

Industrial Wood Pellet Markets:

Past, Present, Future

*An Industry Founded to Combat Climate Change,
Limits to Growth Defined by Sustainability,
And Pellets 2.0?*

Presented by William Strauss, PhD

President, FutureMetrics

May 1, 2019

INTERNATIONAL WORKSHOP

ADEQUACY OF SPATIAL DATABASES FOR CONDUCTING RISK ASSESSMENTS OF
SUSTAINABLE WOOD SOURCING PRACTICES OF THE U.S. INDUSTRIAL WOOD
PELLET INDUSTRY SUPPLYING EUROPEAN ENERGY DEMAND

The Industrial Wood Pellet Industry is Relatively New!

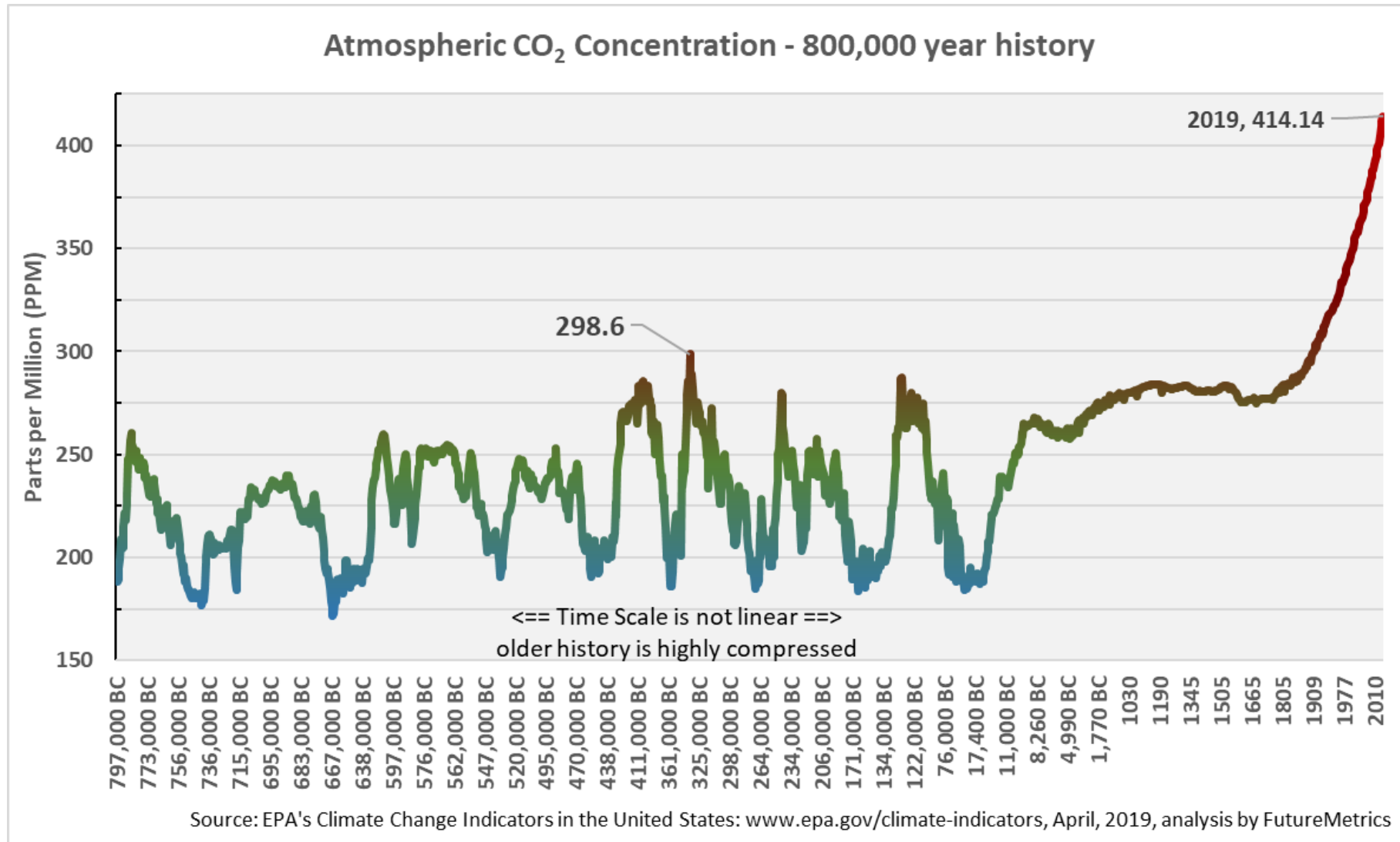
2018 was the twenty-year anniversary of the beginning of the North American Industrial Wood Pellet Export Era

21 years ago on April 6th 1998, the first trans-ocean bulk shipment of wood pellets from north America arrived and began discharging 15,000 metric tonnes of wood pellets at the port of Helsingborg, Sweden.

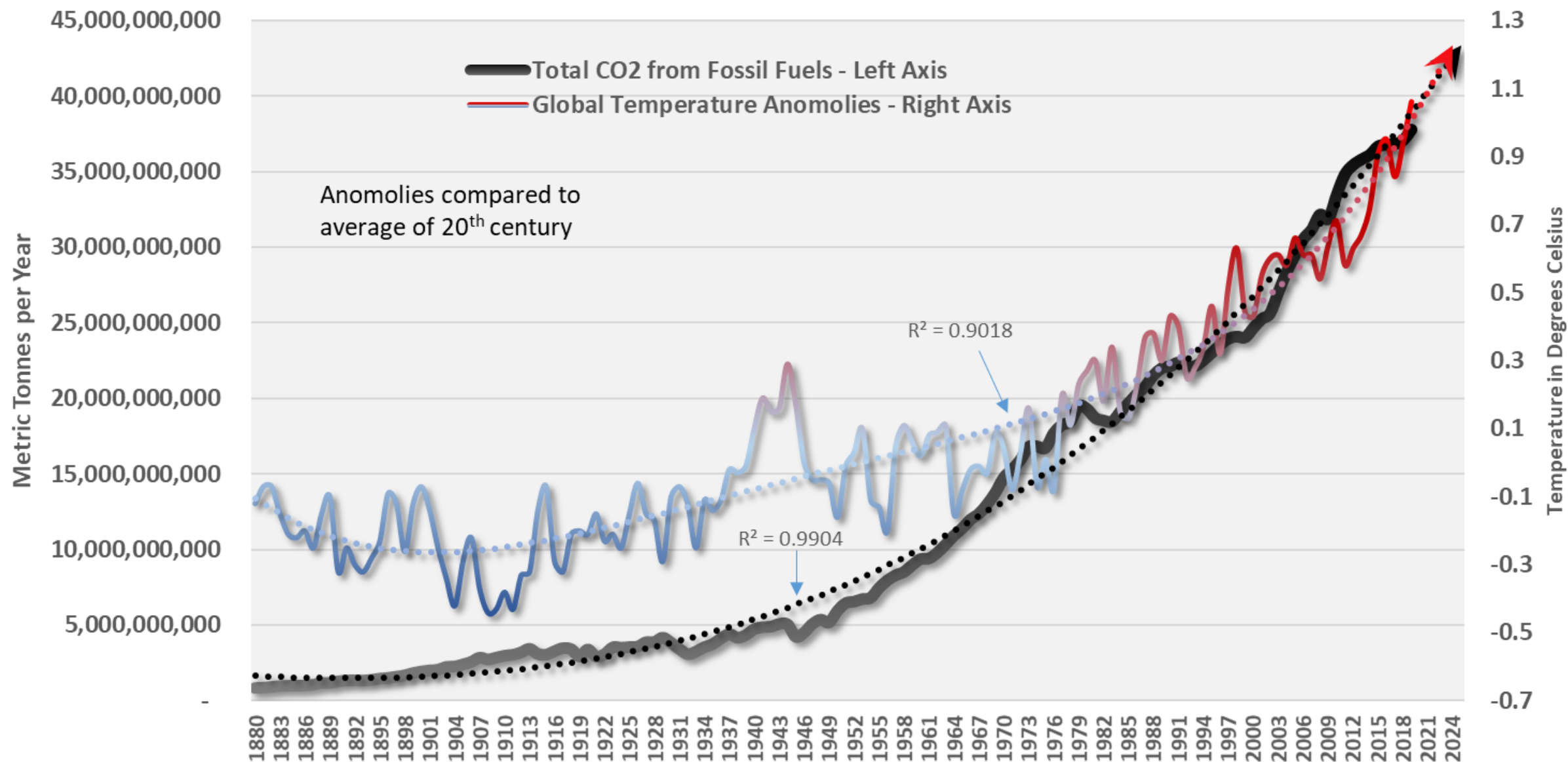
FutureMetrics' partner and operations expert, John Swaan, entered into the first offtake agreement for bulk pellet delivery from north America, produced the pellets at his pellet plant in Prince George, BC, (now known as Pacific BioEnergy) and loaded the ship, the Mandarin Moon, in Prince Rupert, BC on February 9, 1998.



