Growth in the Industrial Pellet Sector
An Opportunity for New US Demand for Pellets

Co-firing Wood Pellets with Coal

A Rational and Pragmatic Off-Ramp to a Decarbonized Future

What is the Opportunity and does it make Economic Sense?

William Strauss, PhD

President, FutureMetrics
Director, Maine Energy Systems
Chief Economist, Biomass Thermal Energy Council

FutureMetrics

Globally Respected and Award Winning Consultants in the Wood Pellet Sector

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Expert advice, analysis, and strategic guidance for the wood pellet sector.

Selection of Current and Recent Clients of our Team

draxbiomass

VIRIDIS ENERGY INC.

enviva

FULGHUM FIBRES

Hancock Natural Resource Group

ENGIE by people for people

Formerly GDF Suez

VATTENFALL

INTERFOR

ROMSPEN

RENTECH

BTEC Biomass Thermal Energy Council

THERMA GLO FEEL THE HEAT™ A MOHEGAN ECO-FRIENDLY COMPANY

DEPARTMENT OF CONSERVATION MAINE Maine Forest Service STATE OF MAINE

NREL NATIONAL RENEWABLE ENERGY LABORATORY

LAHMEYER INTERNATIONAL

AGRINIKA

CATE STREET CAPITAL

MESYS MAINE ENERGY SYSTEMS

IOGEN CORPORATION

Holson

NCIC

Trans Pacific Fibre

BioDean

BFL CANADA

May, 2014
Deal Valued at $50.1 Million

NEW ENGLAND WOOD PELLET
Jaffrey, New Hampshire
HAS BEEN ACQUIRED BY
RENTECH
Denver, Colorado

FutureMetrics and its consulting partners initiated the acquisition process and provided early stage advice, analysis, and due diligence for Rentech

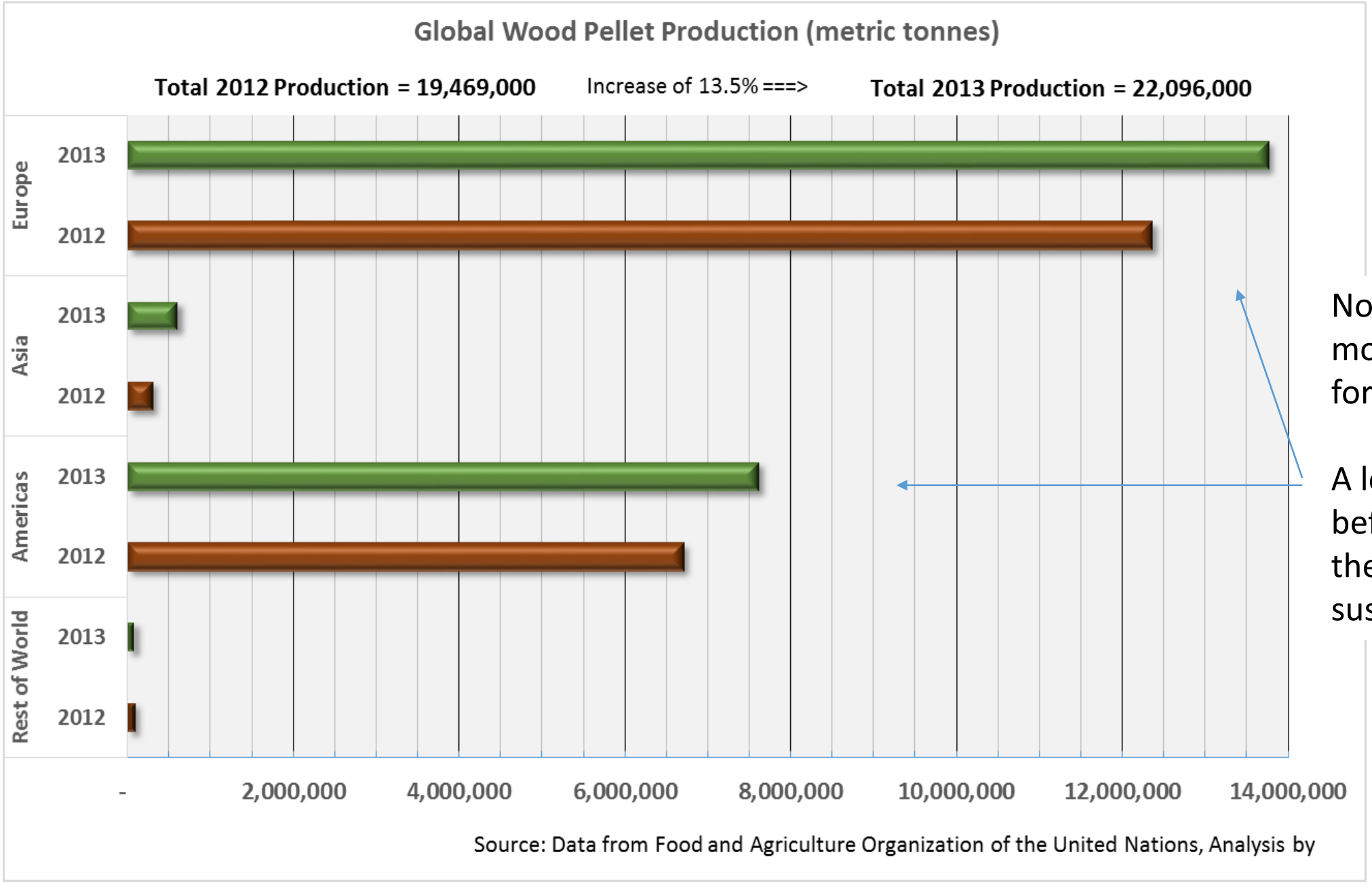
Award Winning Team Members

Dr. William Strauss, President, FutureMetrics

Recipient of the 2012 International Excellence in Bioenergy Award

John Swaan, Senior Associate, FutureMetrics

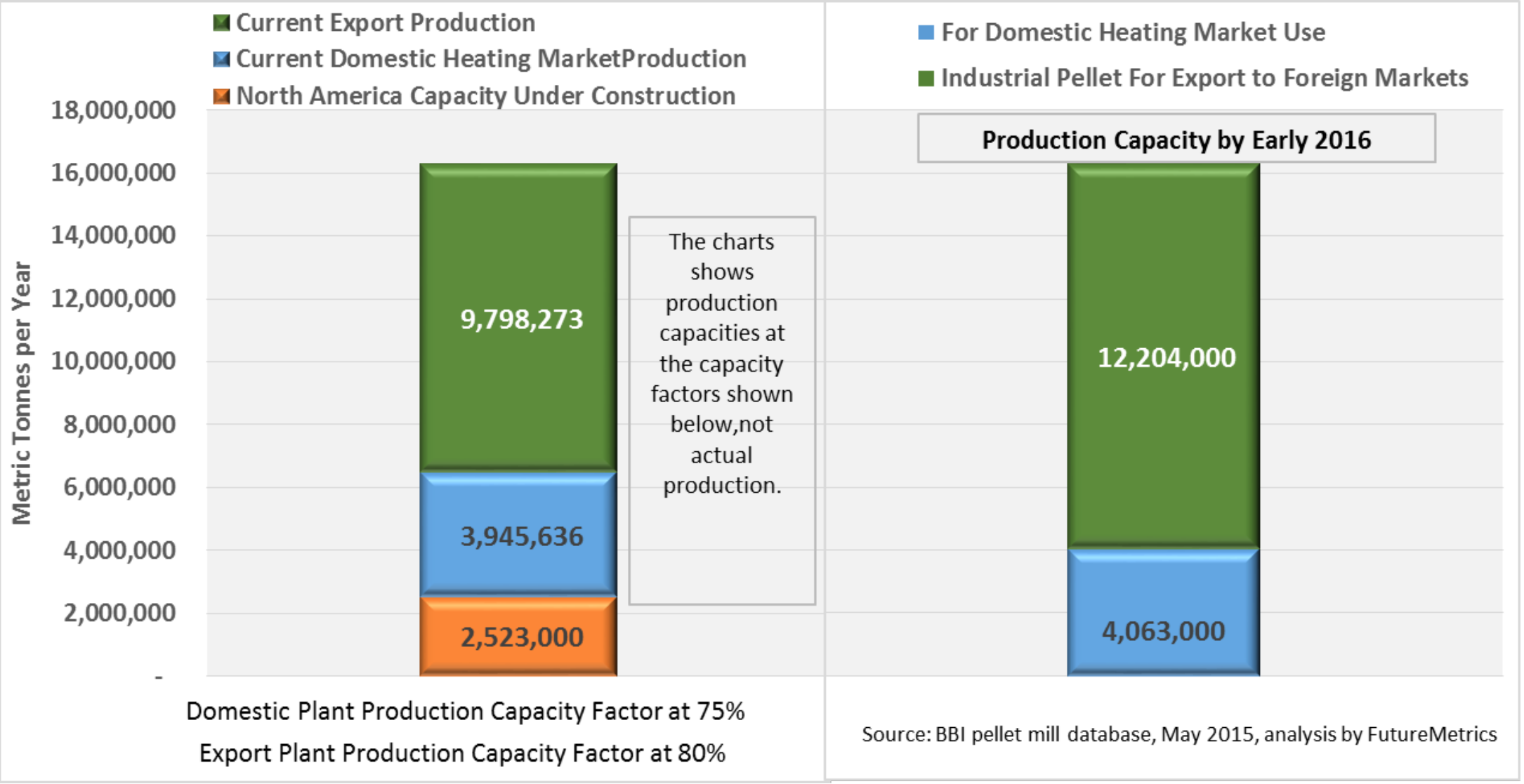
Recipient of the 2014 International Founders Award

