Industrial Wood Pellet Fuel in Pulverized Coal Power Plants

A rational, pragmatic, easy to implement, and lowest cost solution for transitioning toward a zero coal future.

BIOCLEANTECH FORUM

November 1-3, 2016
Ottawa

Presented by William Strauss, PhD
President, FutureMetrics

The FutureMetrics Team for Power Plant Co-firing and Full-firing

FutureMetrics
RESEARCH, ANALYTICS, EXPERT ADVICE

- Leading global consultant in the wood pellet sector
- Provides information, analysis, operations guidance and strategic advice to many of the world's leading companies in the wood pellet sector

drax biomass
A Drax Group company

- Major manufacturer of wood pellets produced from sustainably managed working forests for use as a renewable, low-carbon fuel
- Subsidiary of Drax Group, the world leader in industrial-scale biomass technology, logistics and operations

RAMBØLL

- Global leader in providing engineering services to power stations
- Significant experience and in-house expertise in power plant modifications from coal to co-firing or full conversion to wood pellet fuel

DOOSAN

- Global leader in building and modifying power plants
- Significant experience in conversion projects, including EPC roles that include guarantees on both reliability and rating

FutureMetrics

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Holson

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

IOGEN CORPORATION

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Award Winning FutureMetrics Team Members

Dr. William Strauss, President,
FutureMetrics

Recipient of the 2012 International Excellence in Bioenergy Award

Named on of the most influential people in bioenergy in 2016 by Argus Media.

John Swaan, Senior Associate,
FutureMetrics

Recipient of the 2014 International Founders Award

FutureMetrics - Globally Respected Consultants in the Wood Pellet Sector

COMMODITIES | Mon Sep 19, 2016 |

Canada will impose nationwide carbon price

Canada will impose a carbon price on provinces that do not adequately regulate emissions by themselves, Environment Minister Catherine McKenna said on Sunday without giving details on how the Liberal government will do so.

This presentation will discuss one pathway to compliance.

Industrial Wood Pellets

Why Wood Pellets are an Easy Substitute for Coal in Pulverized Coal (PC) Power Plants

- Wood pellets are **upgraded solid fuel** made from biomass.
- They are grindable.
- They are dry (~6% moisture content).
- They handle easily.
- They have an energy density of ~18 Gigajoules/tonne.

At low co-firing ratios (less than ~6% white wood pellets) no modifications are required.

At higher blend ratios modifications are needed but they are well understood and proven in large PC plants.

Pellet Production

Sawdust or Chips ➔ Dry ➔ Mill ➔ Densify in Pellet Presses ➔ Cool and Condition ➔ Store ➔ Transport

Photo of Fram Renewable Fuels 475,000 ton per year plant in Hazelhurst GA, built by Astec Industries

Drax Power Station in the UK – Three 645 MW lines: two running on 100% wood pellet fuel and the third on 85% pellets / 15% coal

- 3 unit conversion
- No impact on efficiency and no loss of output
- Flexible output from 200MW to 645MW per unit

England's largest power station supplying about 7% of the UK demand.

The Drax station consumes about 7.2 million metric tonnes per year of industrial wood pellets

OPG's 240 MW Atikokan Ontario Plant

Full firing on industrial wood pellets

Shinchi power station is a 2 x 1,000 MW supercritical coal plant in Japan.

Co-firing at ~3% wood pellets with no mods to the plant.
~160,000 tonnes per year.

Bill Strauss

Purpose built ship unloader for pellets.

Korea Southeast Power (KOSEP) is co-firing ~5% wood pellets with coal with <u>no modification</u> to the power plant.

Yeongheung, Korea 5,000 MW Power Station

Pellets are simply metered into the coal before the pulverizers.