The reason that this industry exists:
CO₂ AND as a transition to a non-fossil fuel future.

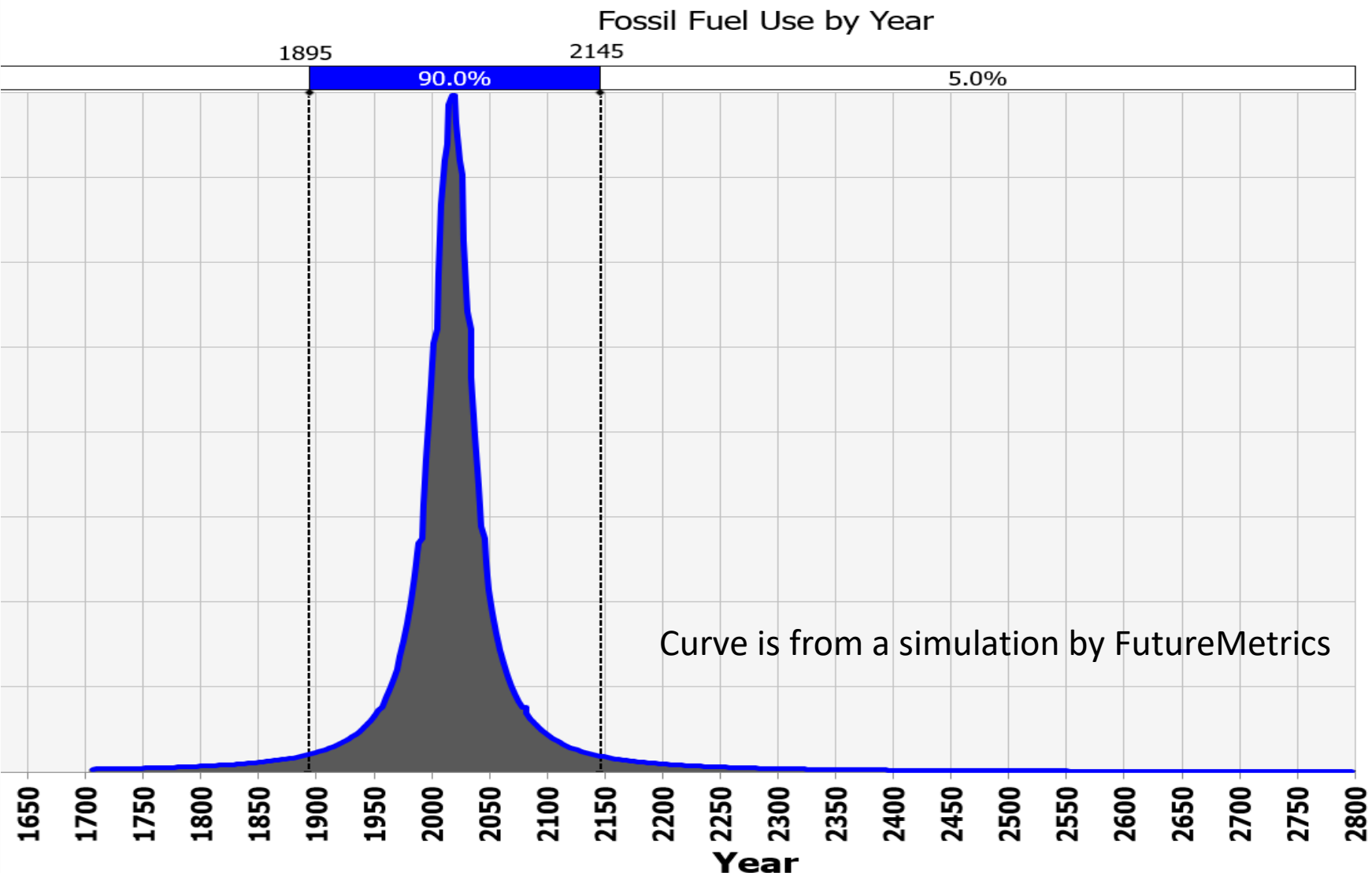


CO₂ Released from Fossil Fuel Combustion and Global Land and Sea Temperature Anomalies



source: TA, Marland, G and Andres, RJ 2013. Global, Regional, and National Fossil-Fuel CO₂ Emissions, Carbon Dioxide Information Analysis Center, World Bank, Temperatur Anamolies from NASA, April, 2019, 2019 gigatonnes forecast and analysis by FutureMetrics

If the trend in the chart below is followed, we will release most of the geologic carbon sequestered over hundreds of millions of years over a span of about 250 years.



Industrial Wood Pellet Markets

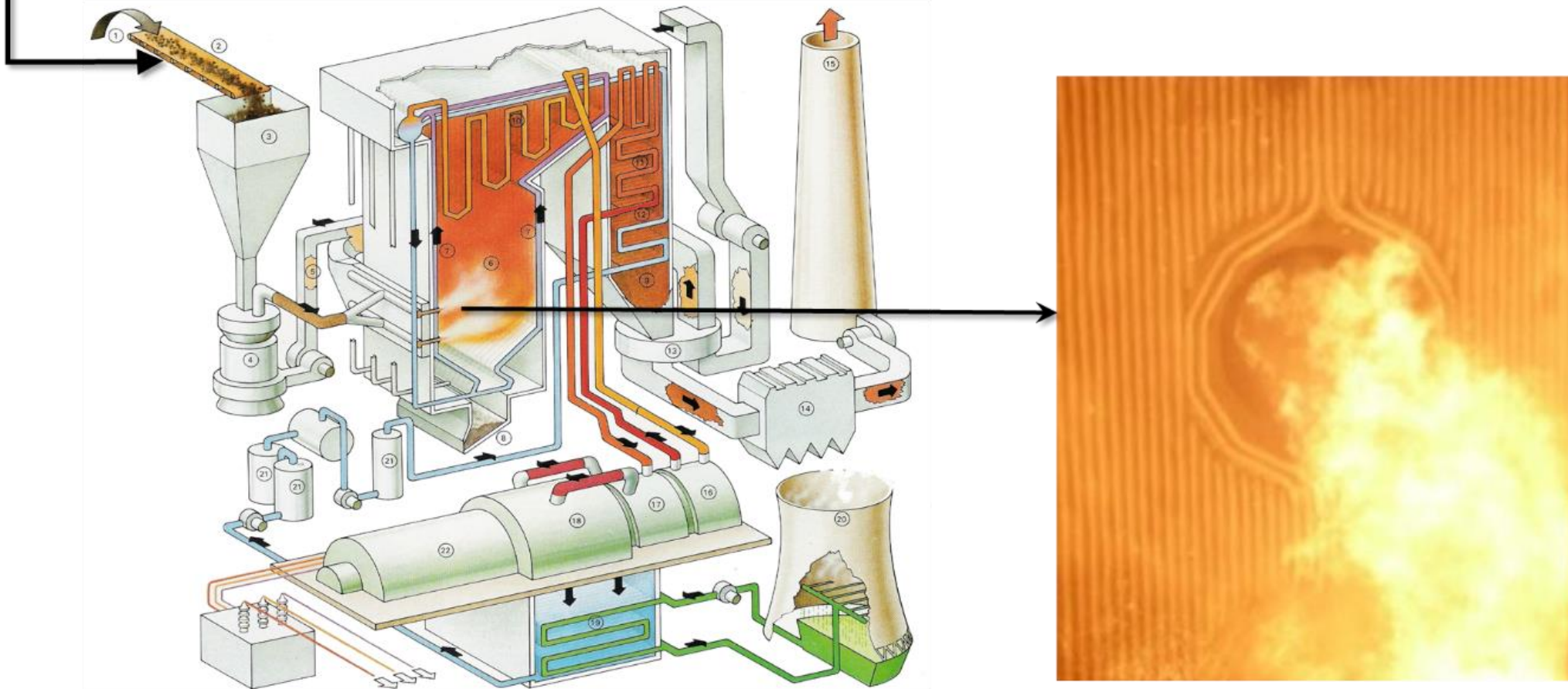
Industrial wood pellets are used as a substitute for coal in large “pulverized coal” power plants.

The fuel is pulverized into dust and then transported in pipes to burners on the sidewalls of the boiler.

Pellets pulverize into dust, wood chips do not.