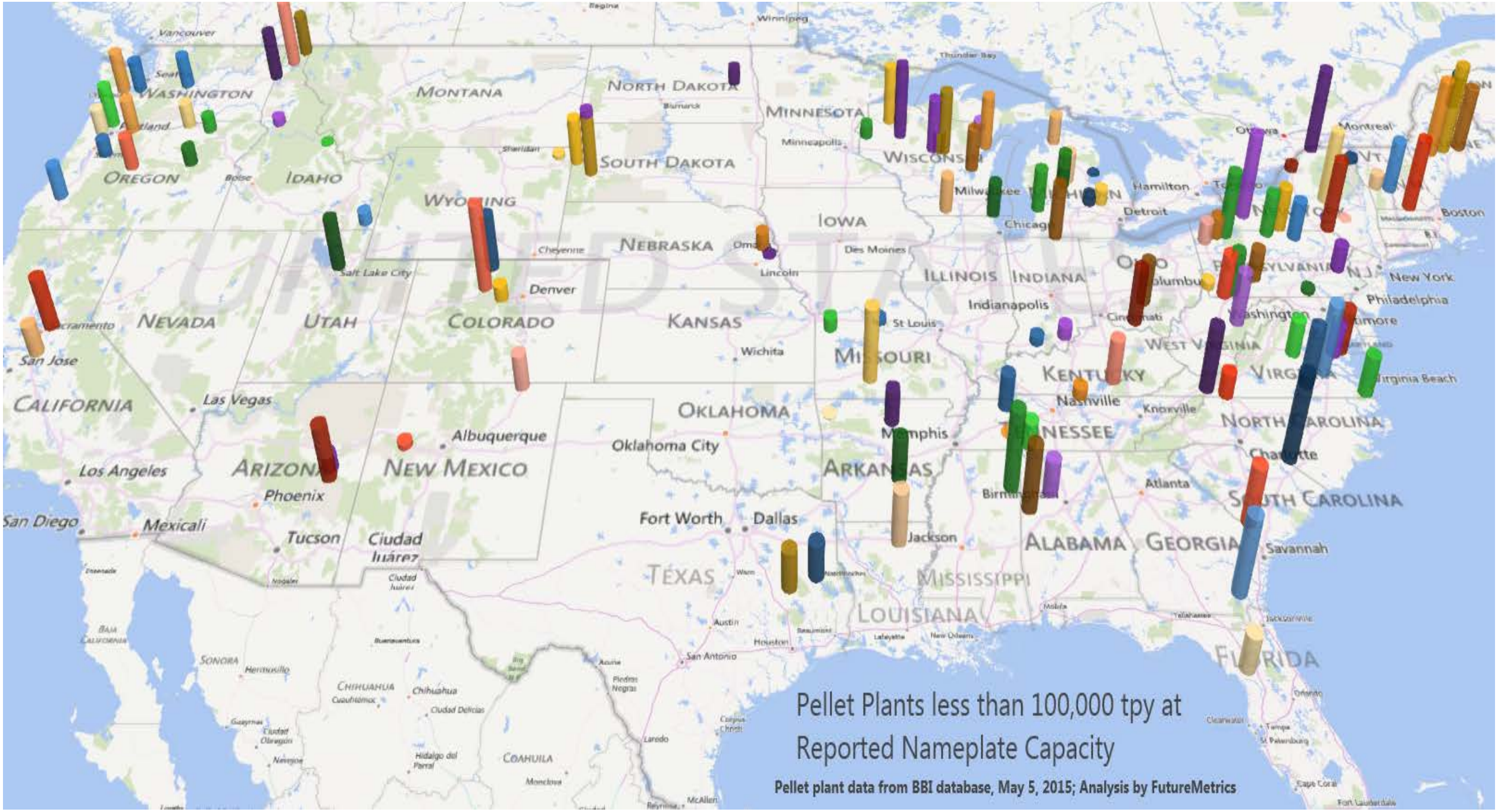


North America has more working forest than Europe.

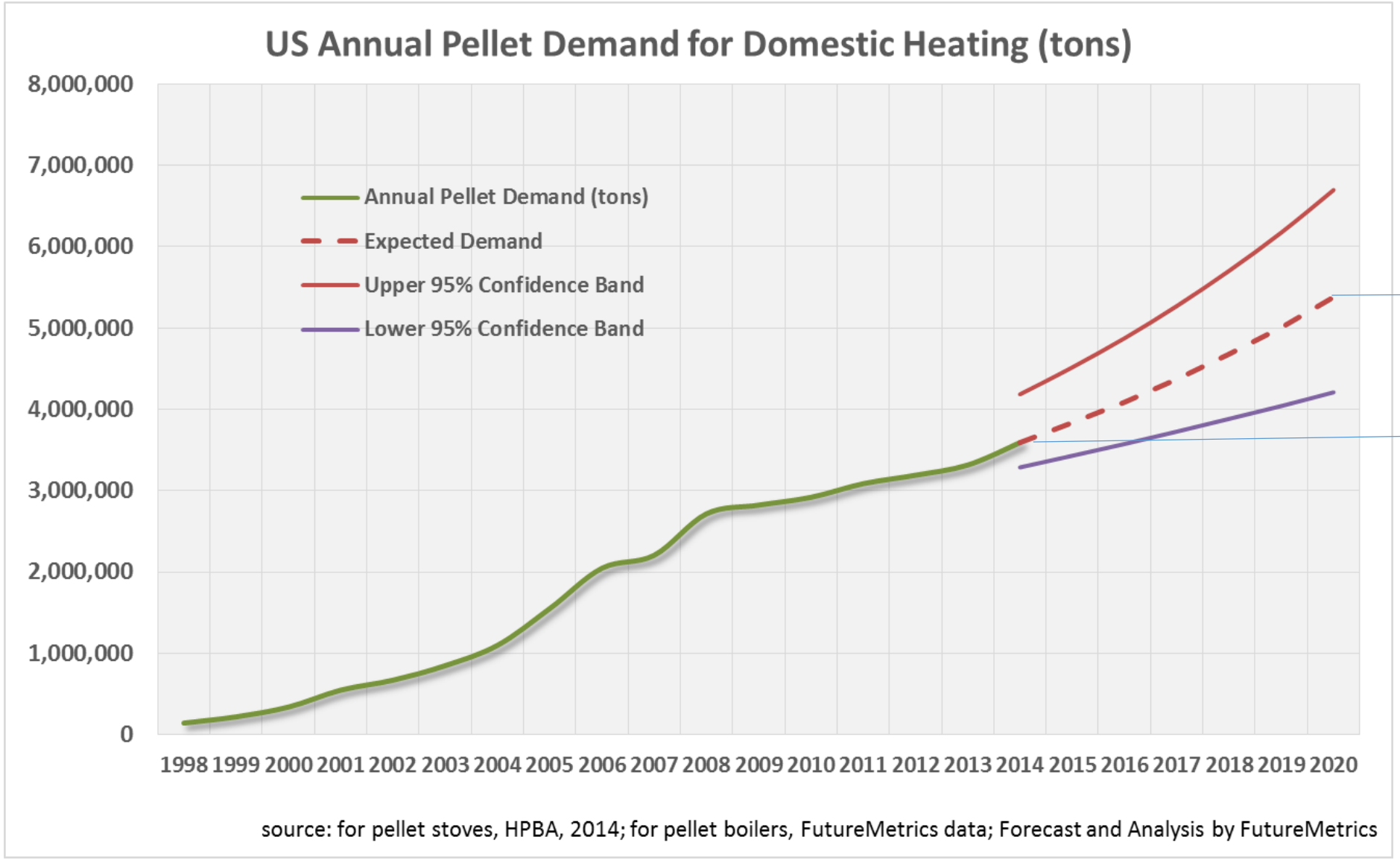
A long way to go before reaching the limits of sustainability.