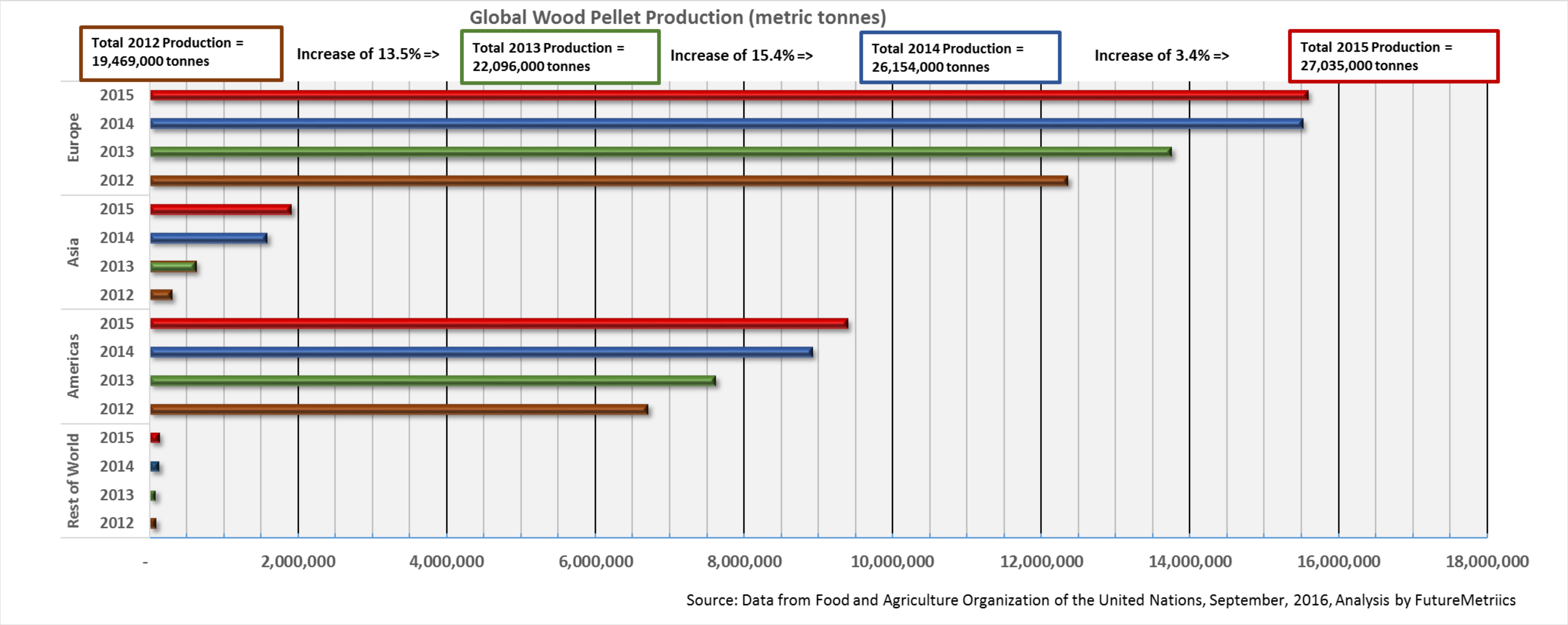
Dong Energy’s Avedore Station
Full Firing Wood Pellets – 1.2 million tonnes per year

RWE’s Amer 9 645 MW plant in the Netherlands

Expected to be co-firing at 50% within the next 6 months

Overview of Global Pellet Markets

Global wood pellet markets have had significant growth in the past decade. The wood pellet market has experienced an annualized growth rate of about 10% from about 19.5 million metric tonnes in 2012 to about 27 million metric tonnes in 2015.

