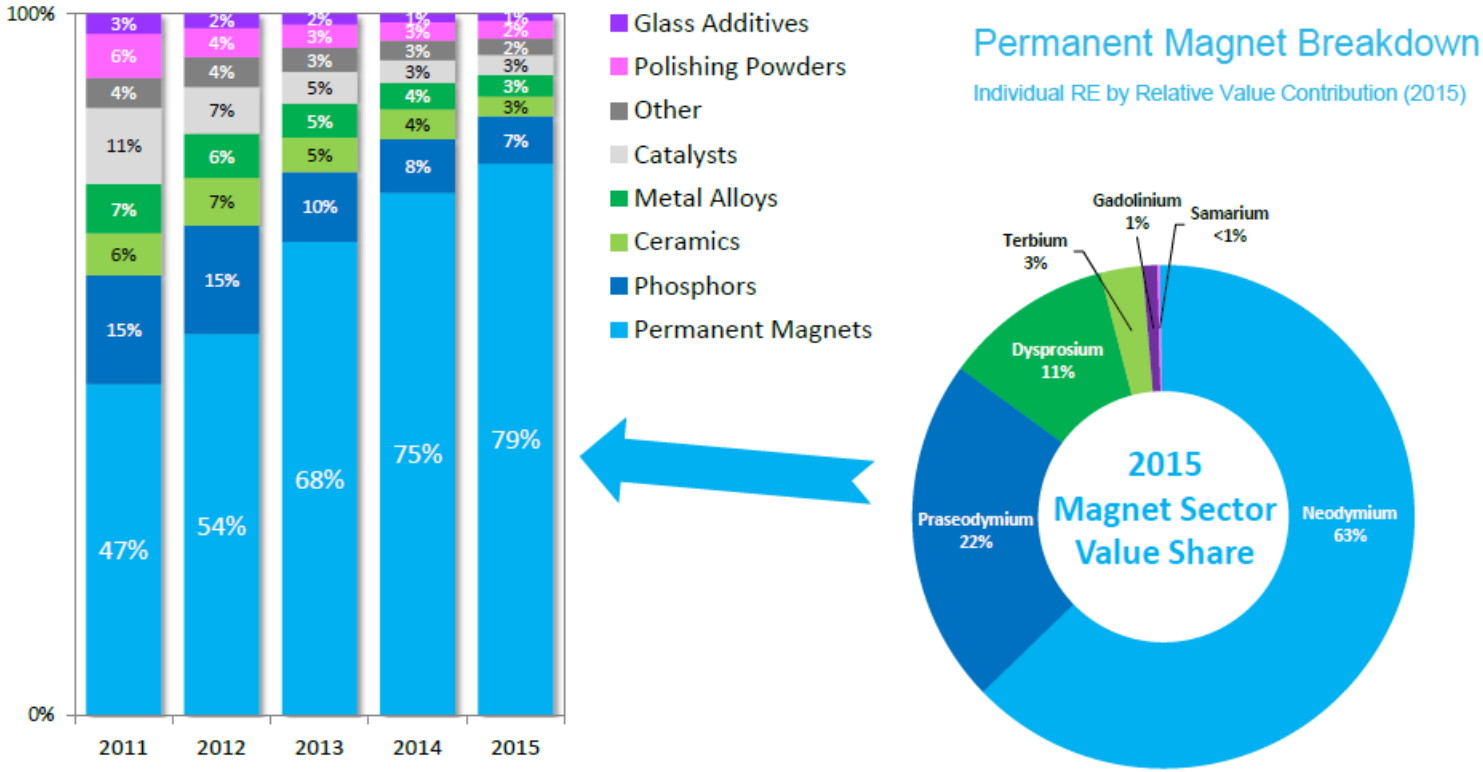
Market Overview

- **Annual global market ~$5 billion in 2015**
  - U.S. consumes ~11%, or $550 MM
  - Almost all REEs are imported
- **Majority of REEs imported as part of finished goods, not raw materials**
  - Electronic equipment imports $333 billion in 2015 (14% of total)
  - Phone devices (e.g. iPhone) almost a third of that at $102 billion
  - These can contain as many as 16 different REEs
- **Market remains complicated**
  - Risks of substitution
  - Current oversupply

Recent REE Market Value Evaluations

Rare Earth Market Value by Sector

PEAK RESOURCES LIMITED



Future Opportunities – Rare Earth Elements

Where are Rare Earth Elements Found in coal?