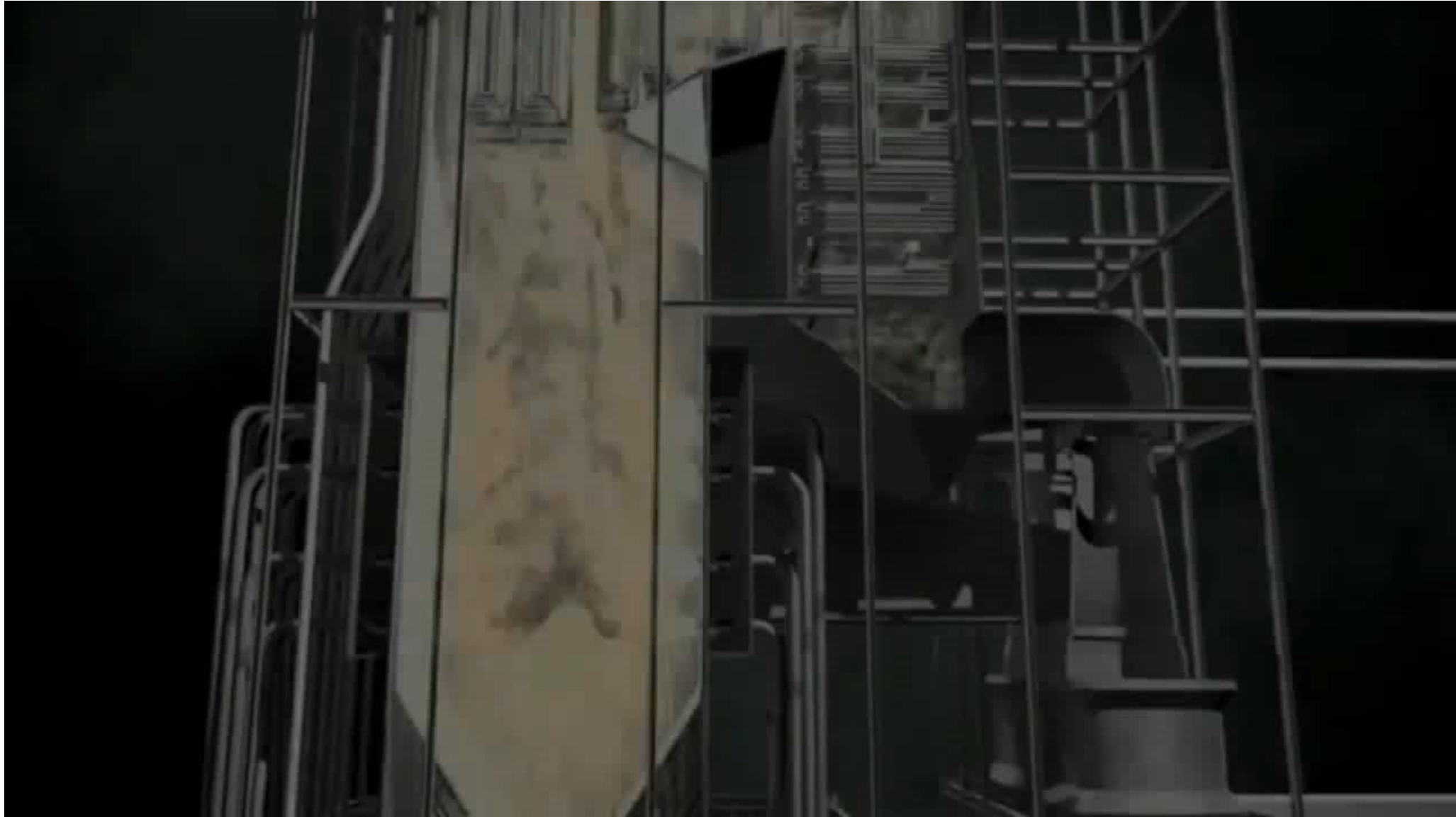
Also, the dried and densified pellet fuel optimizes transportation costs.

Wood pellets are used in large power boilers that rely on pulverized coal. Wood pellets pulverize and can substitute for coal. If properly modified, there is no lost of power output or reliability.



FutureMetrics - Intelligent Analysis, Operations Expertise, and
Strategic Leadership for the Pellet Sector

About 99% of all large utility power boilers are pulverized coal systems



Why Wood Pellets?

Because the net carbon released by generating from wood pellets is significantly lower than the net carbon released by generating from coal

AND

Thermal power generation provides on-demand and baseload power.

The foundation for zero carbon emissions in combustion is the SUSTAINABILITY OF THE FOREST RESOURCES.

As long as the growth rate equals or exceeds the harvest rate, the net stock of carbon held in the working forest landscapes are held constant or are increasing and the atmosphere sees no net new carbon dioxide.

The limits to the growth of the industry are set by the growth rates of working forests.

Drax Power Station, UK. Largest thermal power station in the UK.

Produces an average of 6.5% of UK power demand from renewable pellets.

Four of six 650 MW units run on 100% pellets. About 7.5 million metric tonnes of pellet fuel per year.

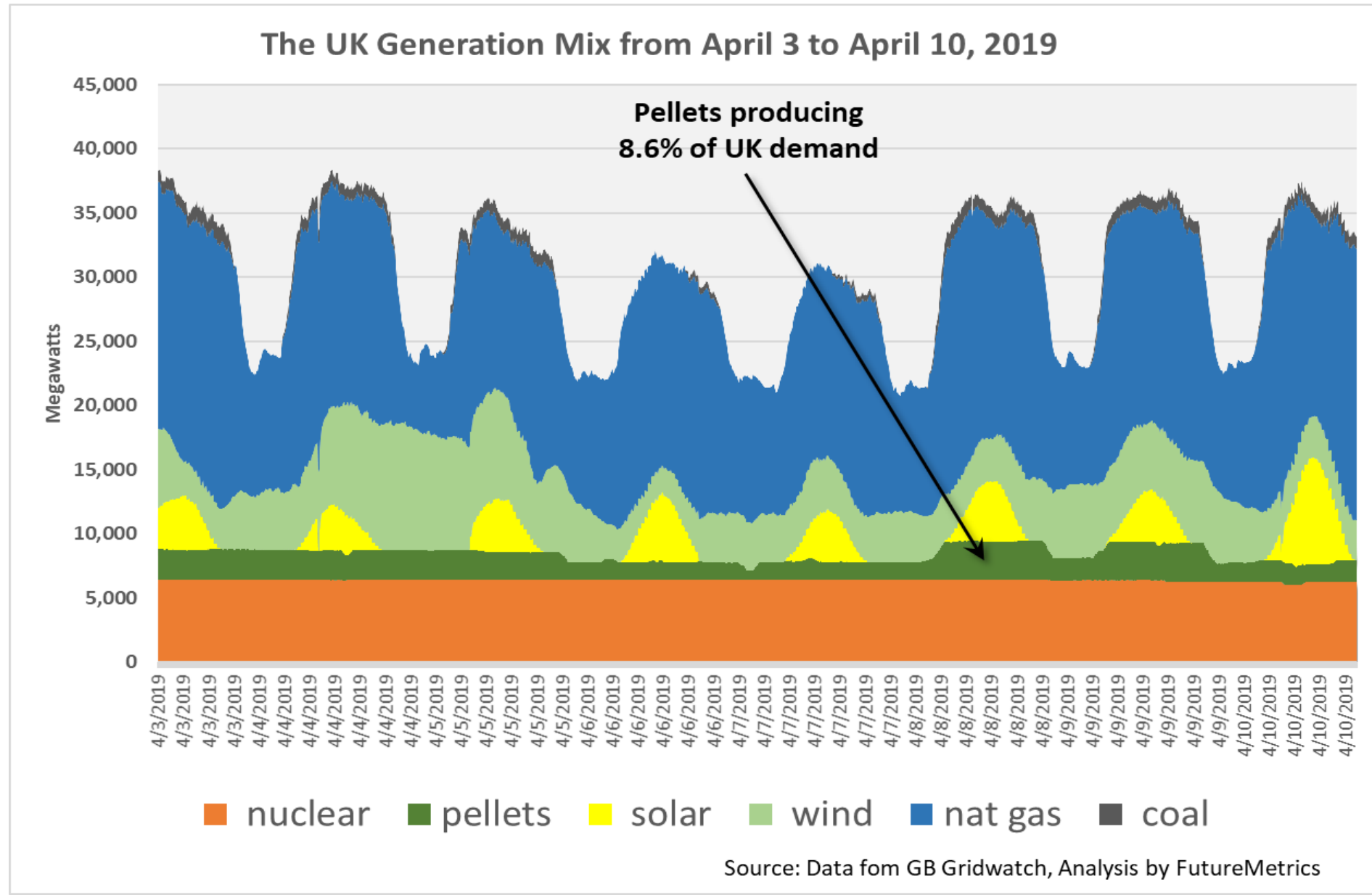


Ontario Power Generation has converted the
200 MW Atikokan station from coal to
100% white pellets with no loss of reliability or output.