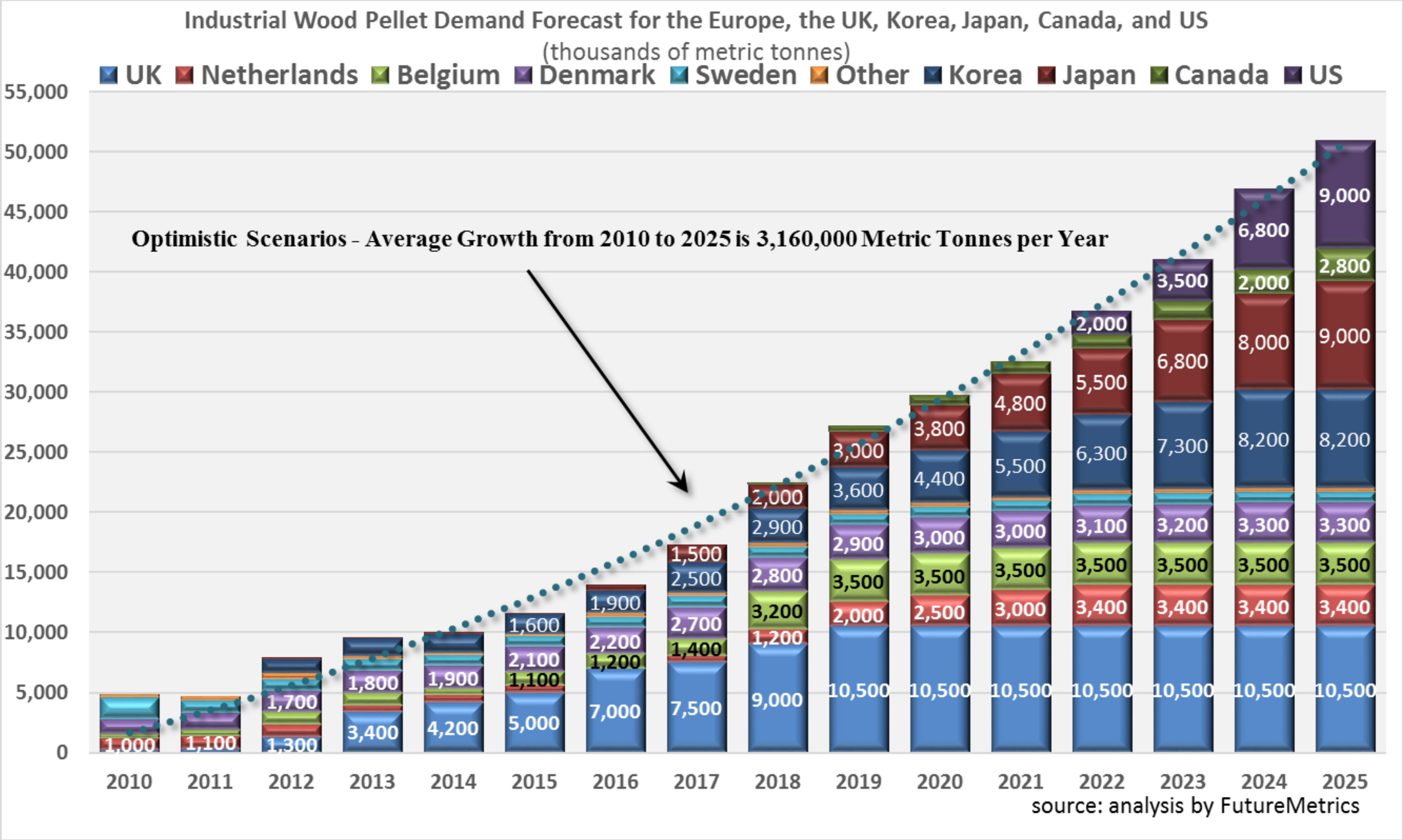


The industrial pellet supply chain is robust and is gaining maturity.

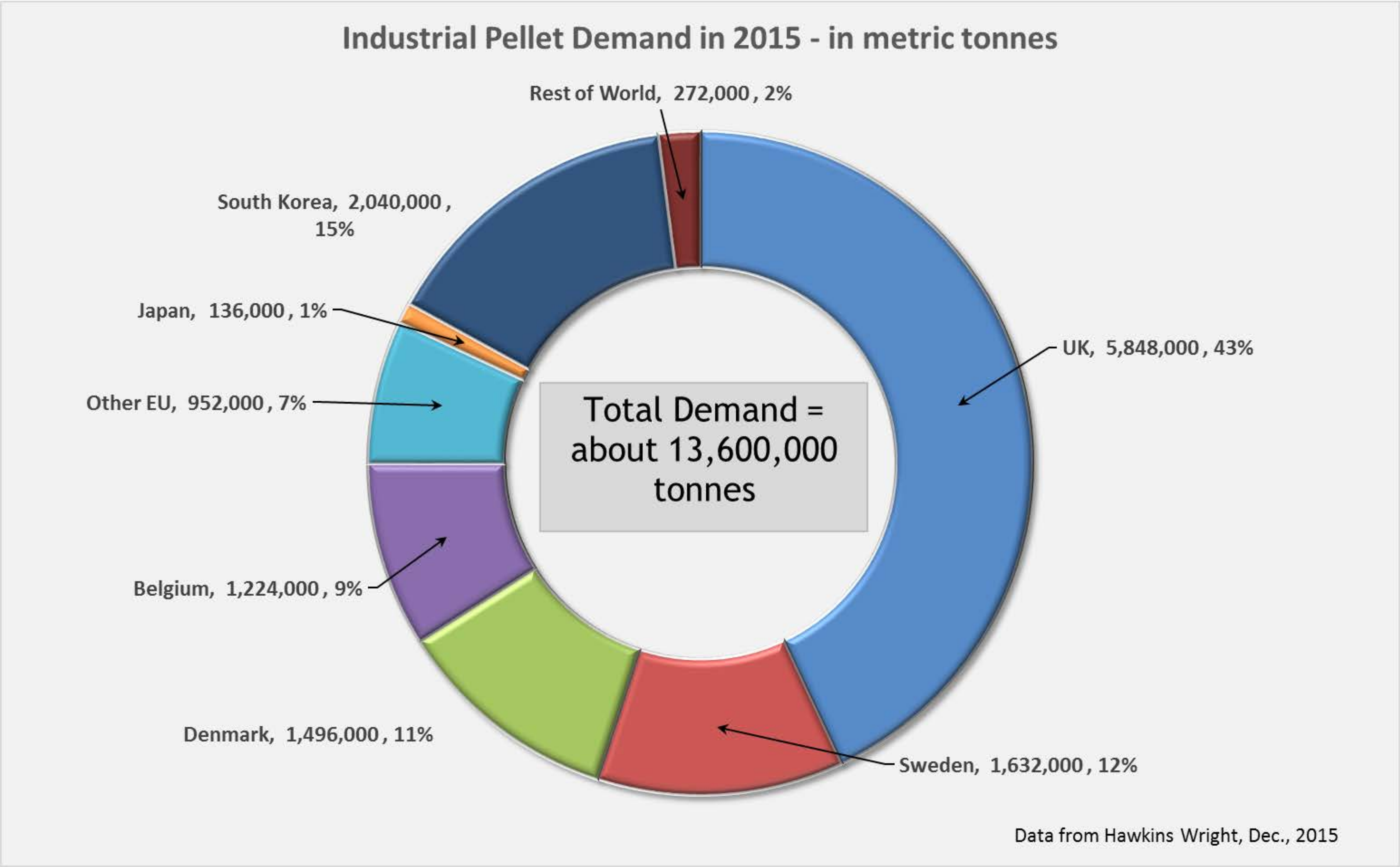
A handymax sized ship (40,000 MT) is loaded with industrial pellets about every 1.5 days.