- **Coal & surrounding strata**
  - Coal type and seam
  - Over- and under-burden types
  - Wide variations in element distribution, even in a single coalbed
- **Coal byproducts**
  - Combustion residuals
  - Mining waste & tailings
  - Mine drainage sludge

Examples of REE Containing Coal Materials

Future Opportunities – Rare Earth Elements

REEs from Coal and Coal Byproducts: Opportunities & Challenges

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Significant volumes of low concentration REEs in potentially no or low cost feedstocks	+	Concentrations vary greatly depending on specific source
Other valuable materials can be co-produced, improving system economics	+	Perceived economic & environmental challenges in processing
Environmental remediation benefits may improve economics	+	Opaque & Volatile Market

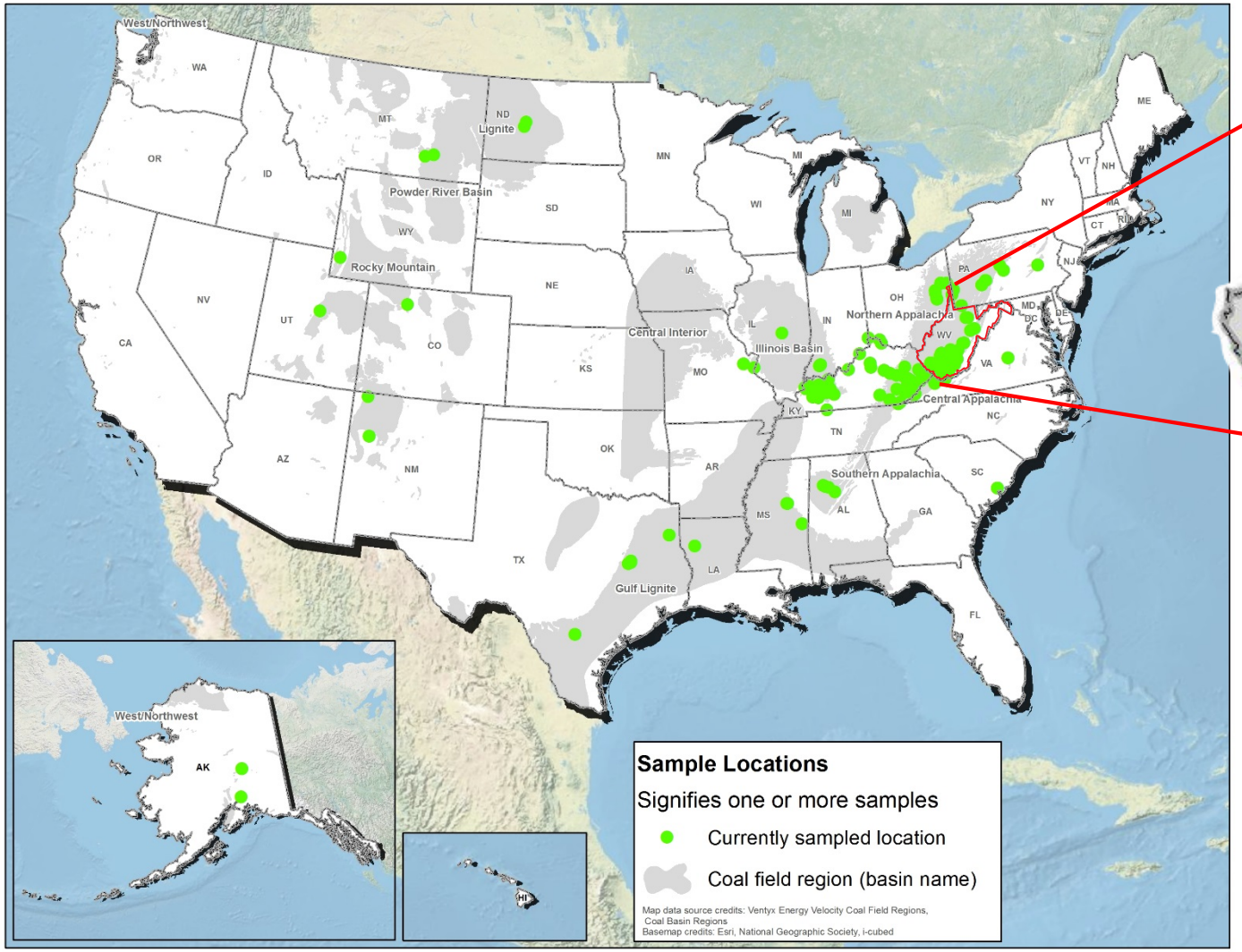
Future Opportunities – Rare Earth Elements