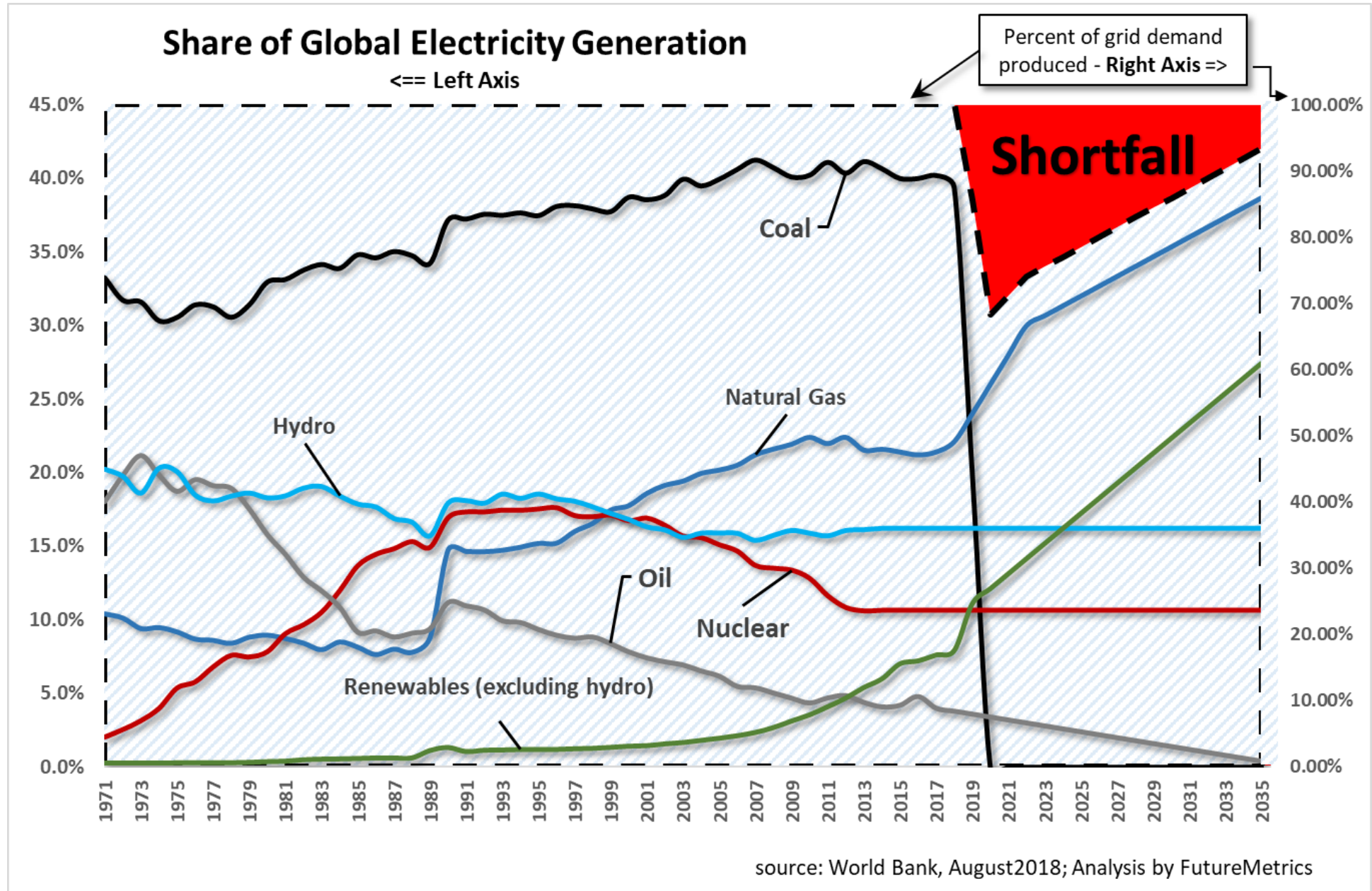
Pellet storage silos



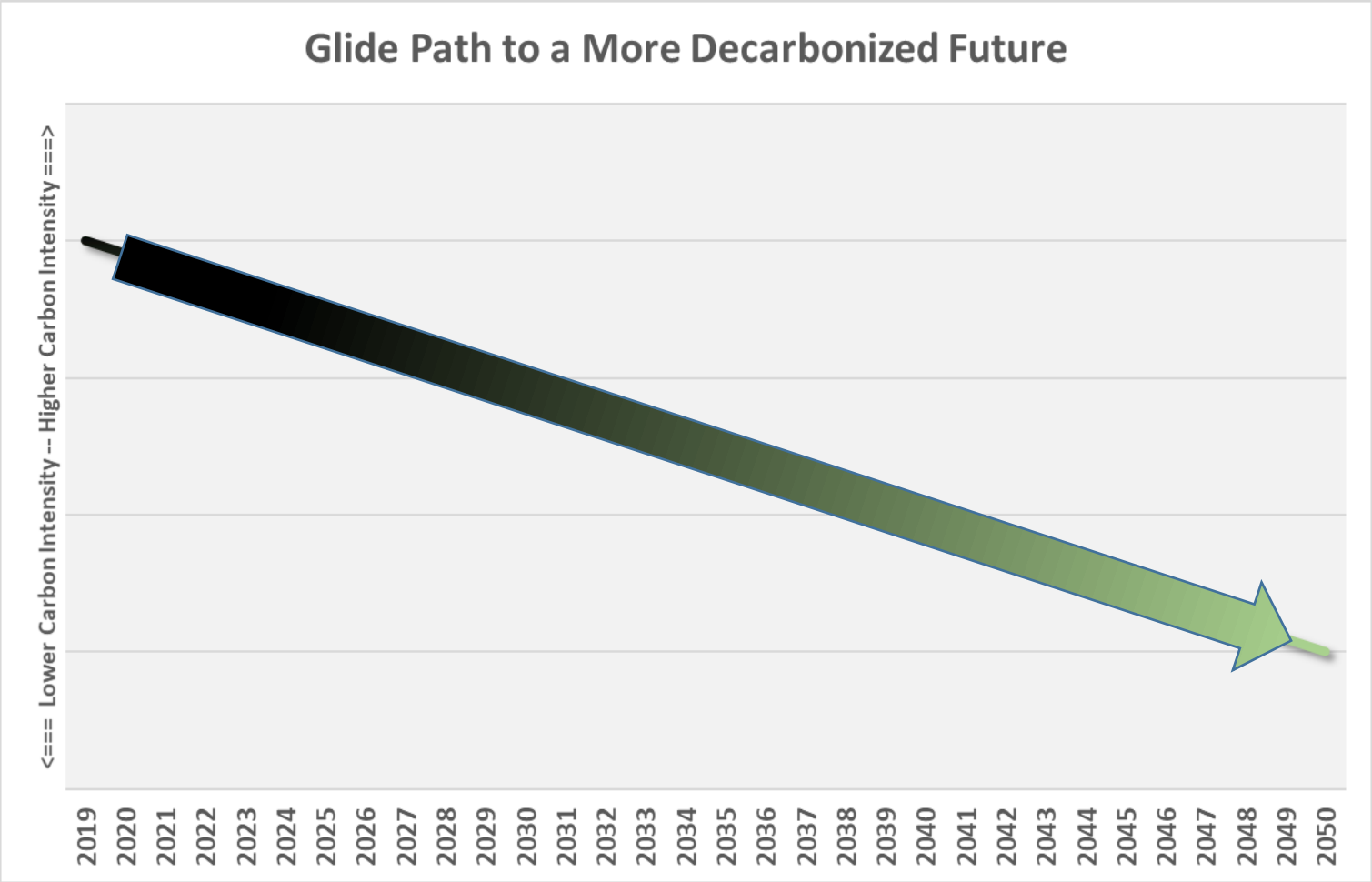
Over one week in the UK we can see how wind and solar fluctuate dramatically.
The grid needs steady reliable low-cost on-demand or baseload **low-carbon** power.