North American Capacity

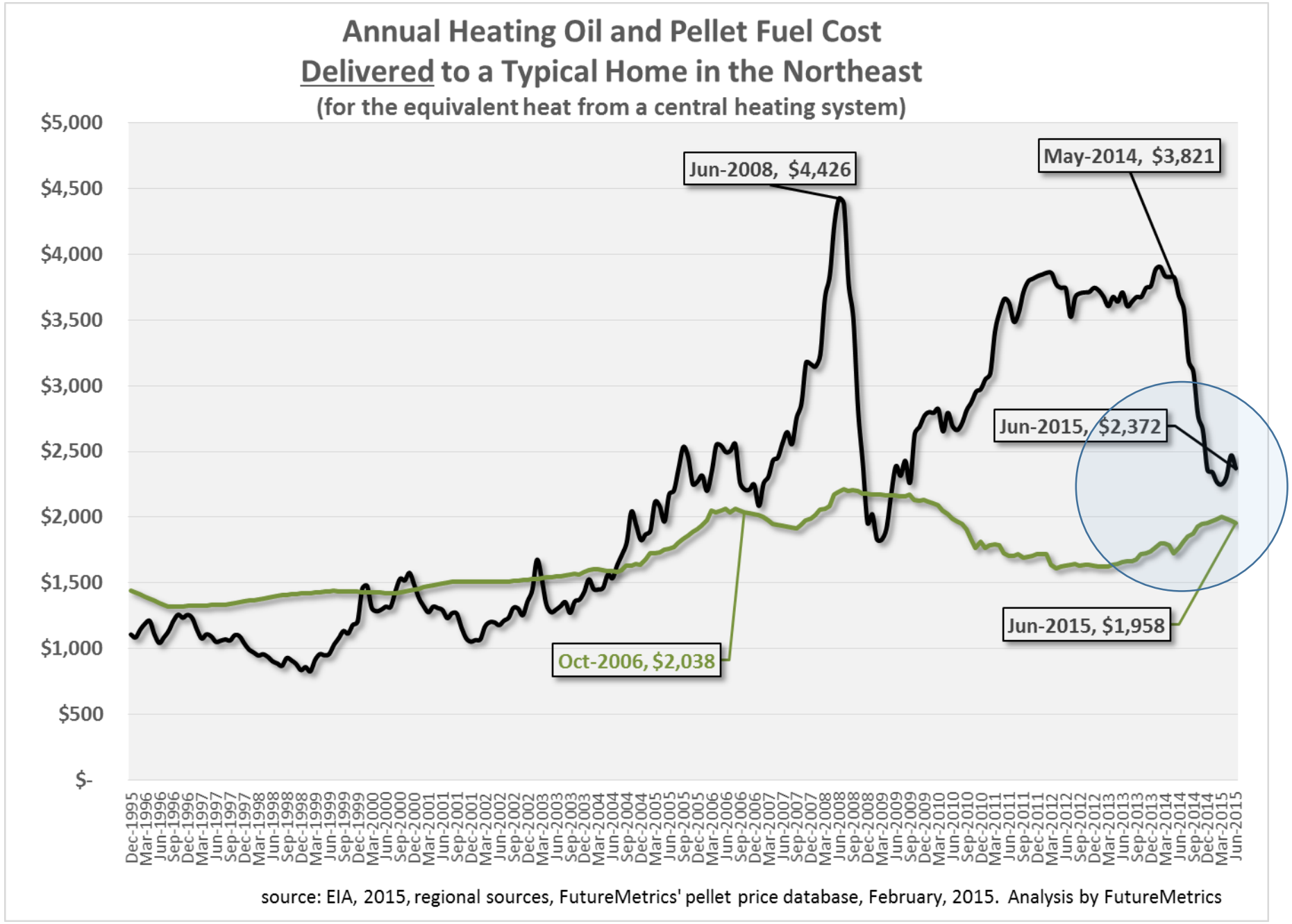



Pellet Plants less than 100,000 tpy at
Reported Nameplate Capacity
Pellet plant data from BBI database, May 5, 2015; Analysis by FutureMetrics

Wood pellets for heating in the US.



About 1.8 million tons of new demand.



There has been a slowdown in demand for new pellet stoves and boilers.

But it is unlikely that current owners of stoves and boilers will stop using pellets.

Unless the heating oil line crosses the pellet line!

The potential for significant growth in the industrial pellet market is in the co-firing in, or conversion of, North American pulverized coal (PC) power plants.

There are many PC plants around the world co-firing wood pellets.

It is easy for PC plants to co-fire.

At low co-firing rates there are no modifications needed.

For full conversions there are three large “proof of concept” operations:

- Drax in the UK (650 MWs per unit)
- Ontario Power Generations' Atikokan and Thunder Bay plants in Ontario

There are hundreds of others that can co-fire and can economically produce low cost, dispatchable, and job creating electricity.

Co-Firing: Many Examples

Korea Southeast Power (KOSEP) is co-firing 6% wood pellets with coal with no modification to the power plant and no dry storage solution at the power plant.

Yeongheung, Korea 5,000 MW Power Station

Pellets are simply metered into the coal before the pulverizers.

The power station consumes about 10 million tonnes per year of coal. Co-firing a “modest” amount of pellets in terms of percentage is **600,000 tonnes per year of pellets**.

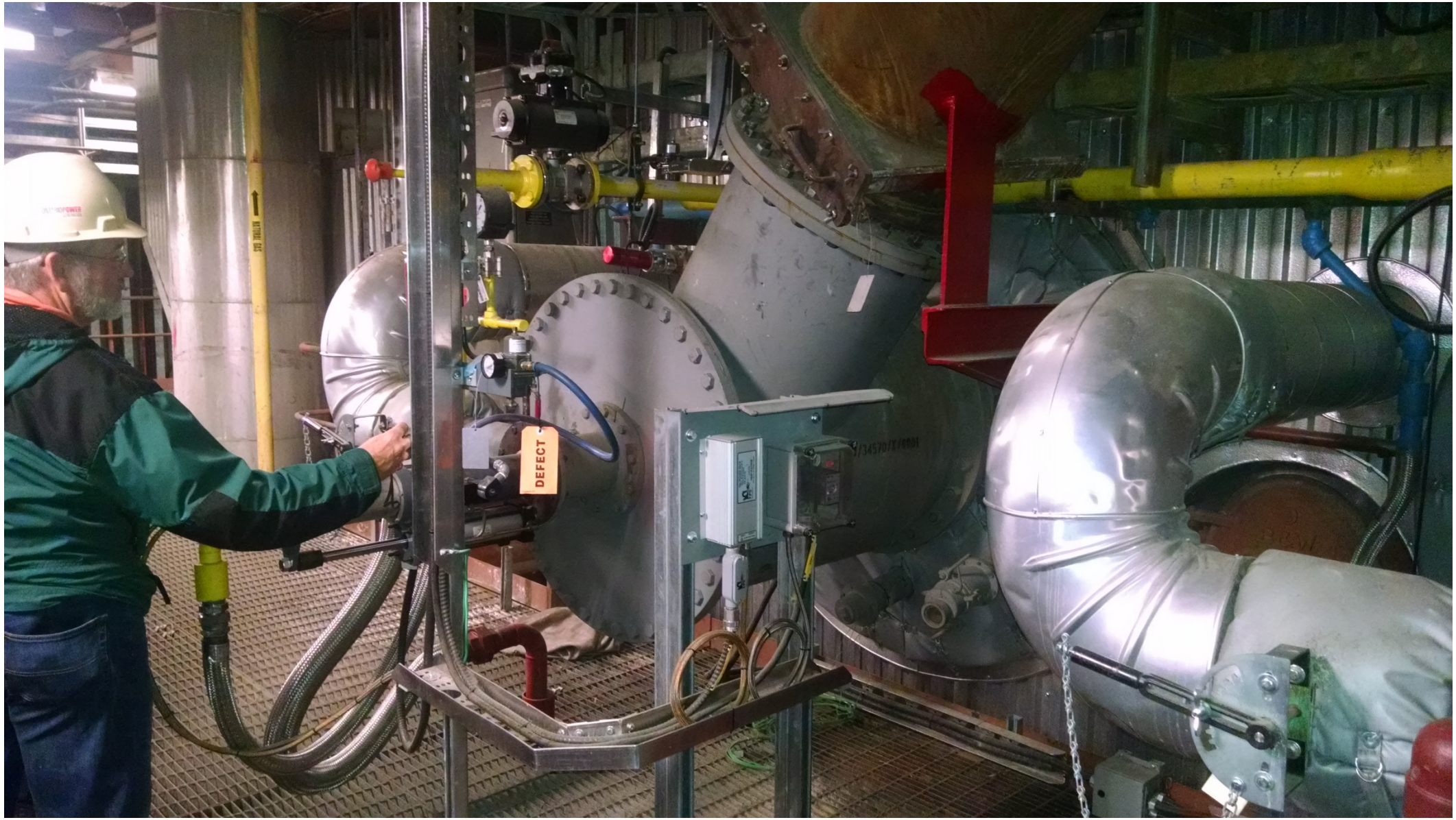
Full Conversion: Drax, the UK's largest power plant, is currently running two of six 650 MW lines on 100% pellets. Those two lines consume about 21,000 metric tonnes per day.

How is coal burned in a power plant boiler?

The coal is ground in to dust, pneumatically transferred to a burner in the sidewall of the boiler, and the dust is blown into the burner. Combustion takes place rapidly.

Replacing coal with pellets is very straight forward with almost no modifications at co-firing rates below 10% and with minor modifications for higher co-firing rates or for complete conversions.