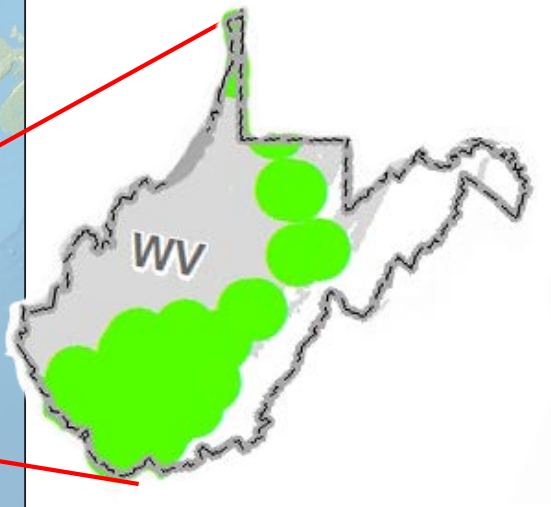
Environmental Remediation & Beneficiation Opportunities

- **Targets**
  - Coal combustion byproducts: fly ash in ponds
  - Fines, tailings, and gob piles
  - Acid mine drainage
- **Opportunities**
  - Revenue stream from products reduces remediation cost
  - Recover heating value of waste coal while adding environmental benefit
  - Obviate or reduce future waste streams
  - High visibility of ash containment ponds can provide driver
- **Barriers**
  - Liability for legacy mining operations
  - Perceived (?) potential environmental damage from disturbing gob or waste