First ever Panamax shipload of pellets being unloaded on July 15, 2015 in Immingham, UK. Produced in British Columbia by Pinnacle, shipped from their terminal in Prince Rupert, destined for the Drax power station.

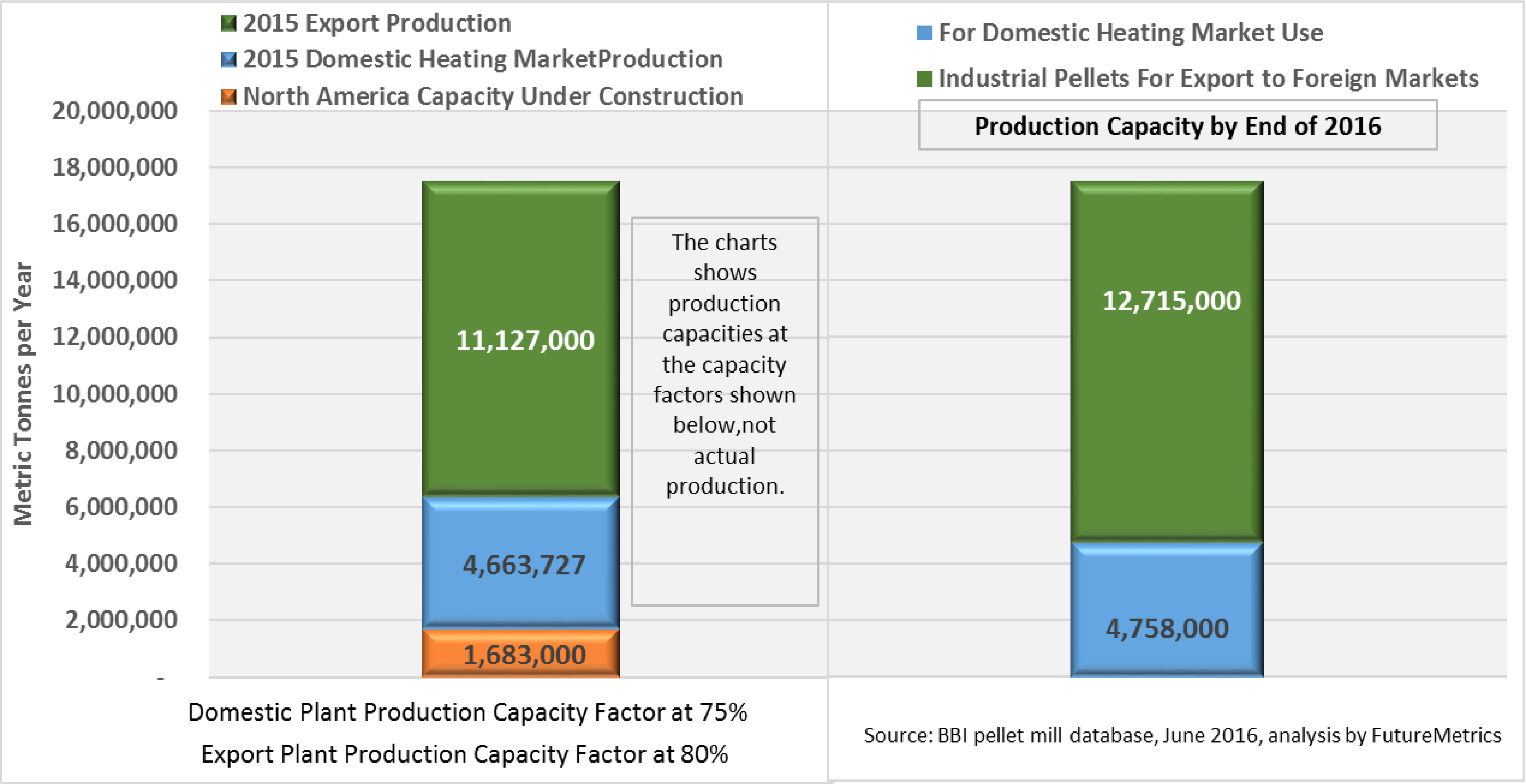
Industrial Pellet Markets



US is contingent on the Clean Power Plan.
Canada is assuming Alberta and other provinces co-firing and full-firing.


Industrial Pellet Demand in 2015 - in metric tonnes
Rest of World, 272,000 , 2%
South Korea, 2,040,000 , 15%
Japan, 136,000 , 1%
Other EU, 952,000 , 7%
Belgium, 1,224,000 , 9%
Denmark, 1,496,000 , 11%
Sweden, 1,632,000 , 12%
UK, 5,848,000 , 43%
Total Demand = about 13,600,000 tonnes
Data from Hawkins Wright, Dec., 2015

North American Current Capacity



Baseload or **on-demand peaking** generation with almost zero carbon emissions is only possible with two low carbon fuels.