Pulverized Pellet Burner (from the outside)



The next slide shows these burners in operation. Firing rate is about 155 tons per hour.


Corner 1
View 1

The enabling legislation in the US is the Clean Power Plan. What is The Clean Power Plan?

- It is the centerpiece of Obama Climate Action Plan
- It targets fossil-fueled power plants as the largest source of US Greenhouse Gas (GHG) emissions
- Goal is a 30 percent reduction in power sector emissions by 2030 compared to 2005 levels
  - Will have interim compliance goals (2020-2029) and final compliance goals (2030)
- Based on section 111(d) of the Clean Air Act (CAA)
  - **States** must develop plans to implement EPA guidelines

Content on the slides on the CPP overview produced by FutureMetrics based on material from Robert Sussman, Sussman & Associates

Key Milestones in CPP development

June 25 , 2013	**President Directs EPA to Develop CPP**
June 2, 2014	CPP Proposed for Comment
October 28, 2014	EPA Publishes Supplemental Proposal
December 1, 2014	Comment Period Closes
May 29, 2015	Draft Final CPP Sent to White House for Review
August 2015 (EST)	Final CPP Signed by EPA Administrator and Released
August 2015 (EST)	Model Federal Implementation Plan Proposed

STATE IMPLEMENTATION PROCESS

- CPP sets separate state-by-state *emission reduction goals*
  - Significant variations between states reflecting generation mix and other factors
- States must develop implementation plans describing how goal will be met
  - Plans subject to EPA review and approval
  - If state doesn't submit approvable plan, EPA will impose federal implementation plan (FIP)
  - States can collaborate on joint plans
- **States have broad discretion to select strategies to reduce emissions**

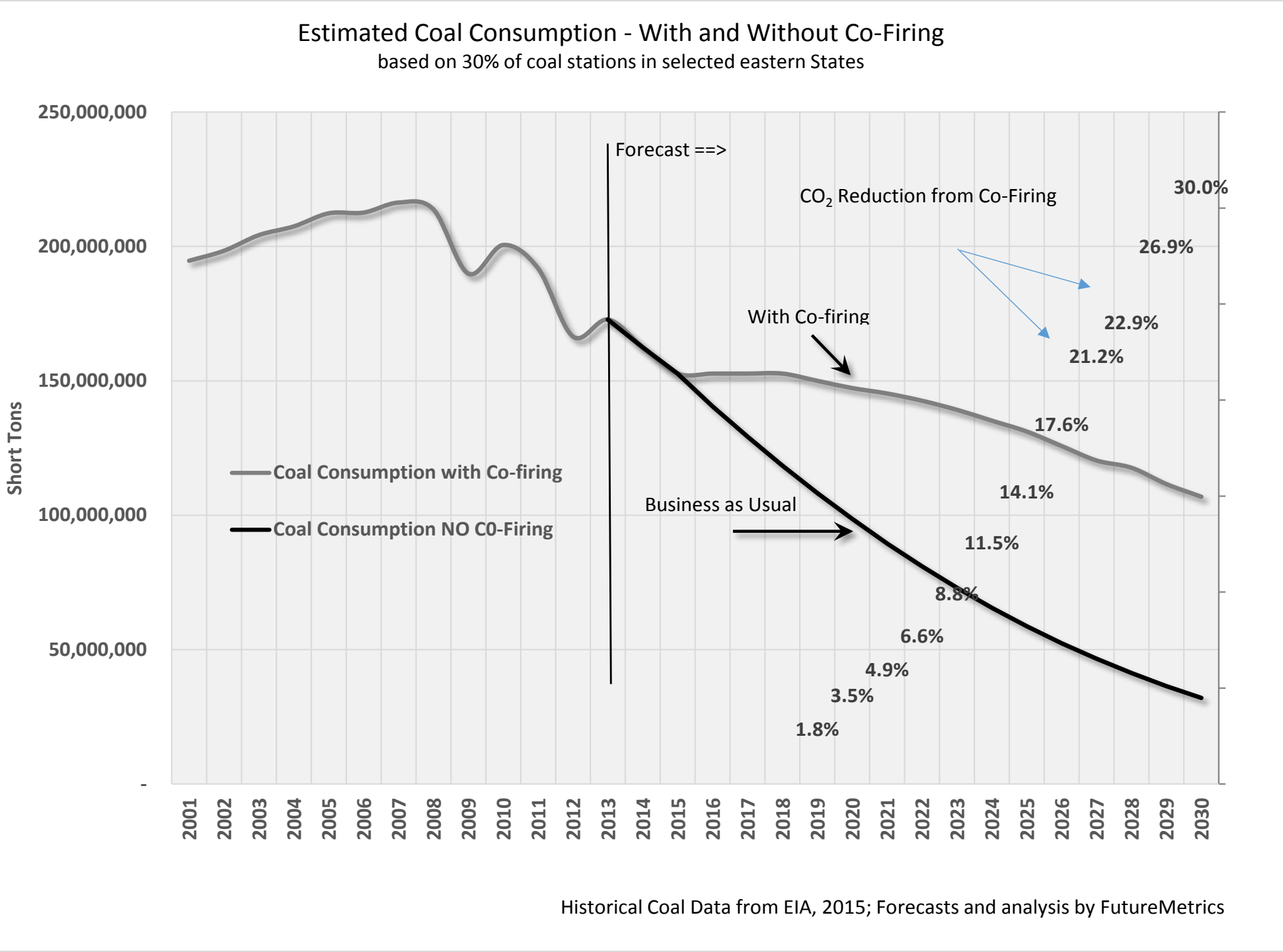
CPP Implementation Timeline

September 2016	**Deadline for Initial State Plans**
September 2017	**Deadline for State Plans with One-Year Extension**
September 2018	**Deadline for Multi-state Plans**
September 2020	**Initial Compliance Date for Interim Goals**
2020-2029	**Compliance Period for Interim Goals**
September 2030	**Final Compliance Date**

How states will respond to final CPP

- Most states preparing to implement CPP and investigating compliance strategies
- But some states are strongly opposed and likely to boycott implementation process
  - Senate Majority Leader Mitch McConnell urging “just say no” strategy
  - These states face federal implementation through FIPs

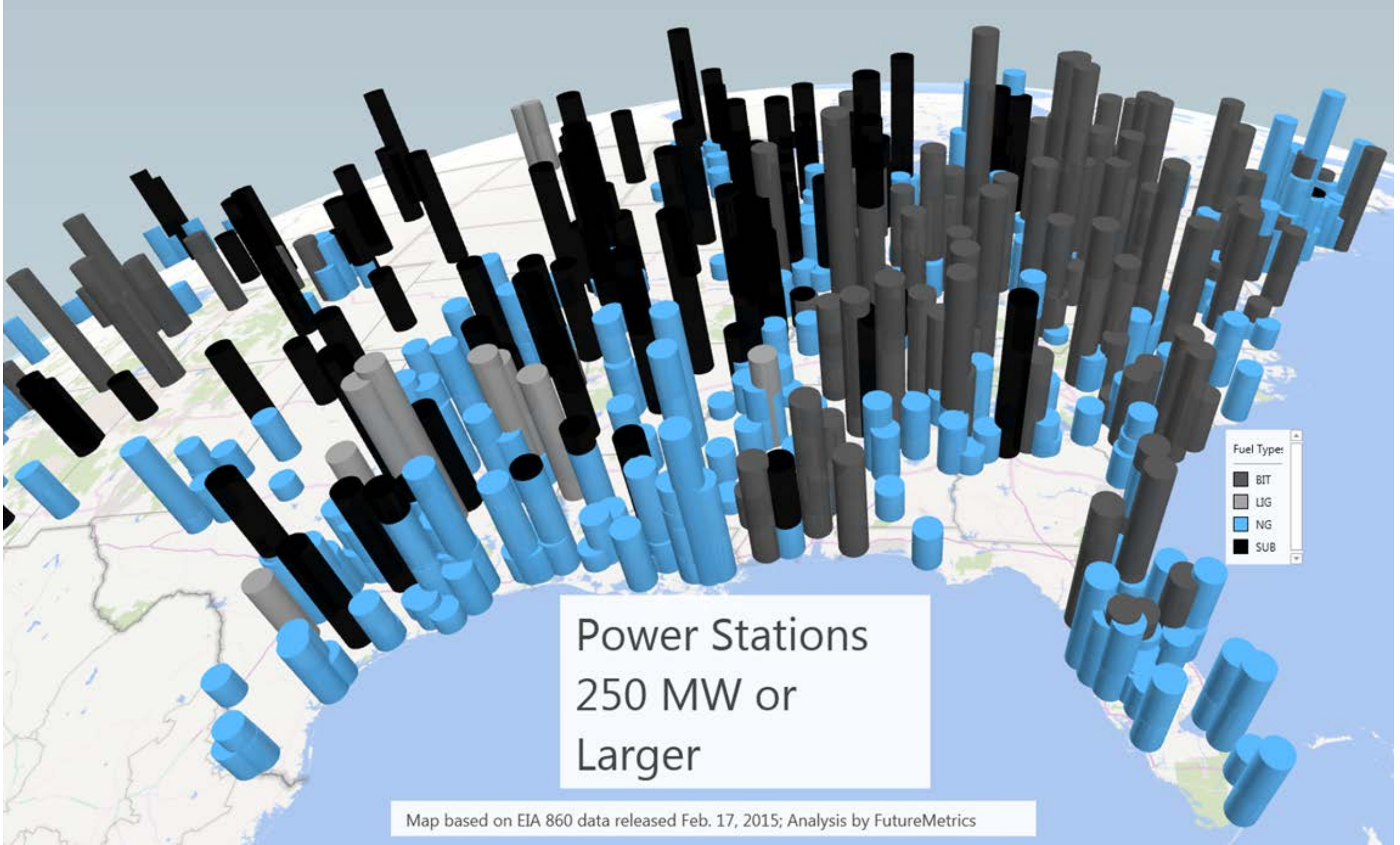
Coal producing states need to learn about the benefits of co-firing as shown on the next slide.