Future Opportunities – Rare Earth Elements

NETL Sampling Program

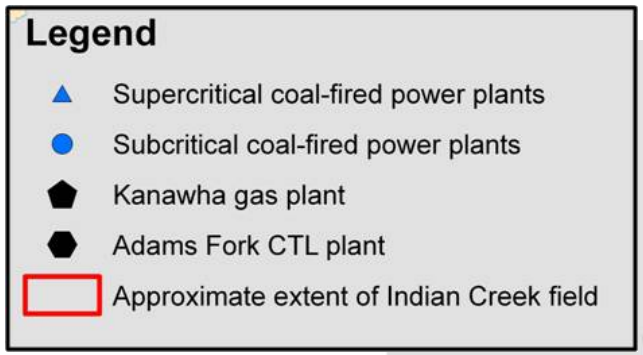


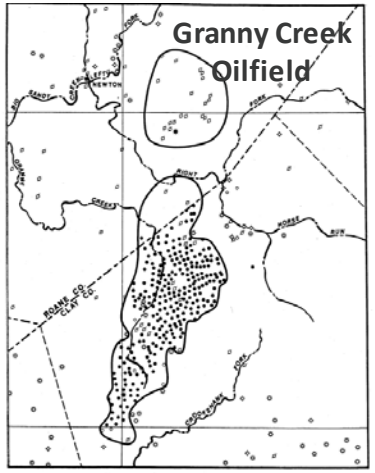


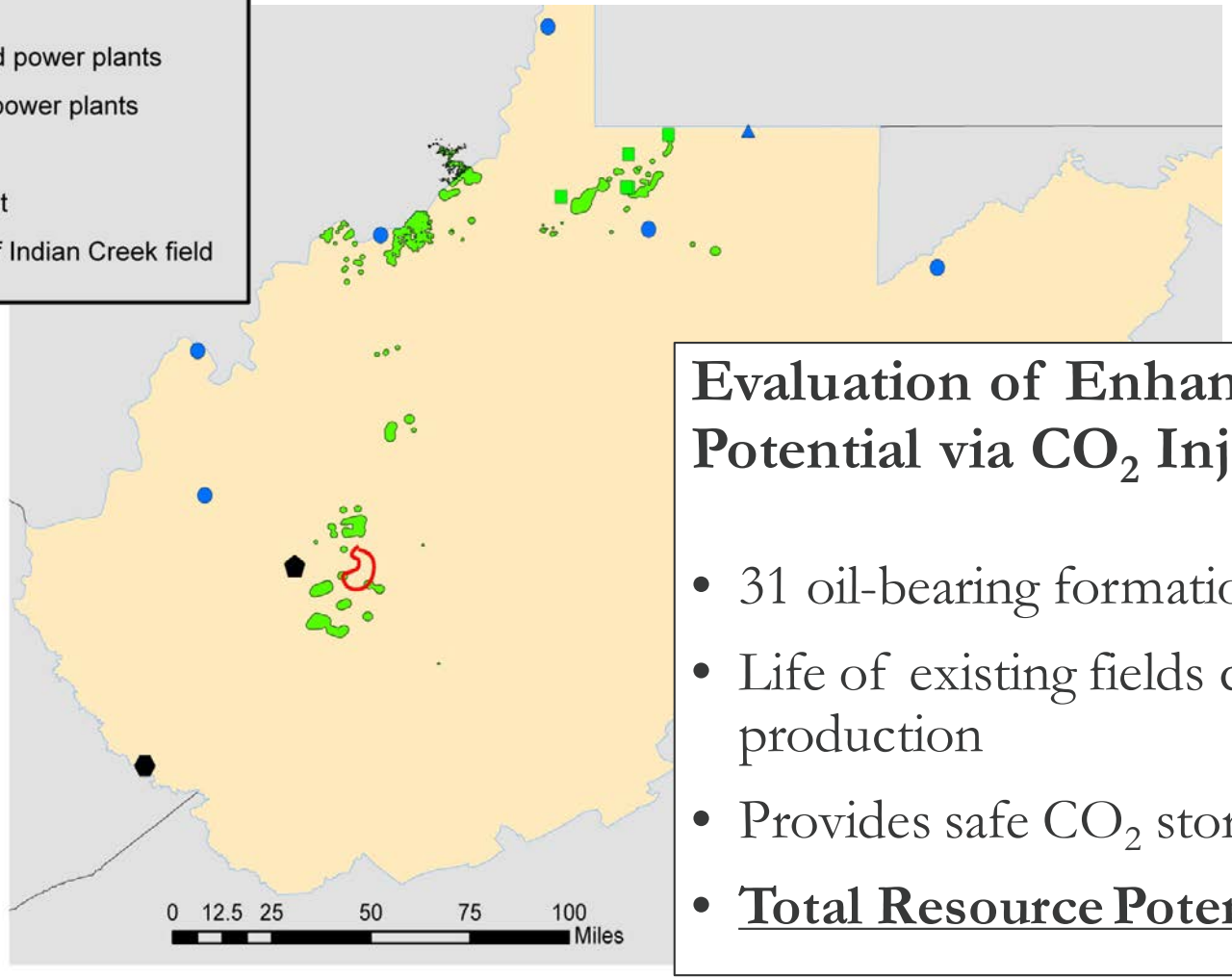
Extensive REE Sampling in WV

Future Opportunities – CO_2 as a Commodity

Enhancing Oil & Gas Production While Storing CO_2







Evaluation of Enhanced Oil Recovery (EOR) Potential via CO_2 Injection in West Virginia