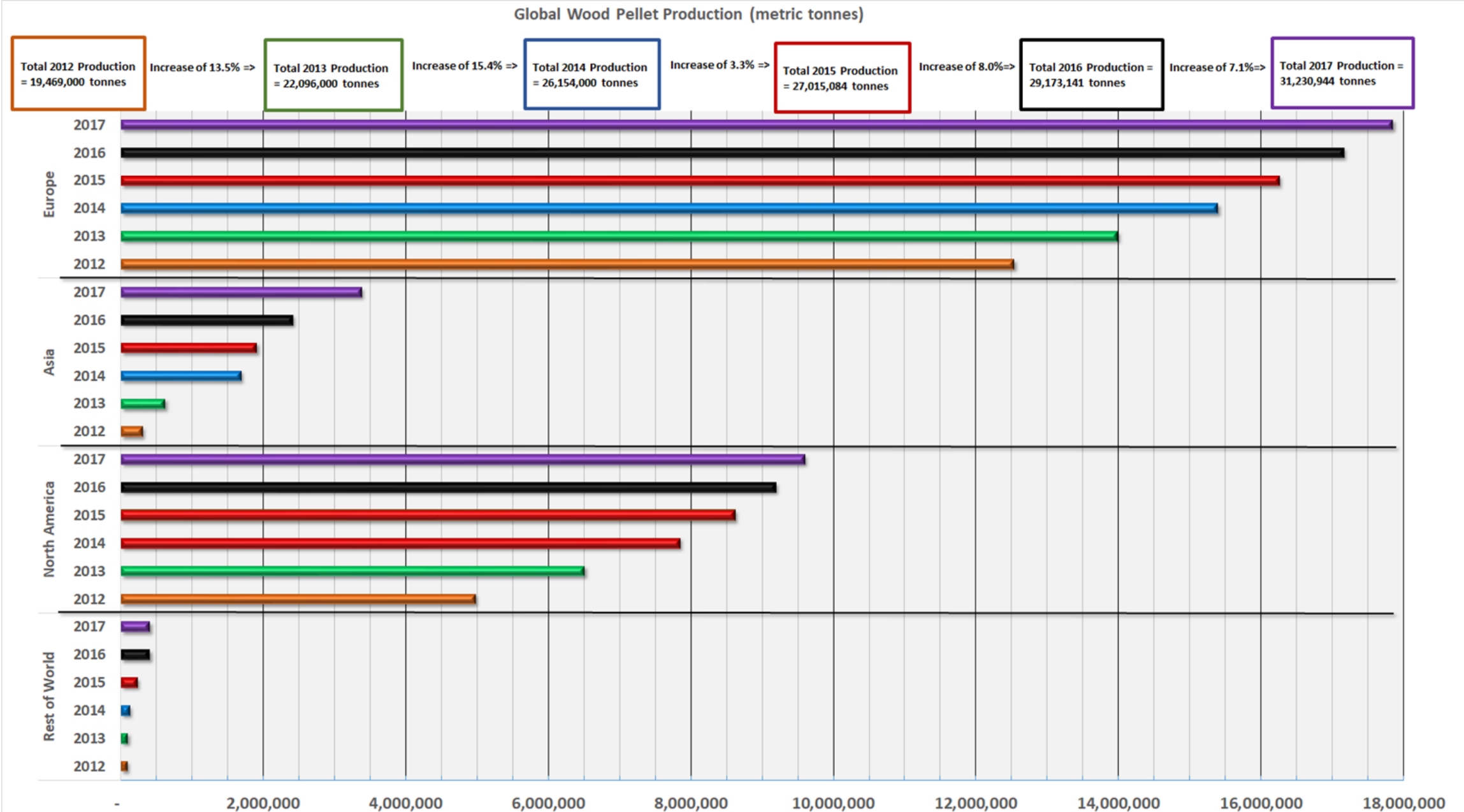
It is not possible to eliminate coal “overnight”.



Sustainably produced pellets as a substitute for coal in power plants is a well-established option that should be included in all strategies for **a rational and reliable off-ramp to a more decarbonized future.**



Historic Wood Pellet Production (includes industrial and heating pellets)



Source: Data from Food and Agriculture Organization of the United Nations, August 2018, Analysis by FutureMetrics

This is a slide you can look closely at later when you download to the PPT.

2018 Biggest Importers are:

- The UK (7.8 million tonnes)
- South Korea (3.5 million tonnes)
- Denmark (3 million tonnes)
- Italy (2.1 million tonnes) <= for heating markets

2018 Biggest Exports:

- US (5.2 million tonnes)
- Baltic States (2.6 million tonnes)
- Vietnam (2.6 million tonnes)
- Canada (2.3 million tonnes)

Net imports by Country (negative numbers in red mean the country is a net exporter)							
Net imports in Metric Tonnes							
	2012	2013	2014	2015	2016	2017	2018
Europe							
Austria	-204,139	-97,342	-141,427	-181,501	-225,123	-253,689	-380,675
Belgium	930,821	501,968	558,869	897,510	783,257	869,188	797,286
Bulgaria	-15,511	-62,275	-134,657	-108,970	-66,549	-117,659	-98,442
Croatia	-137,424	-167,975	-153,549	-186,832	-213,744	-243,286	-209,910
Czech Republic	-121,477	-108,360	-122,672	-203,758	-254,248	-260,749	-298,423
Denmark	1,948,023	2,063,269	1,979,713	2,167,707	1,977,716	2,627,827	3,041,400
Estonia	-415,752	-556,585	-579,166	-865,974	-932,180	-1,242,033	-1,093,030
Finland	-32,914	-18,102	-10,002	-407	15,501	53,689	45,422
France	-75,721	-62,731	43,861	-61,909	52,692	71,386	83,348
Germany	-501,311	-173,606	-263,421	-270,311	53,585	-69,076	-190,483
Greece	17,987	16,060	20,326	25,703	31,431	30,654	42,138
Hungary	-13,938	-6,872	-4,715	-2,871	6,041	9,929	9,758
Ireland	23,455	50,872	24,786	20,886	55,577	-5,403	6,964
Italy	1,191,142	1,749,602	1,947,884	1,630,741	1,650,089	1,771,016	2,105,891
Latvia	-867,944	-1,014,601	-1,188,731	-1,420,984	-1,464,783	-1,378,968	-1,152,706
Lithuania	-225,406	-263,450	-225,756	-228,338	-221,772	-287,036	-277,397
Netherlands	873,551	377,706	213,089	215	-1,612	72,022	16,858
Poland	83,778	-97,938	-132,626	-150,474	-211,177	-251,084	-266,774
Portugal	-551,276	-738,749	-687,560	-632,011	-436,150	-457,692	-506,685
Romania	-275,577	-451,271	-410,125	-315,202	-247,276	-150,694	-90,316
Slovakia	-5,703	-23,871	-40,391	-33,433	-39,171	-56,656	-55,192
Slovenia	8,638	50,791	45,908	29,085	73,917	2,499	48,763
Spain	-32,135	-6,959	-1,259	-3,761	-59,125	-75,916	-65,446
Sweden	297,914	550,162	269,319	101,830	39,661	69,300	219,082
UK	1,434,116	3,326,860	4,622,988	6,446,421	7,045,525	6,767,993	7,782,635
Cyprus	141	433	905	3,853	2,130	3,336	1,857
Luxembourg	-2,996	34	1,918	-1,380	-25,281	-21,367	-4,644
Malta	154	113	291	394	262	369	344
Norway	-5,811	29,138	21,527	13,647	18,319	-30,305	9,397
North America							
Canada	-1,284,707	-1,615,638	-1,607,239	-1,597,847	-2,252,201	-2,020,000	-2,271,028
US	-1,811,390	-2,730,078	-3,835,747	-4,368,301	-4,537,378	-4,985,993	-5,220,726
Northeast Asia							
Japan	68,519	79,052	92,539	232,060	352,851	505,996	1,059,230
South Korea	122,427	484,668	1,849,639	1,469,184	1,716,346	2,432,173	3,450,008
Southeast Asia							
Thailand	4,780	-17,561	-75,011	-24,414	-20,611	-103,894	-268,692
Vietnam	-33,829	-160,123	-744,773	-1,050,249	-1,317,396	-1,648,861	-2,560,183
Malaysia	-31,091	-79,590	-168,464	-154,121	-200,623	-412,114	-595,999
Australia							-70,080
South America							
Brazil	299	966	-6,208	-47,037	-34,937	-107,506	-224,912

source: International Trade Data, February 2019, Analysis by FutureMetrics

Industrial Wood Pellet Past Demand and Forecast

(thousands of metric tonnes)