Nuclear generation provides zero carbon in “combustion”.

The only other fuel that provides zero carbon in combustion and dispatchable generation is industrial wood pellets.

Drax Biomass 450,000 ton per year pellet fuel production plant.

Why Baseload and On-demand Peaking Generation is Necessary

There are essentially two broad categories of utility scale power generation:

1. Baseload and on-demand (peaking). These sources of power are typically from thermal generation*, or from non-thermal generation using hydro power.

2. Intermittent and variable power produced by wind and solar farms.

Peaking generation is used when baseload and intermittent sources need topping up to keep the grid energized either due to low or zero output from wind and solar, or due to very high demand.

So, if the power grid is to remain reliable at all times, it needs sources of generation that can be depended upon at any time to provide, in worst case scenarios, nearly 100% of the demand.

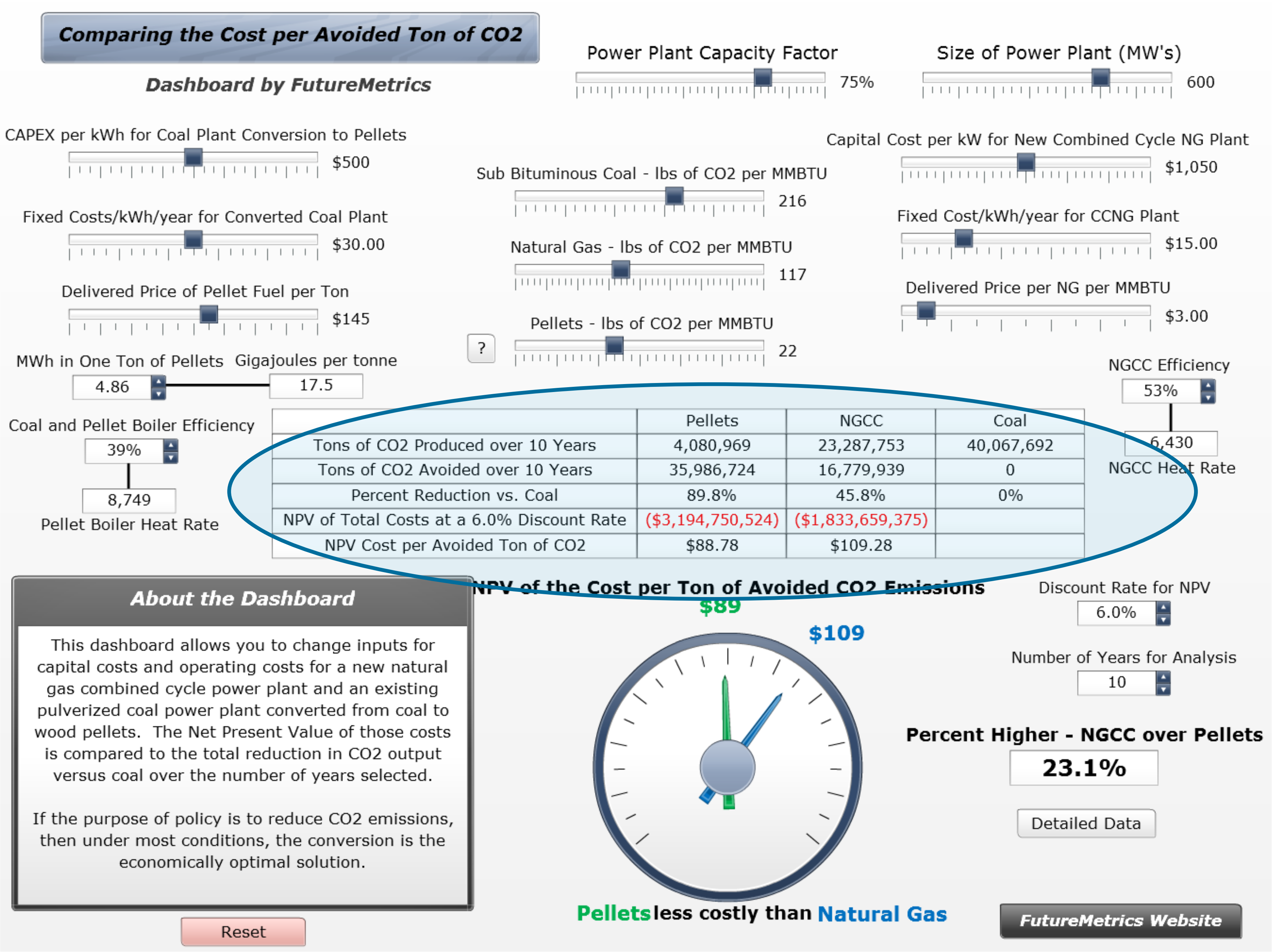
*Thermal generation requires heating a boiler to make high pressure and high temperature steam to spin turbines and generators. The heat is produced from the combustion of coal, natural gas, and, more recently, wood pellets, or from nuclear reactions.