- 31 oil-bearing formations with CO_2-EOR Potential
- Life of existing fields can be extended while doubling production
- Provides safe CO_2 storage
- **Total Resource Potential: 183 million barrels of oil**

Future Opportunities – Safer Resource Production

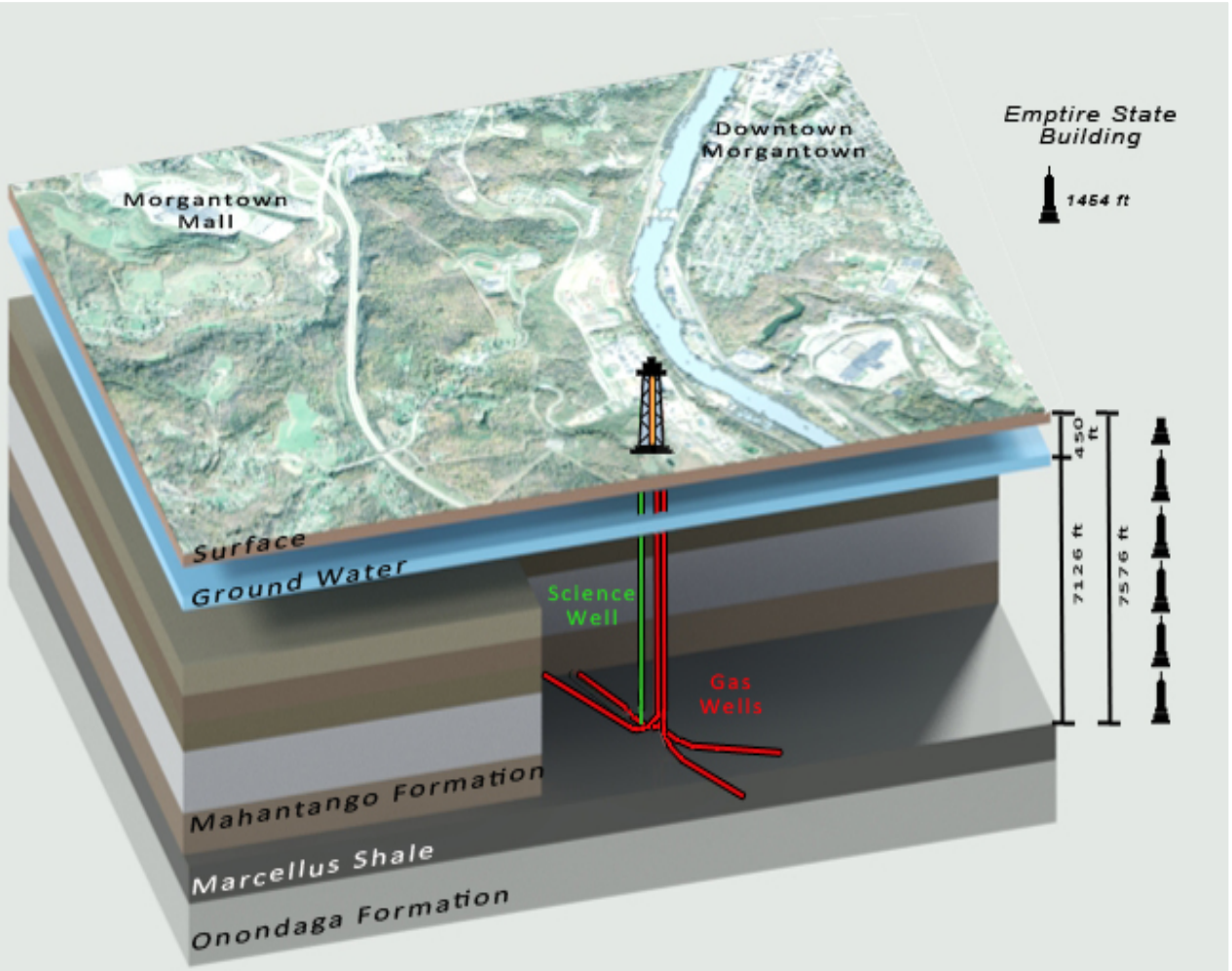
Marcellus Shale Energy & Environment Laboratory (MSEEL) Project