Coal is losing market share by about 10% per year since the shale gas revolution. Business-as-usual will see a continued decline. The co-firing strategy preserves the need for coal power stations and therefore the need for coal.

How will pellets be treated under CPP?

- BEST CASE – Combustion of wood pellets and other forest products is considered carbon-neutral
- Wood pellets would be considered non-emitting and could yield substantial emission reductions as a replacement for coal
- BUT treatment of biomass and carbon-neutrality is opposed by environmental groups and some members of Congress


Fuel Types
BIT
LIG
NG
SUB
Power Stations
250 MW or
Larger
Map based on EIA 860 data released Feb. 17, 2015; Analysis by FutureMetrics

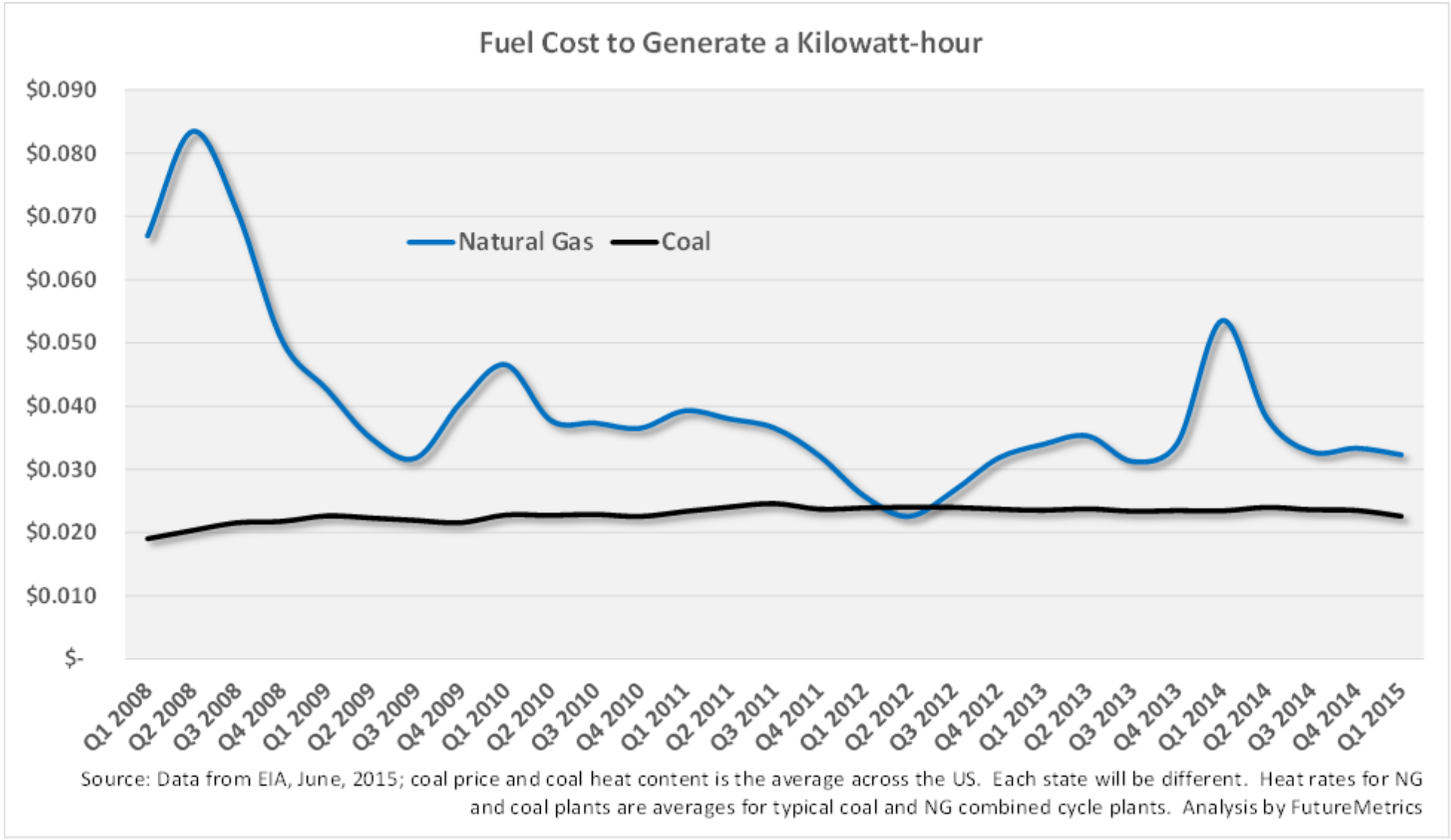
Coal is a major part of the system. Across the US, looking at generators of 250 MW or larger, coal represents 50.25% of all the megawatt-hours generated. Natural gas generates 22.06%.

Data from EIA-860 Annual Electricity Data, Feb. 17, 2015; analysis by FutureMetrics.

At current prices, coal is still the lower cost fuel. At $55/ton for coal and $5.50/MMBTU for natural gas, the fuel cost per MWh of electricity is $23.77 for coal and $31.28 or NG*. But the lower capital cost and lower fixed and variable O&M costs for NG results in a lower total cost per MWh. That would change if natural gas prices for power plants go to $9.19/MMBTU. At $9.19/MMBTU and $55/ton, the total cost per MWh is the same for NG and coal.

Is it wise for utilities to put all of their generation into NG? We think not.

*Assumes 38% efficiency for coal and 60% efficiency for a combined cycle gas plant.



Source: Data from EIA, June, 2015; coal price and coal heat content is the average across the US. Each state will be different. Heat rates for NG and coal plants are averages for typical coal and NG combined cycle plants. Analysis by FutureMetrics

	Primary Generation Sources					
	Coal	Natural Gas	Nuclear	Solar	Wind	Other or Mixed Fuels
West Virginia	86.4%	7.1%	0.0%	0.0%	3.4%	3.2%
Kentucky	71.3%	24.6%	0.0%	0.0%	0.0%	4.1%
Indiana	65.2%	21.9%	0.0%	0.2%	5.0%	7.7%
Ohio	56.8%	30.7%	6.3%	0.1%	1.3%	4.8%
Missouri	54.9%	27.7%	5.2%	0.0%	1.9%	10.3%
Michigan	36.7%	36.4%	12.9%	0.0%	3.5%	10.6%
Alabama	35.1%	38.0%	15.0%	0.0%	0.0%	12.0%
Illinois	34.0%	32.4%	24.4%	0.1%	7.0%	2.2%
North Carolina	33.7%	39.0%	16.6%	1.0%	0.0%	9.7%
Arkansas	33.5%	44.5%	11.3%	0.0%	0.0%	10.6%
Georgia	32.7%	43.5%	9.8%	0.1%	0.0%	13.9%
Pennsylvania	30.8%	28.1%	21.7%	0.1%	2.8%	16.5%
South Carolina	25.2%	26.0%	27.6%	0.0%	0.0%	21.2%
Virginia	22.3%	34.7%	13.8%	0.0%	0.0%	29.3%
Texas	21.3%	62.3%	4.3%	0.1%	10.3%	1.6%
Florida	16.5%	61.8%	5.6%	0.1%	0.0%	16.0%
Mississippi	16.5%	72.2%	8.2%	0.0%	0.0%	3.1%
Louisiana	12.4%	73.1%	7.3%	0.0%	0.0%	7.2%
New Jersey	10.3%	58.0%	20.1%	1.6%	0.0%	10.1%
New York	6.1%	48.8%	13.2%	0.1%	4.0%	27.9%

In 2013 those states consumed 576,000,000 tons of coal.

Date from EIA, 2015, with analysis by FutureMetrics.

Perhaps in several decades the decarbonization of the power system will be based on nuclear, wind, solar, and other sources such as tidal and wave power. But today, in most states that do not have hydroelectric resources, fossil fuels dominate the generation mix.

This strategy of co-firing a renewing and sustainable low-carbon solid fuel with coal is a **ready-to-deploy** method of beginning the transition to a decarbonized grid while maintaining the reliable and necessary generation sources that currently are a significant part of the world's most reliable electricity grid.

Co-firing to meet the 30% reduction by 2030 requirement.