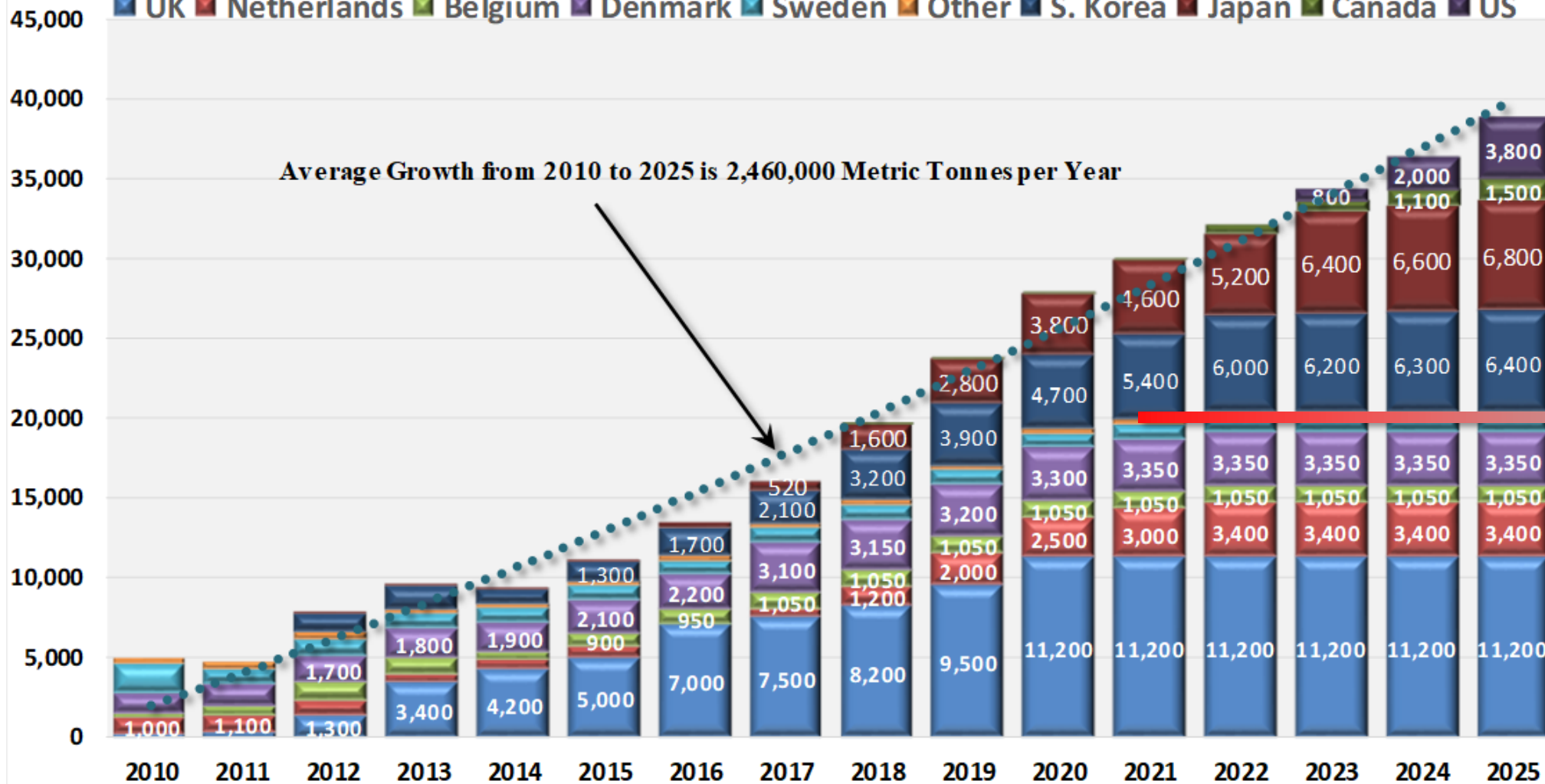
UK Netherlands Belgium Denmark Sweden Other S. Korea Japan Canada US

US !!

Average Growth from 2010 to 2025 is 2,460,000 Metric Tonnes per Year

After 2020, under
current policy,
growth in Europe
and UK is over.

Japan and South
Korea are the
major new
growth markets.

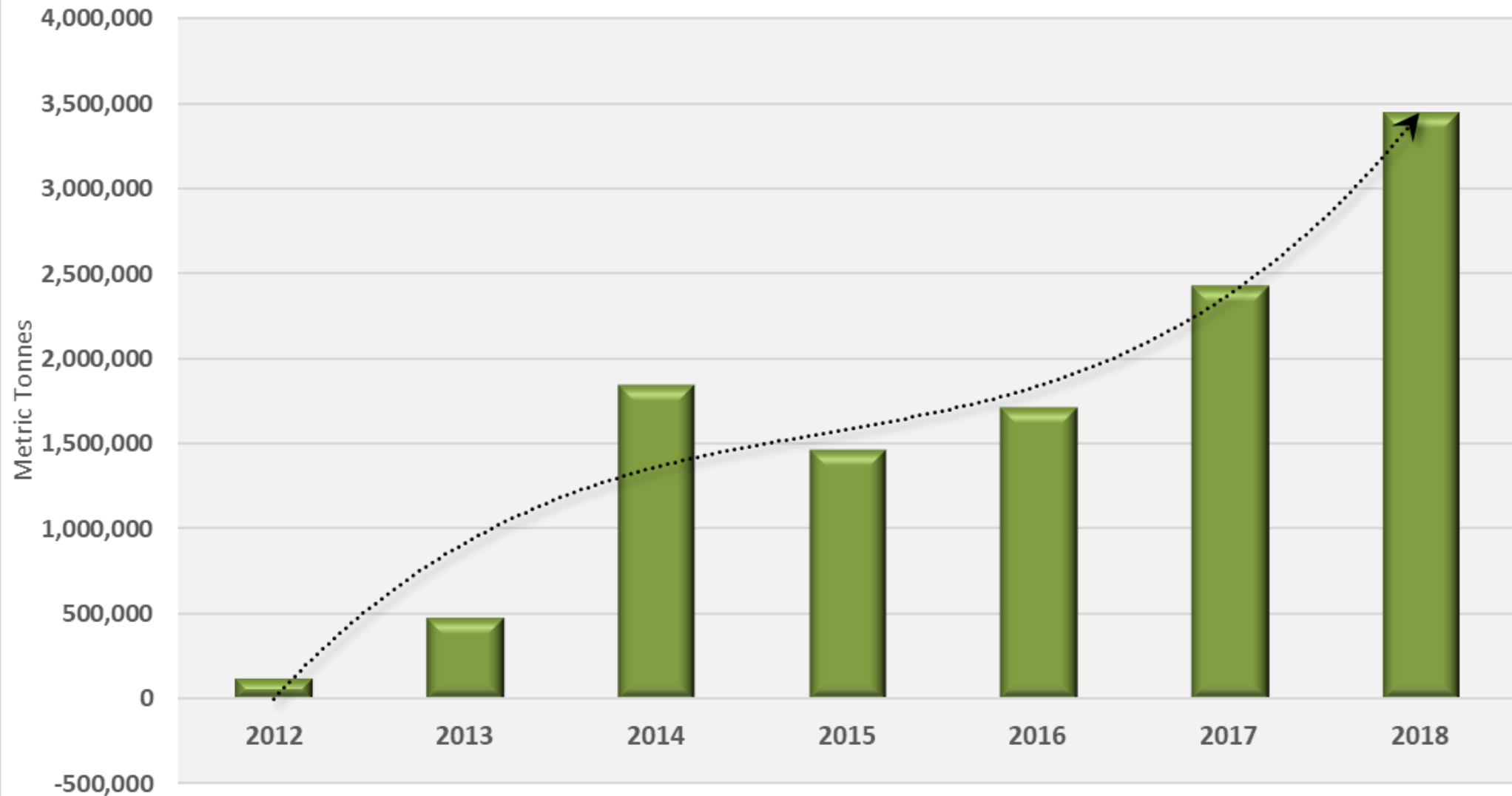


source: analysis by FutureMetrics

S. Korea

South Korea

Wood Pellet Imports into S. Korea



Source: Argus. Analysis by FutureMetrics

S. Korea Renewable Portfolio Standard (RPS).

The RPS program requires 21 power companies to steadily increase their renewable energy mix in total power generation.

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Previous	2.0%	2.5%	3.0%	3.5%	4.0%	5.0%	6.0%	7.0%	8.0%	9.0%	10.0%	
Revised	2.0%	2.5%	3.0%	3.0%	3.5%	4.0%	5.0%	6.0%	7.0%	8.0%	9.0%	10.0%

Utilities must generate or buy REC's to meet their RPS obligation, or pay a fine of 150% of the average REC price for every MWh they are short of their obligation.

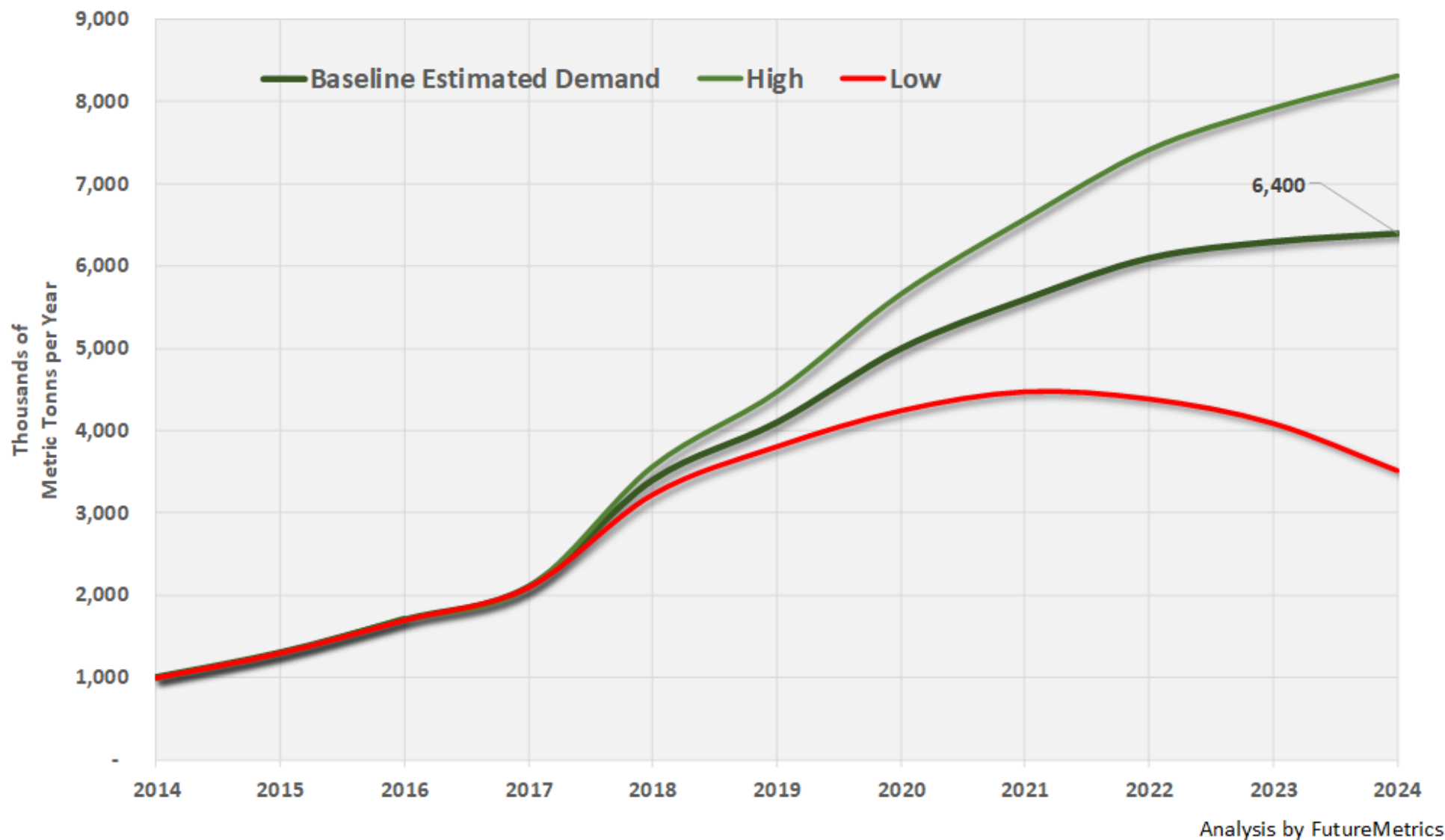
S. Korea - New REC Weighting for Biomass