MSEEL mission

- Provide a long-term experimental station for testing and monitoring Marcellus gas production

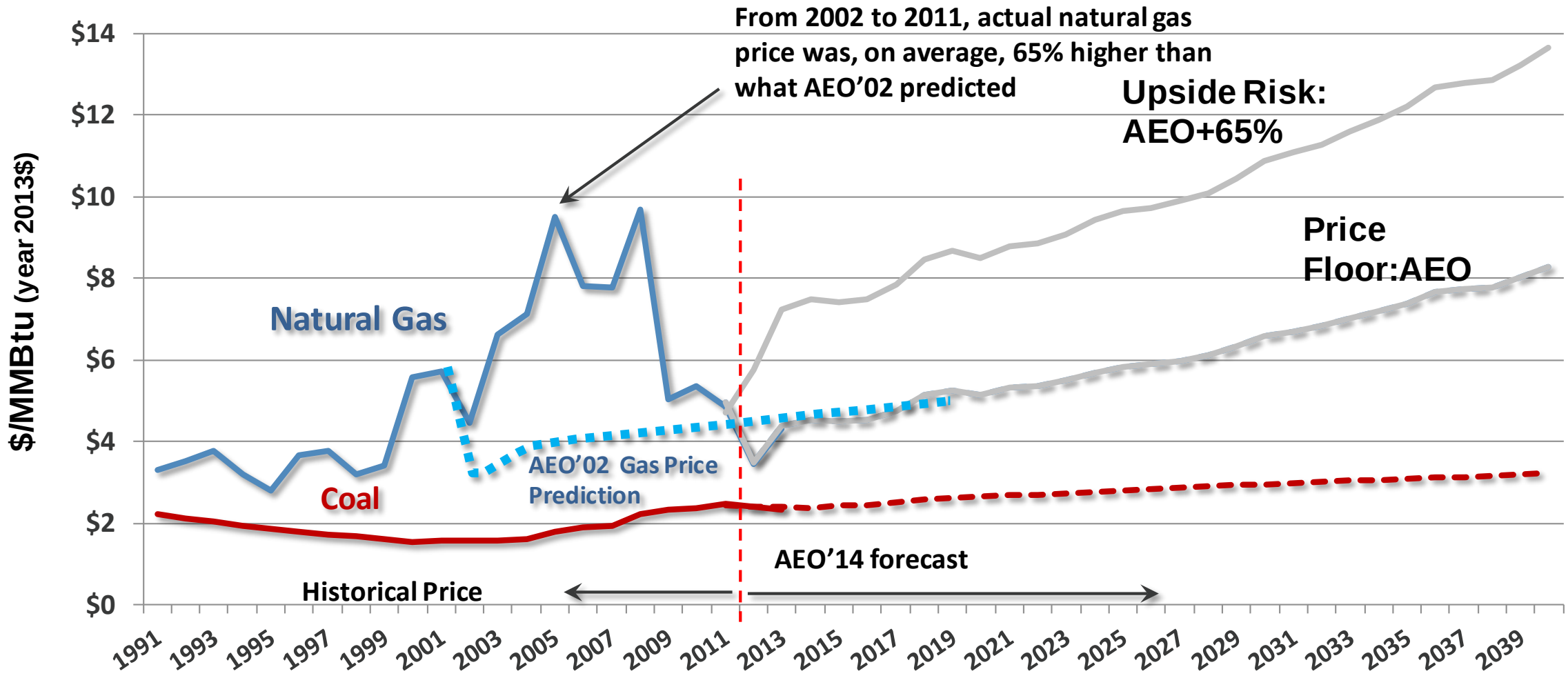
Technical objectives

- Improve recovery efficiency
- Minimize environmental implications
- Develop and validate new technologies