Isn't Natural Gas Generation a Solution to Lower Carbon On-demand Generation?

A recent FutureMetrics white paper compares the analytics of two scenarios that provide on-demand dispatchable power:

1. Retire coal power plants and replace them with new combined cycle natural gas generating stations, and
2. Modify existing pulverized coal power plants to use renewable industrial wood pellets as a substitute for coal.

The paper shows that when comparing the two scenarios, and when factoring in the reduction in CO_2 emissions from each technological solution, **the solution that provides significantly higher CO_2 reduction at a lower net monetary cost per avoided ton is by repurposing existing pulverized coal power plants to run on industrial wood pellets.**



From a dashboard that is free to use on the FutureMetrics website.

How are Pellets Considered Carbon Neutral in Combustion?

No fuel that has to be mined, harvested, extracted, refined, and transported is carbon neutral. Fuel passing along supply chains that use fossil fuel gathers a carbon footprint as the fuel makes its way to the power station.

Adding to that footprint is the CO_2 released in combustion by fossil fuels, including natural gas, which permanently increases the stock of CO_2 in the atmosphere.

But wood pellets are a refined solid power-plant fuel that is derived from a renewing feedstock that captures carbon.

Industrial wood pellets used in power plants to achieve carbon emissions reductions <u>must</u> be derived from certified sustainable feedstocks.

Carbon Neutral in Combustion?

The fundamental criteria for carbon neutrality in combustion is that the stock of carbon in the atmosphere cannot be increased by the use of the fuel.

Here is how that works for industrial wood pellets:

- The source of material for producing the pellets has to be a forest that is certified to be managed sustainably.
- Sustainable management means that <u>the forest cannot be allowed to shrink in size</u>.
- A forest that does not shrink in size also means that the <u>stock of carbon held in the forest does not shrink</u>.
- For example, the raw materials for the pellet production plant are procured from a forest tenure that produce new growth at a rate of 1,000,000 tons per year.
- The daily harvest is about 1 million divided by 365 or about 2,740 tons per day.
- Those tons are converted to roughly 1,400 tons per day of industrial pellets (about 500,000 tons per year)*.
- Those pellets are co-fired in a pulverized coal power plant as <u>low</u> carbon fuel. The supply chain carbon still counts for pellets just as it does for coal; but the net is that pellets produce about 88% less carbon emissions than coal for the same MWh's.
- The carbon released by the combustion of 1,400 tons of pellets is absorbed contemporaneously by the 2,740 tons of new growth that same day.
- <u>There is no net new carbon added to the atmosphere</u>.

*A 600 MW PC boiler would consume about 165,000 tonnes per year of pellets co-firing at a 10% rate.
At 100% pellets the consumption would be about 2.2 million tonnes per year.
A typical industrial pellet mill in western Canada will produce 300,000 – 500,000 tons per year.

Case Study

Alberta

Alberta is planning to phase out all its coal-fired electricity plants by 2030.

Now the federal government has confirmed it wants other provinces to do the same thing. This is a big turnaround, for sure.

Alberta was never considered a leader when it came to carbon reduction strategies before Premier Rachel Notley and her NDP government were elected just over a year ago.

But now Justin Trudeau's Liberals are using Alberta's climate change action plan as a model for other provinces that still burn coal to produce electricity — namely Saskatchewan, Nova Scotia and New Brunswick — and intend to keep doing so until the 2040s.

Trudeau needs those provinces to drastically reduce their use of coal for firing up electricity generators much sooner than that if the federal government is to reach its stated goal of reducing Canada's greenhouse gas emissions by 30 per cent under 2005 levels by 2030.

He is obviously counting on the notion that if Alberta, formerly known as a "laggard" when it came to climate change policies, is taking steps to eliminate all coal-fired electricity in just under 15 years so can the other provinces.

That's because Alberta is Canada's most coal intense province: it produces more coal pollution than all other Canadian provinces combined.

From the Toronto Star, September 8, 2016, by Gillian Steward

For Alberta, which remains highly dependent on coal for power generation, a solution that leverages its existing coal assets makes a lot of sense.