Technology	Previous	Update - Operational	Update - New
New Build	1.5	1.5	0.5*
Full Conversion	1.0	1.0	0.5
Co-Firing	1.0	1.0	X

- The new weightings significantly reduce or eliminate REC awards for all types of biomass.
- Positive – Has the effect of firming REC prices.

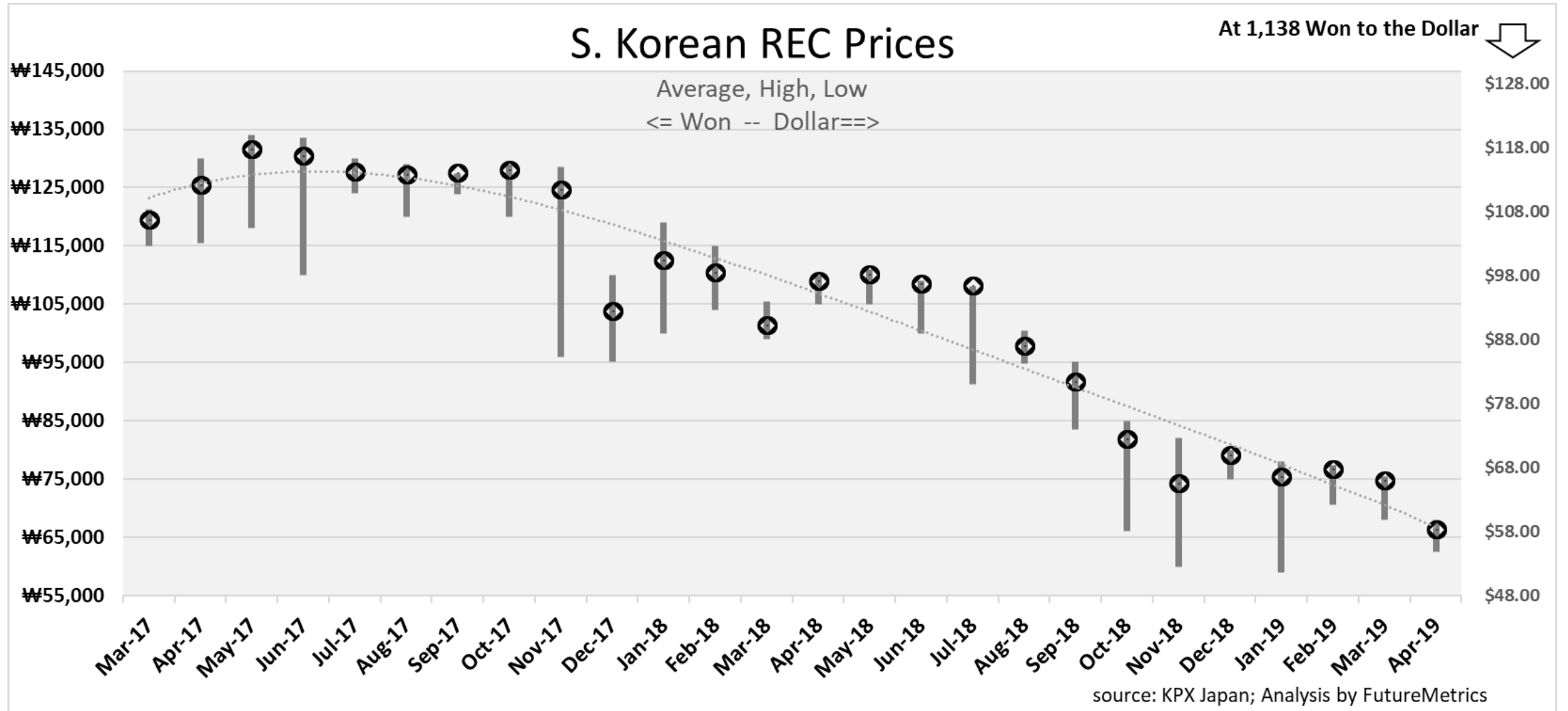
* New builds started by Dec 2018 still receive 1.5 RECs; after that 1.0 RECs through June 2019; thereafter 0.5 RECs.

South Korea Potential Demand for Pellets



**Strong
downside risk
due to
uncertain REC
prices.**

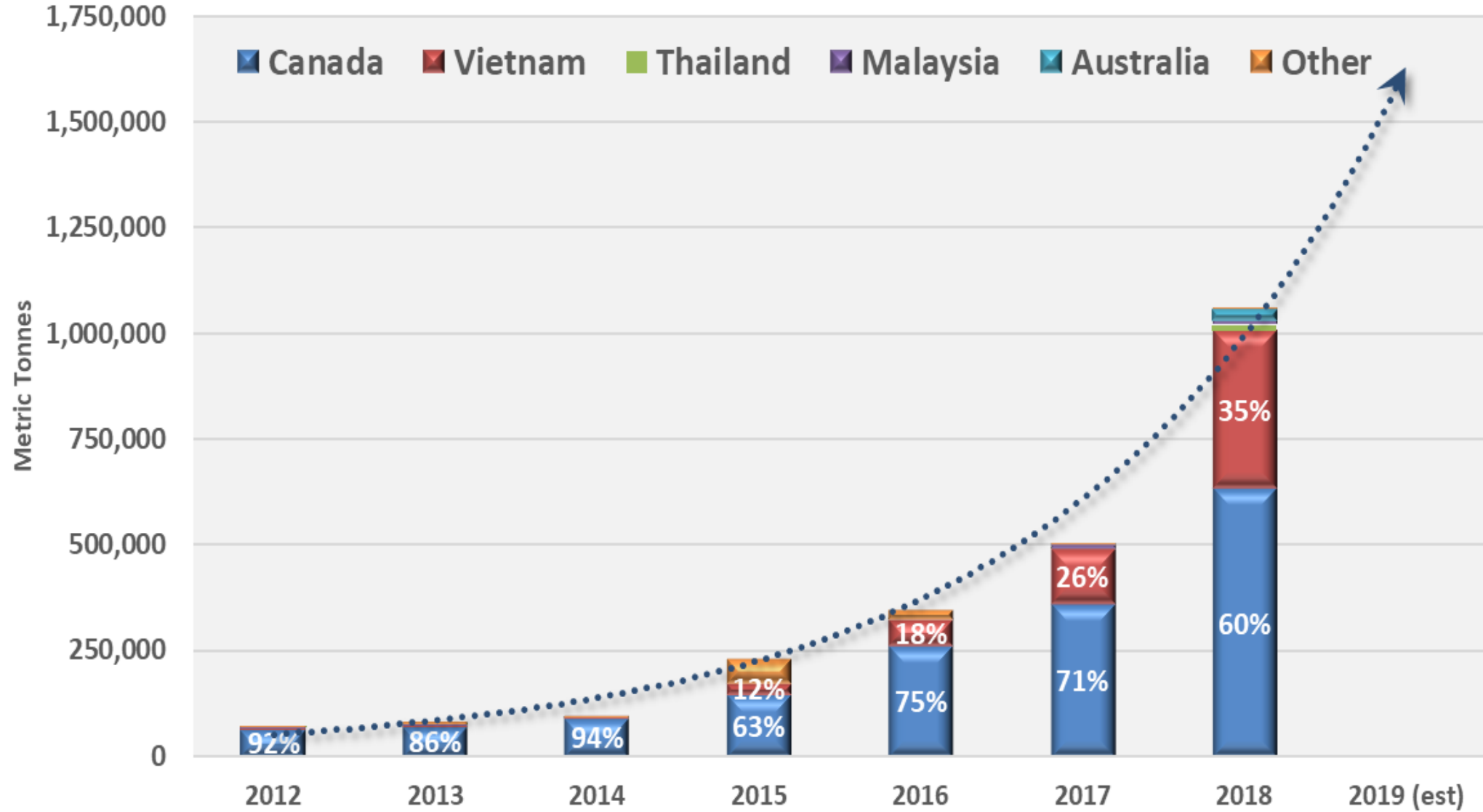
If REC prices go low enough, S. Korean utilities may go to 100% coal and pay the fine!