A Look at the Past to See the Future

History of Natural Gas Prices vs Projections



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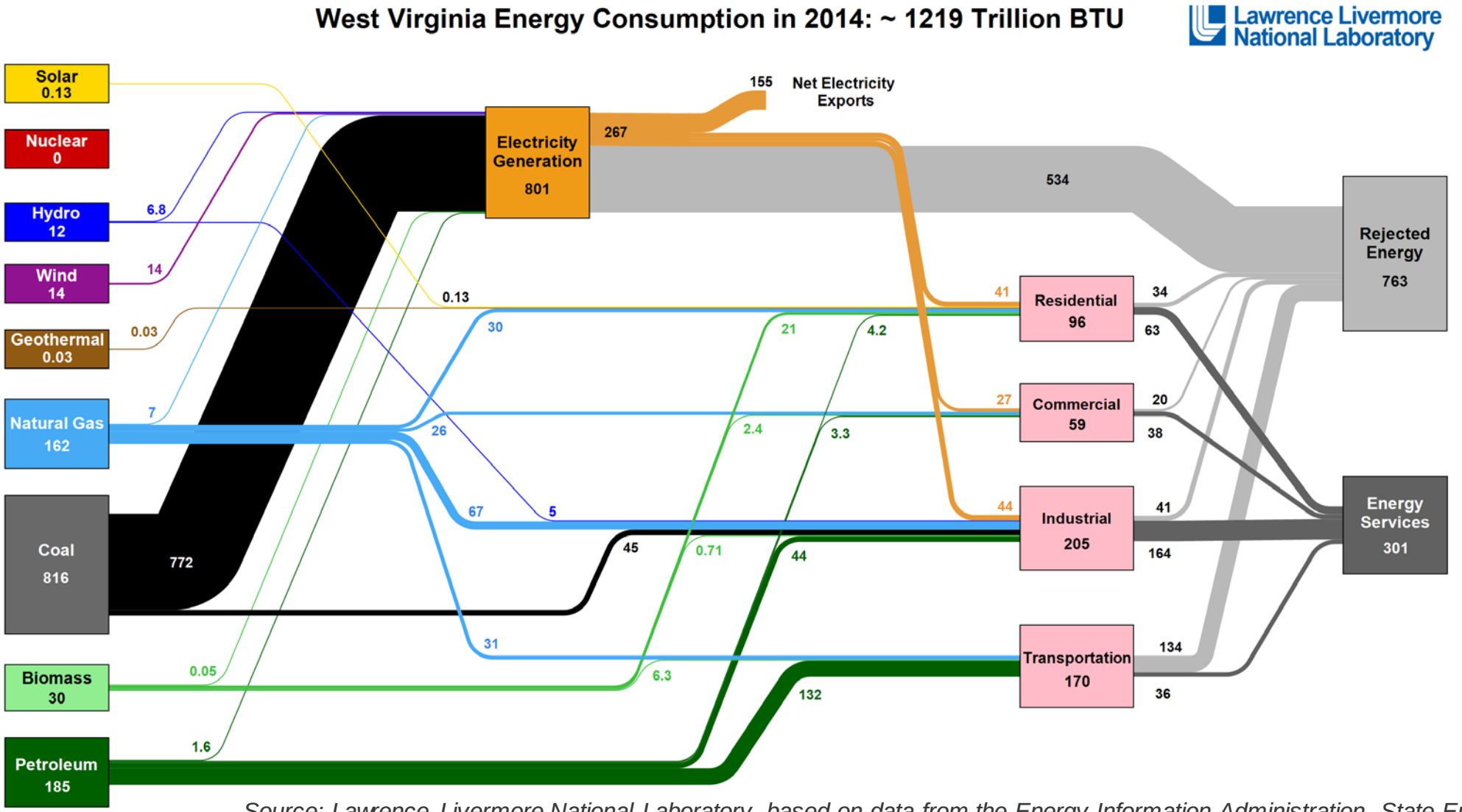
Energy Today – WV Consumption Overview



Source: Lawrence Livermore National Laboratory, based on data from the Energy Information Administration, State Energy Data System