We model a typical PC plant

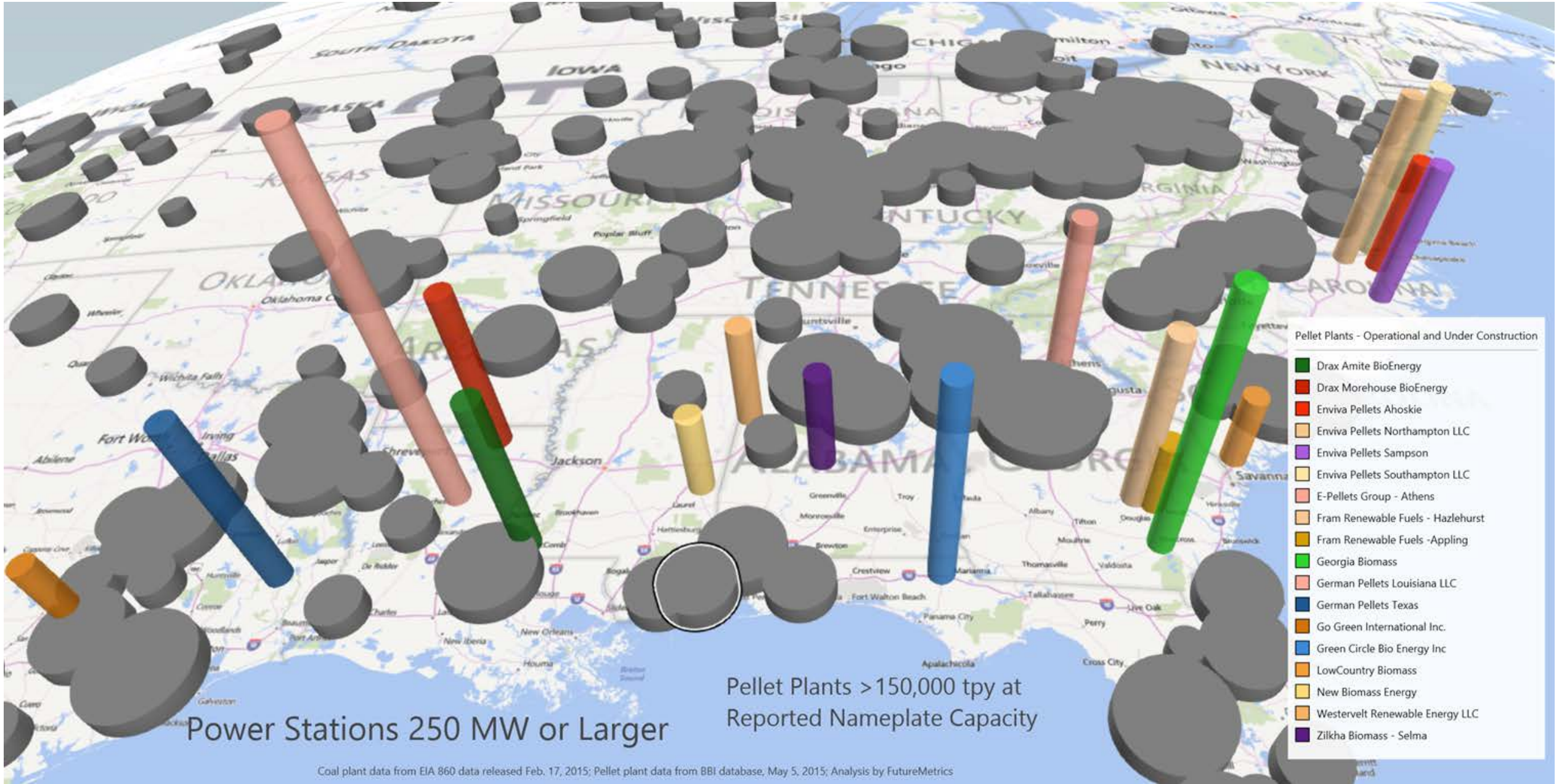
- Heat rate (efficiency)
- Delivered coal cost
- Delivered pellet cost
- EPA emission abatement cost
- Other pollution control costs

Putting typical values into a model in which the plant generates a proportion of its MWh's from pellets and a gains a 10% reduction in CO_2, a 400 MW boiler line will use about 972,000 tons/year of coal and about 123,000 tons per year of pellets (11.24% pellets and 88.76% coal).

The **increase in the cost of generation is only $0.0079/kWh (about 3/4 of a penny/kWh)** or $7.924/MWh.

What about the feedstock to make pellets?

Locations of Pulverized Coal Power Plants and Industrial Pellet Plants



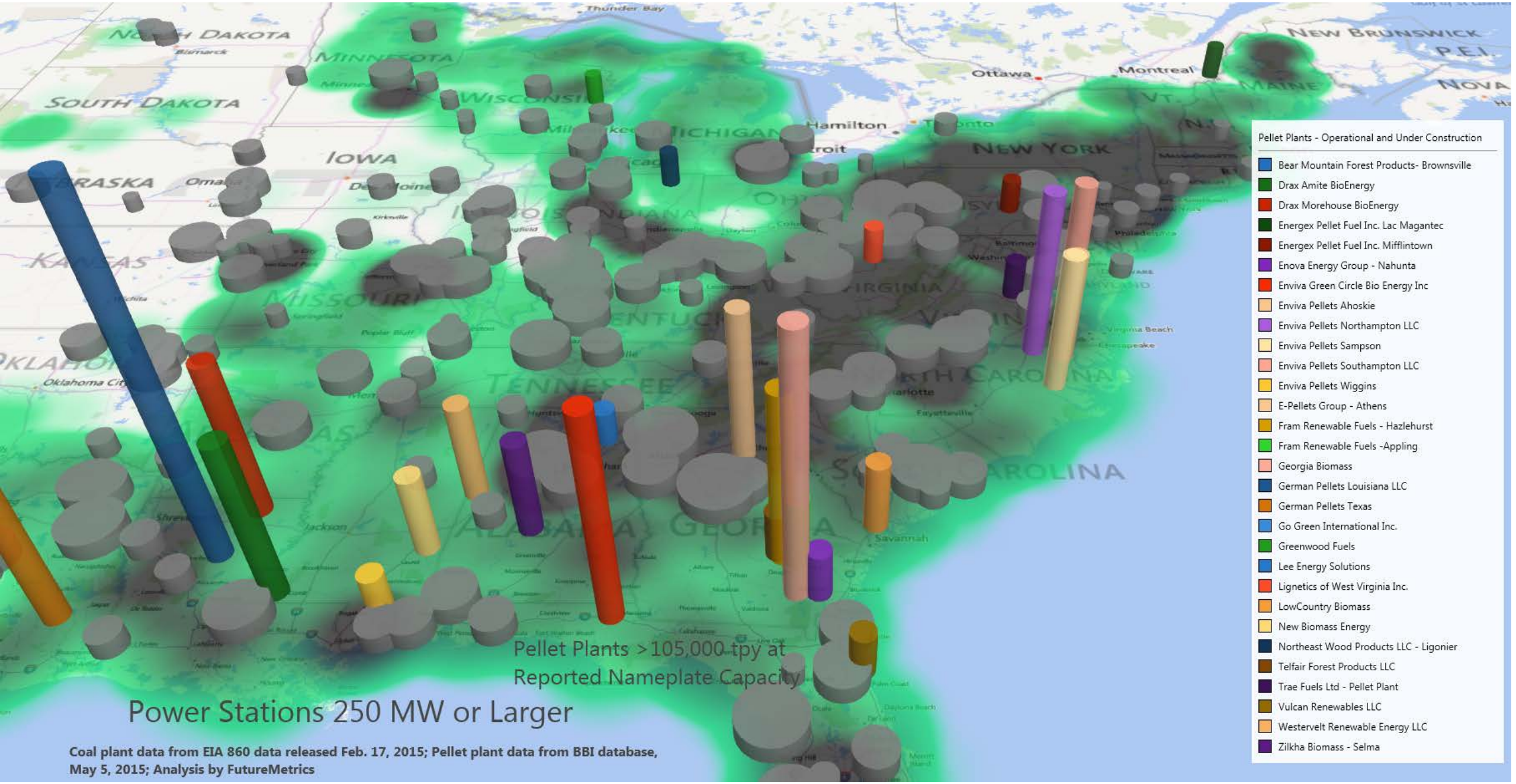
In some locations the traditional forest products users such as pulp mills, sawmills, and OSB mills continue to use the wood that has been grown for generations to supply those industries.

In many states, those industries have significantly declined.

Forests planted 20-40 years ago that were expected to be used in those industries will be stranded.

If there were co-firing in those states, <u>those otherwise stranded assets</u> would regain their value and the jobs that come with managing and harvesting and transporting would be renewed and sustained.