Alberta's Electricity Generation - 2015

As of December 2015

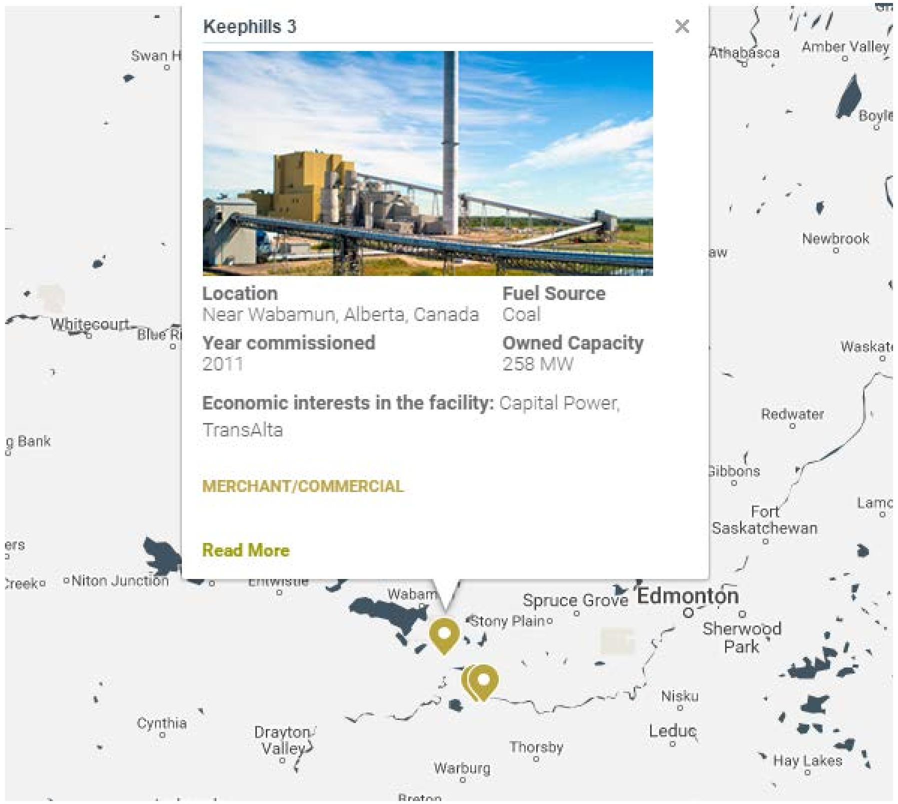
Generation	Gigawatt Hour (GWh)	Generation Share By Fuel
Coal	41,378	51%
Natural Gas	32,215	39%
Hydro	1,745	2%
Wind	3,816	5%
Biomass	2,149	3%
Others*	318	0%
Total	**81,621**	**100%**

*Others include fuel oil and waste heat

Source: Alberta Utilities Commission (AUC)

At least one plant, the 5 year old Keephills Unit 3, may be a candidate for a full conversion from coal to wood pellets. Genesse #3 also…

Alberta’s Coal-fired Power Fleet			
	Capacity (MW)	Year Completed	Age
Battle River			
3	150	1969	47
4	150	1975	41
5	370	1981	35
Genesee			
1	410	1989	27
2	410	1994	22
3	495	2005	11
HR Milner 1	150	1972	44
Keephills			
1	406	1983	33
2	409	1983	33
3	495	2011	5
Sheerness			
1	380	1986	30
2	380	1990	26
Sundance			
1	280	1970	46
2	80	1973	43
3	406	1976	40
4	392	1977	39
5	392	1978	38
6	392	1980	36
Averages ==>	**341.5**		**33**



Keephills #3 is a 50/50 joint ownership between Capital Power and TransAlta.

It cost **$1.98 billion** to build. It is less than 5 years old.

It is a 495 MW high-efficiency super-critical PC power plant about 70 km west of Edmonton.

A similar scenario could be told about the Genesee #3 plant which is not far from the Keephills #3 station.

It is also a JV with Capital Power and TransAlta and is about the same size as Keephills #3 and is just 11 years old.

Each plant if fully converted would consume about 1.7 million tonnes per year of pellets.

Alberta's Coal-fired Power Fleet

	Capacity (MW)	Year Completed	Age	Age in 2030
Battle River				
3	150	1969	47	61
4	150	1975	41	55
5	370	1981	35	49
Genesee				
1	410	1989	27	41
2	410	1994	22	36
3	495	2005	11	25
HR Milner 1	150	1972	44	58
Keephills				
1	406	1983	33	47
2	409	1983	33	47
3	495	2011	5	19
Sheerness				
1	380	1986	30	44
2	380	1990	26	40
Sundance				
1	280	1970	46	60
2	80	1973	43	57
3	406	1976	40	54
4	392	1977	39	53
5	392	1978	38	52
6	392	1980	36	50
Averages ==>	**341.5**		**33**	**47**

By 2030 most of Alberta's coal fleet will be over 50 years old.

The province will have <u>grid reliability challenges</u> if all those plants retire and other dispatchable baseload or peaking generation is not in place by 2030.

Some New Natural Gas Plants are Probable…

But one would expect that the utility would prefer to not strand these very new, highly efficient, and costly assets.

What are the Costs of Co-firing or Full Conversions?