There are locations in PA, WV, VA, KY, and other states with high fiber and high coal power plant concentrations



Example with a 300 MW plant running at 85% capacity

Co-firing rate ramps up slowly in early years

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
CO_2 Reduction	0.7%	1.5%	2.9%	5.7%	8.5%	11.2%	13.8%	17.7%	21.4%	26.1%	30.0%
Co-firing Cost	$ 1,548,000	$ 3,555,000	$ 5,762,000	$12,075,000	$17,875,000	$23,675,000	$30,475,000	$39,189,000	$49,402,000	$60,902,000	$67,482,000
Net Cost/MWh	**$ 0.51**	**$ 1.16**	**$ 1.88**	**$ 3.95**	**$ 5.84**	**$ 7.74**	**$ 9.96**	**$ 12.81**	**$ 16.14**	**$ 19.90**	**$ 22.05**

<u>The generator can enter into the co-firing strategy very gently</u>.

The generator can assess the plant's reliability, costs, etc. after the first few years. Co-firing best practices will evolve as will technology.

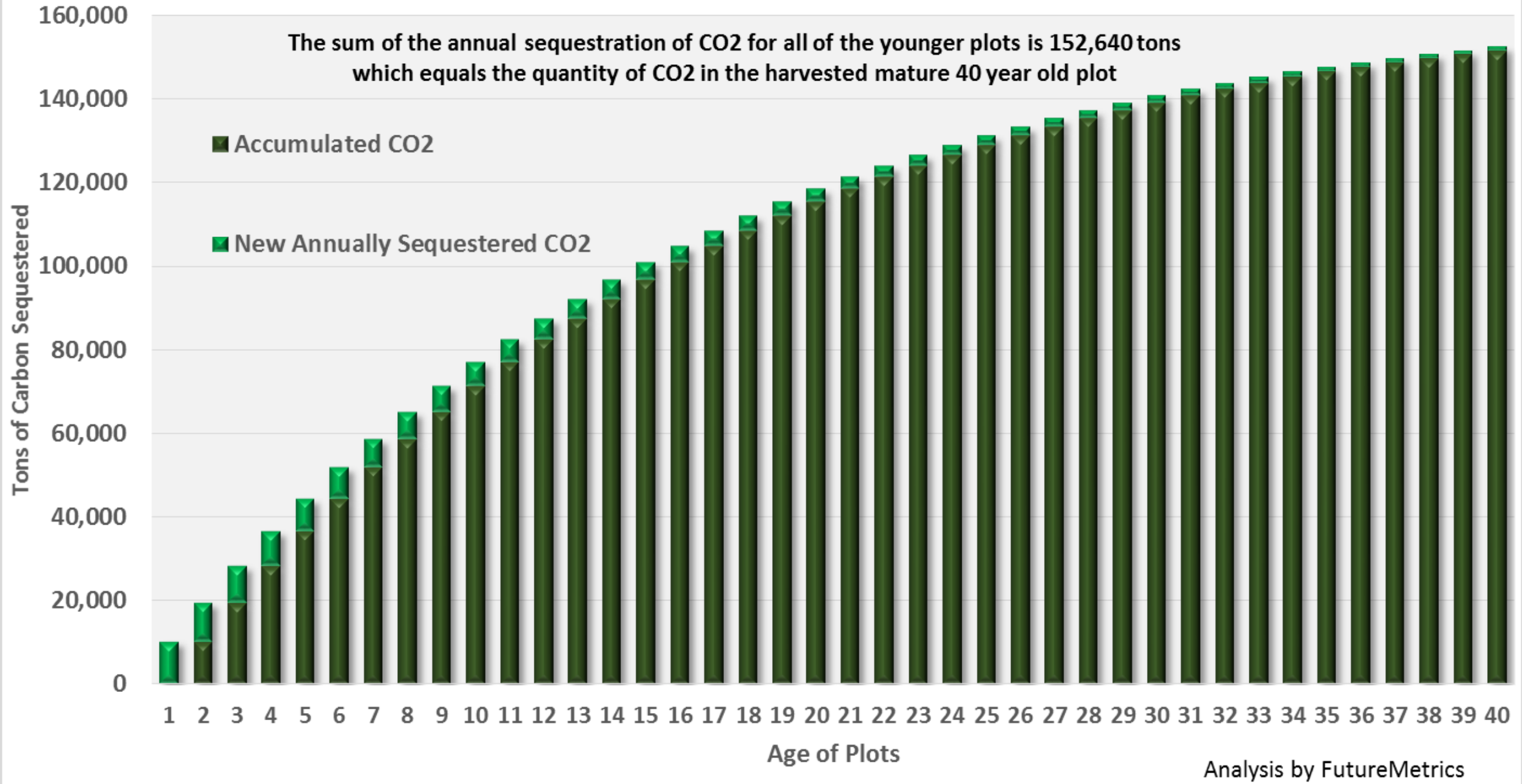
Can the US and Canadian working forests support the supply of the fiber needed to produce 40 million tons/year?

Based on US and Canadian estimates of annual allowable harvest rates that would not deplete the forests and would sustain the carbon stock, the answer is yes.

If the North American pulp and paper industry, which uses hundreds of millions of tons per year, continues to decline then there is more room to spare.

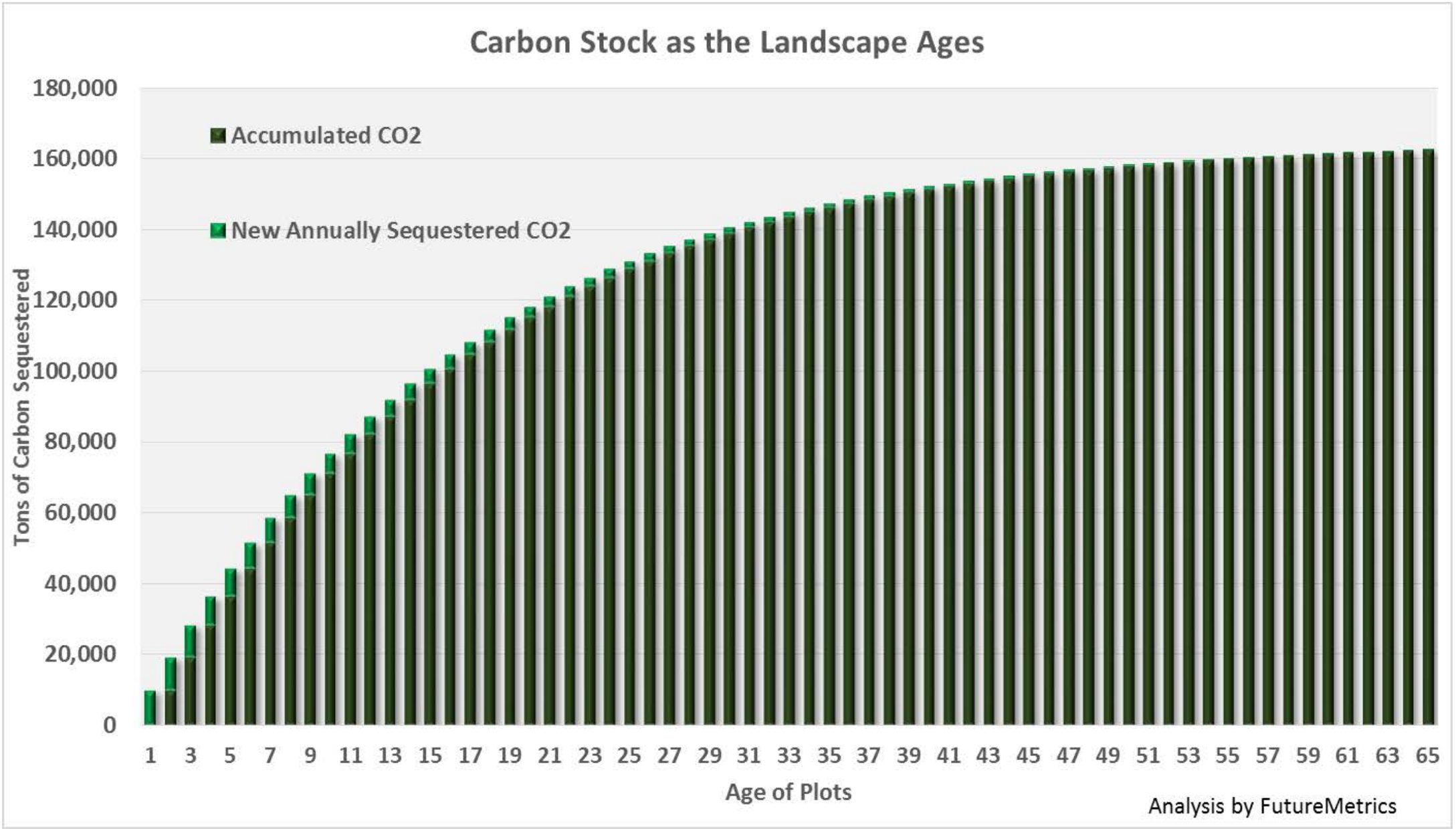
The limits to the co-firing strategy are the sustainability criteria that must assure that the forest carbon stock does not diminish. If that constraint is met, then every ton of carbon emitted from the pellet portion of the power plant fuel supply is absorbed contemporaneously.