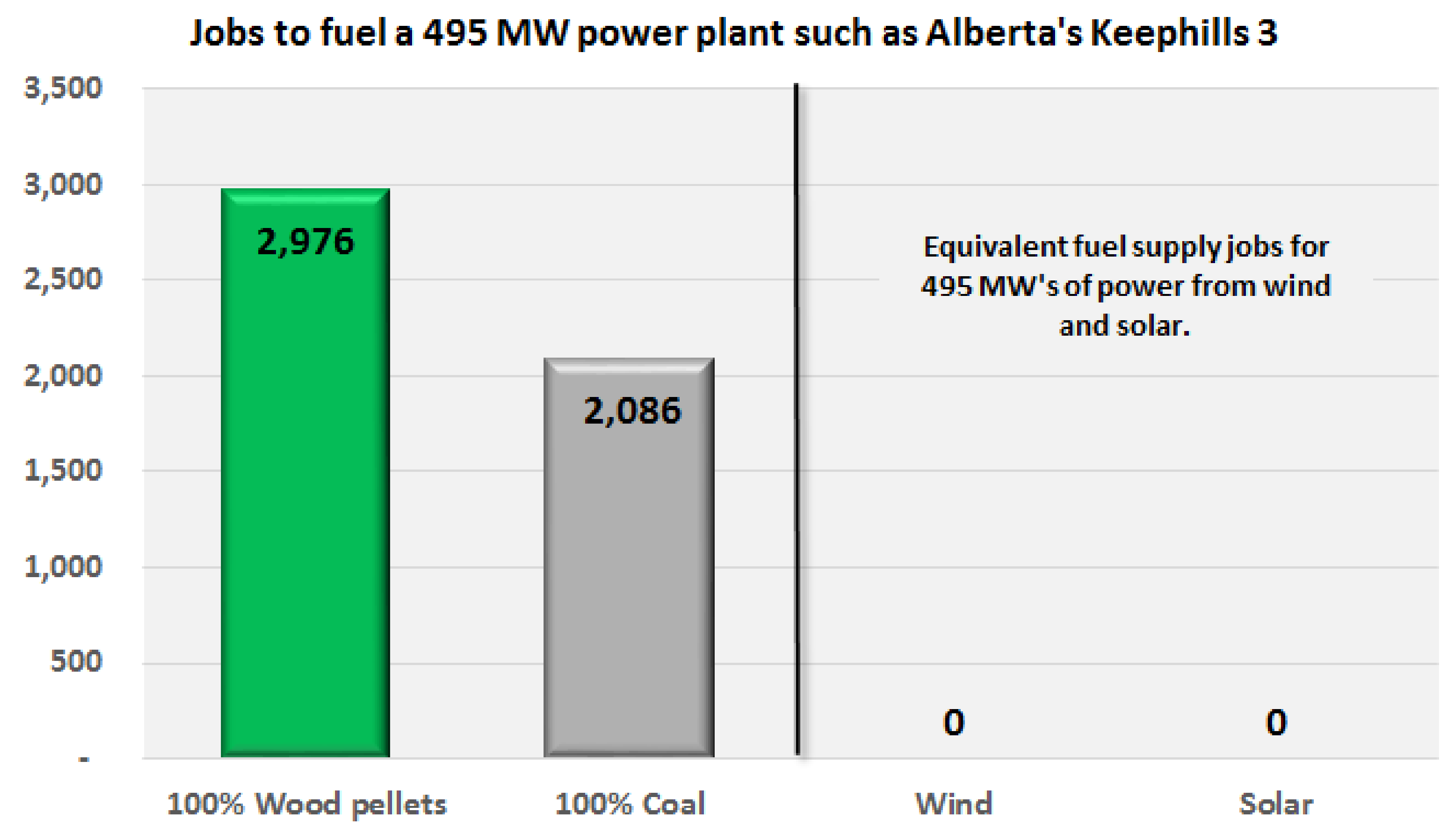
At low co-firing rates, modifications to the fuel feed and burner systems are minimal or not needed.

At power stations that are 100% firing pellets, the cost of conversion per installed kW is between $350 and $600.

<u>This 1/3 to 1/2 the cost of a new efficient natural gas combined cycle power plant.</u>

<u>And the converted plant yields much higher reductions in carbon pollution.</u>

This is a job sustaining and job creating solution for complying with carbon reduction policy.



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

Policy Needs to Support the Least Costly Pathway to Decarbonizing the On-Demand Generation Mix

Decarbonization policies are necessary to address climate change.

The best strategic plans should be broader than only including support for wind and solar generation.

Baseload and on-demand peaking plants must exist to compliment the variability and potential very low output of wind and solar generators.

The current trend of retiring coal fired power plants and building new high efficiency natural gas fired plants is rational if minimizing operating costs is the only decision metric.

However, if policymakers' primary goal is to lower carbon emissions, it makes better economic and environment sense to choose the pathway with the highest reduction in carbon emissions and the lowest total cost per avoided ton of CO_2.

Summary

Blending industrial wood pellets with coal is a proven easy to implement and low cost solution to carbon emission reduction that delivers baseload and on-demand power.

This pathway to compliance should be recognized as a valuable component in the portfolio of carbon reduction strategies and should be explicitly supported by utilities and policymakers.

Thank you – William Strauss
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Bill Strauss Near Revelstoke, BC in Feb., 2016