Diagram of Forest Landscape with 40 Stages of Growth and Assumed Starting Sequestration Rate of 10,000 Tons of CO2 per Plot per Year

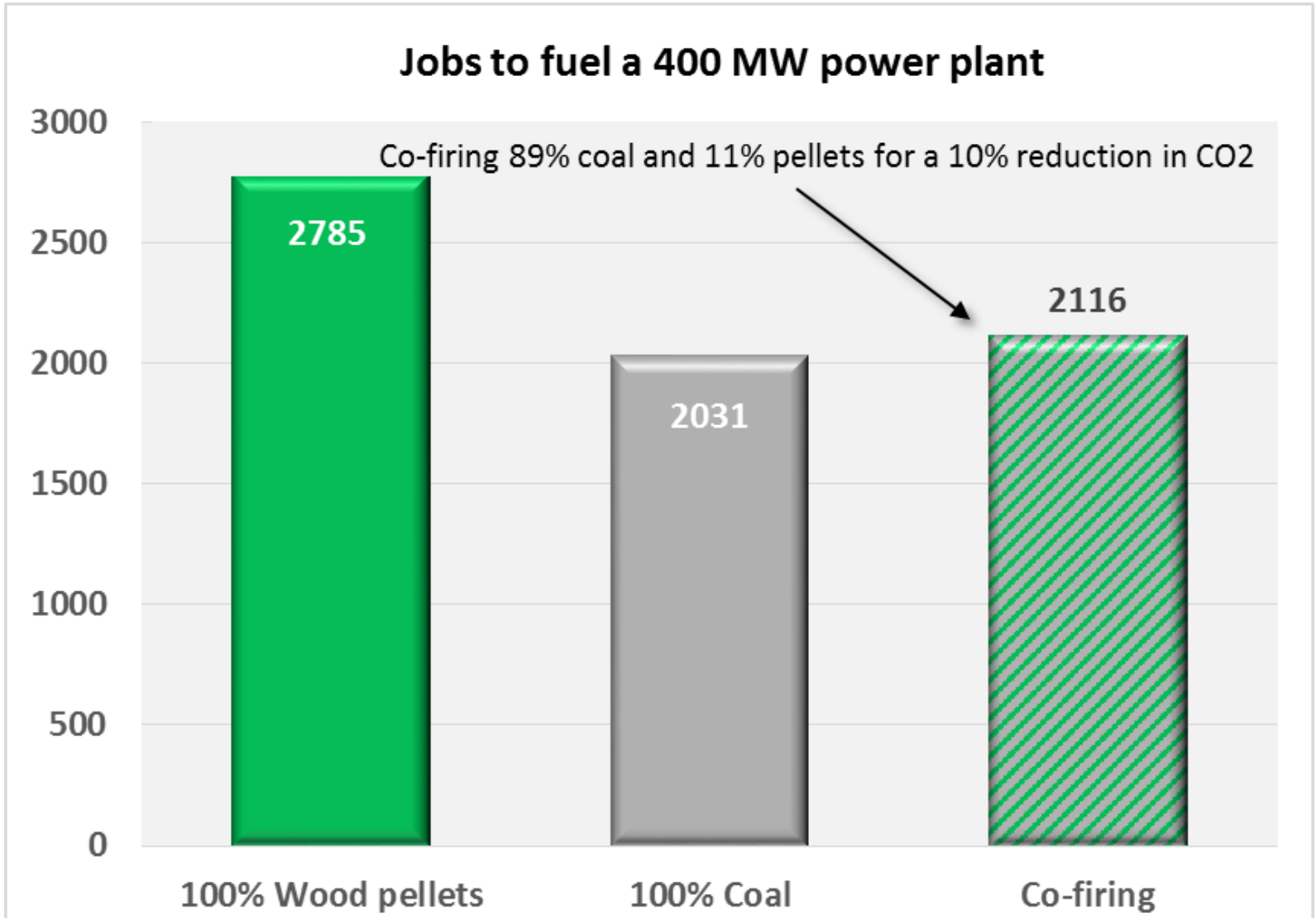


Analysis by FutureMetrics

There is very little extra carbon benefit to an aging forest as the growth to mortality ratio reaches one.

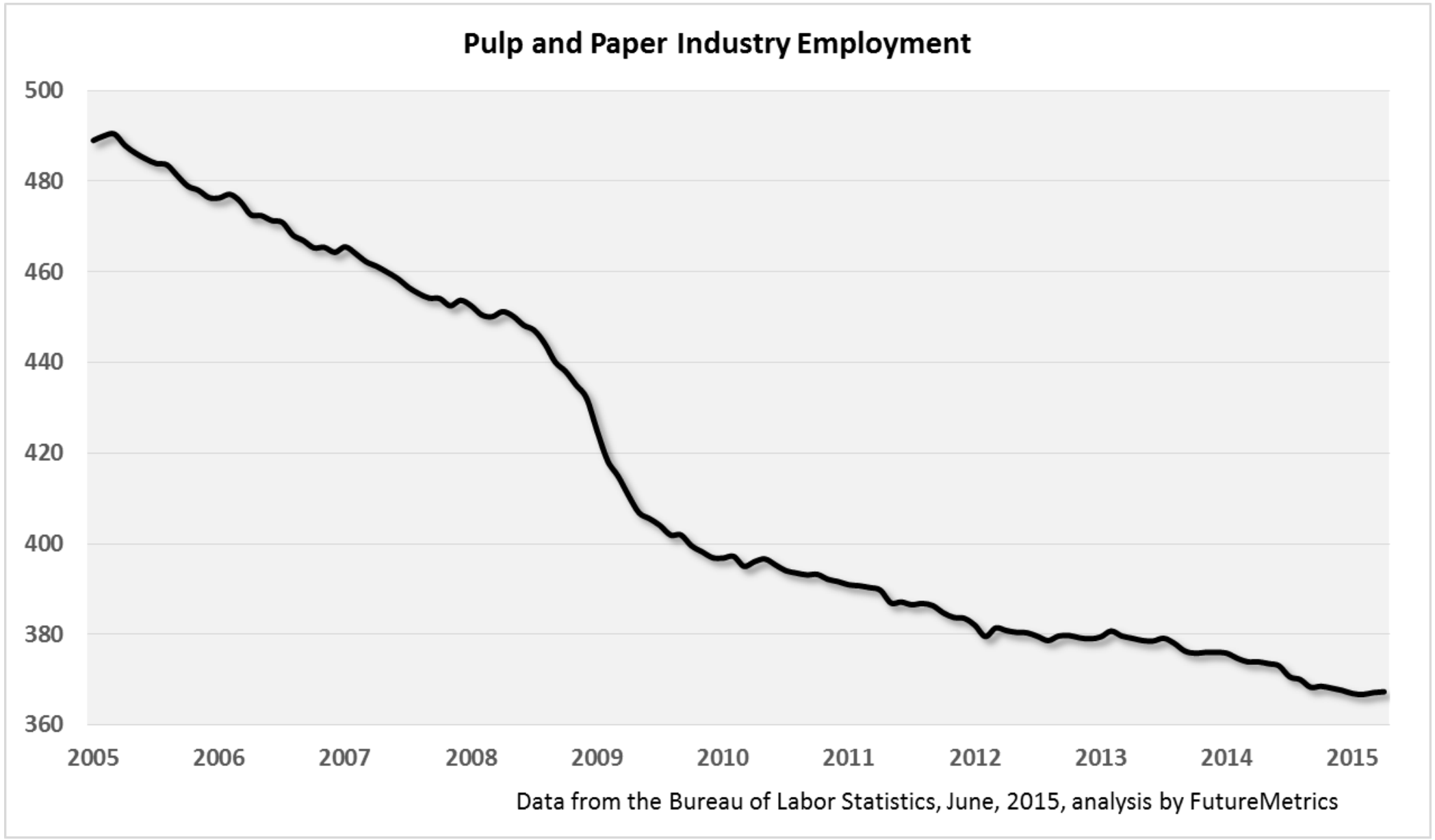


Low cost and job creating!



Analysis on pellet jobs by FutureMetrics using IMPLAN. Data on coal employment from "U.S. Coal Exports: National and State Economic Contributions", Ernst & Young, May, 2013. Both include direct, indirect, and induced jobs. Analysis by FutureMetrics

A Domestic Industrial Pellet Market will Sustain the Forest Products Sector



What is needed is a pragmatic and rational solution to lowering CO_2 emissions. This strategy achieves that.

Over several decades, in a non-disruptive way, the grid can achieve the goals of the Clean Power Plan.

The environmental benefits are real and quantifiable. CO_2 emissions can be lowered to 30% or more below the benchmark with a policy that unites the states with the power plants, the coal producers, and the pellet producers.

The economic benefits are real and quantifiable.

Jobs will be created not destroyed, and power rates will remain low in every state that adopts this policy as part of the CPP compliance strategy.

The certainty that the strategy will bring to the generators and to the producers of solid fuel will allow investment into both sectors.

The new or expanded pellet plants needed to support the co-firing levels described in this presentation will require more than $11 billion in capital costs for new construction.

Thank you

William Strauss

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