South Korea's wood pellets demand dipped in the week, as a result of lower renewable energy credit (REC) spot prices in the country. The REC price closed at ₩70,000/REC (\$60.83/REC) on 23 April, according to Korea Power Exchange data, which is about \$24/REC weaker than the average REC spot closing price in 2018 of ₩97,689/REC (\$84.89/REC). **At least one South Korean utility was heard to be considering putting the co-firing of wood pellets on hold because of the fall in REC spot prices.** [from Argus Direct, April 24, 2019]

Japan

Wood Pellet Imports into Japan



source: Argus; Analysis by FutureMetrics

Biomass demand in Japan is primarily driven by three policy components:

- **The Feed in Tariff (FiT) support scheme for renewable energy**
 - **Coal thermal plant efficiency standards**
 - **Carbon emissions targets**

The only policy instrument that provides a monetary incentive is the FiT.

Evolution of the FiT

The FiT tariff was revised downwards from 24 yen to 21 yen and is now it is determined by public tender.

The FiT is fixed for 20 years (no adjustment for inflation)

FiT money comes from the ratepayers, therefore it is designed to have a ceiling in order to avoid too much burden on the ratepayers.

Current approved FiT projects support substantial quantities of renewable power.

Minimum Efficiency Requirements

In 2016, METI released a paper from its Working Group on Thermal Power Generation describing efficiency standards for thermal plants. The paper develops standards based on “Best Available Technology” (BAT) that is economically viable for various types of fuel. The standards presented in the paper are 41% design efficiency for coal plants.

Thermal Power Plant Efficiency Calculation

$$efficiency = \frac{power\ output\ (MWh)}{fuel\ input\ (MWh)} \quad 35\% = \frac{35\ MWh}{100\ MWh}$$

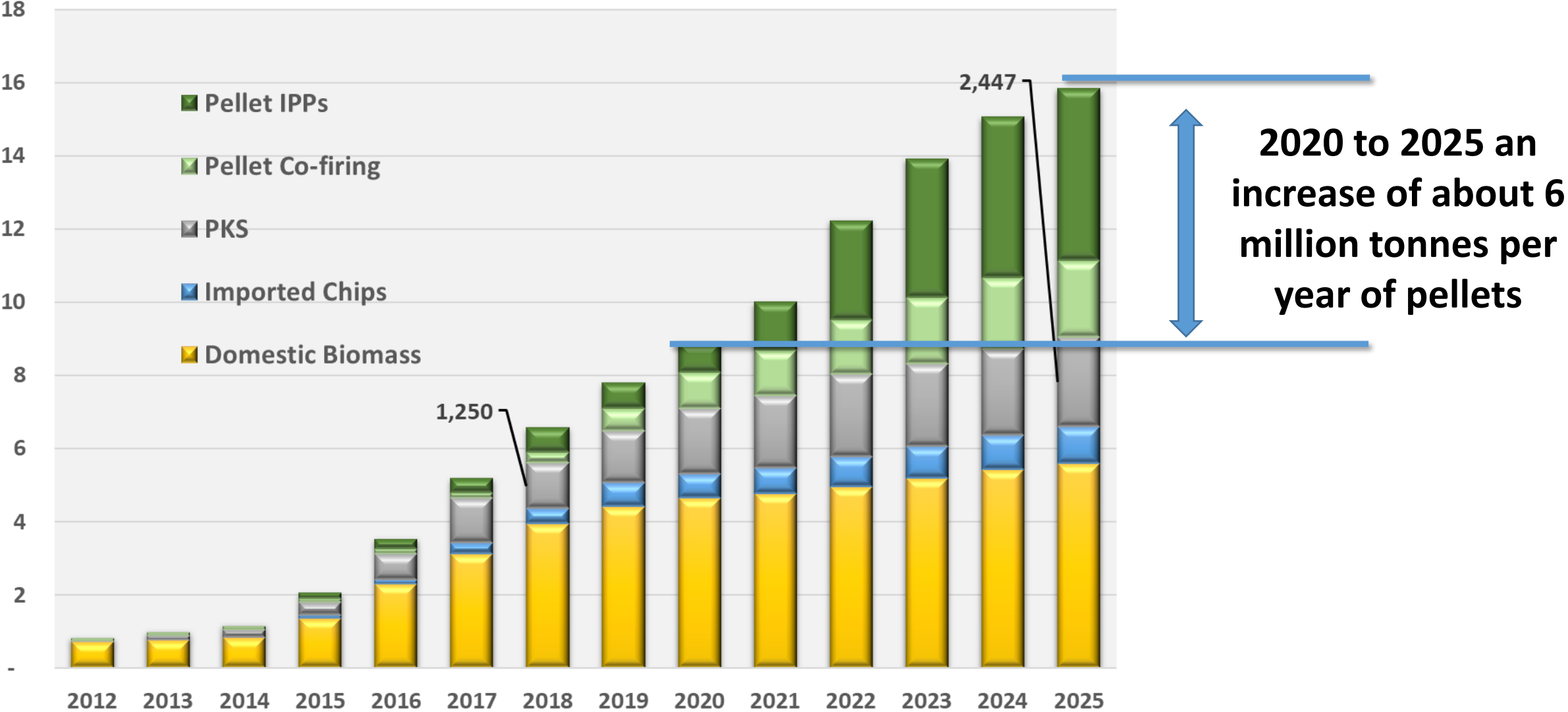
Coal Plant Efficiency Calculation with Biomass Co-Firing Deduction

$$efficiency = \frac{power\ output\ (MWh)}{coal\ input\ (MWh) - pellet\ input\ (MWh)} \quad 41.2\% = \frac{35\ MWh}{100\ MWh - 15\ MWh}$$

Estimate of Pellet Demand to Meet Minimum Efficiency Requirements

Type of Power Station	Share of Coal Generation	Output (GWh/year)	Actual Efficiency	Coal Consumption (Tonnes/year)	Target Efficiency	Co-firing needed get to Target	Wood Pellets required (Tonnes/year)
Ultra Super-Critical	60.12%	134,600	41.5%	44,938,500			-
Super-Critical	27.82%	62,300	39.9%	21,649,800	41.00%	2.71%	899,520
Sub-Critical	12.06%	27,000	37.7%	9,927,800	41.00%	8.05%	1,226,264
	100.00%	223,900	40.61%	76,516,100	41.00%		2,125,784

Japanese Biomass Demand in Millions of MT (pellet equivalent)



source: METI, February 2019, Analysis and Forecast by FutureMetrics

Pellets 2.0?

The future of pellets?

Pellets have been the same for many decades.

It is time for an evolution to version 2.0.

But the benchmark has to be competitive in terms of delivered cost per gigajoule with white pellets.

Black pellets, generally refer to two distinct technological approaches to developing an advanced wood pellet: torrefaction and steam explosion (“SE”).

FutureMetrics has not as yet analyzed a torrefaction technology that is economically competitive with white pellets.

FutureMetrics has analyzed the Arbaflame technology for producing SE pellets and has determined that the technology is competitive with white pellets on a \$/GJ basis.

Several advantages of SE pellets are:

- In contrast to white pellets, SE pellets will not disintegrate when they get wet. They maintain their mechanical characteristics after prolonged exposure to moisture.
- SE pellets have a higher volumetric and gravimetric energy density than white pellets (~31% more GJ/m³). This means significantly more energy can be stored or transported per unit of volume.
- SE pellets are hard and durable and produce significantly less dust (fines) when handled. Much lower explosion risk.
- Power requirements for pulverizing SE pellets at the pulverized coal power station are significantly lower than the power requirements for pulverizing white pellets. This saves power plants hundreds of thousands of dollars (or more!) per year in operating costs.

The steam explosion process causes the lignin to emerge on the surface of the fine wood fibers in the form of small beads.

These beads, when the fiber is densified in the pellet press, form a film-like surface coating on the broken-down wood fibers and results in hard, highly water-resistant pellets that produce almost no dust (fines).

Photos of Arbaflame SE pellets



Verification program with Vattenfall,
4300 tons at Reuter West, Berlin



Handled as coal through the value chain



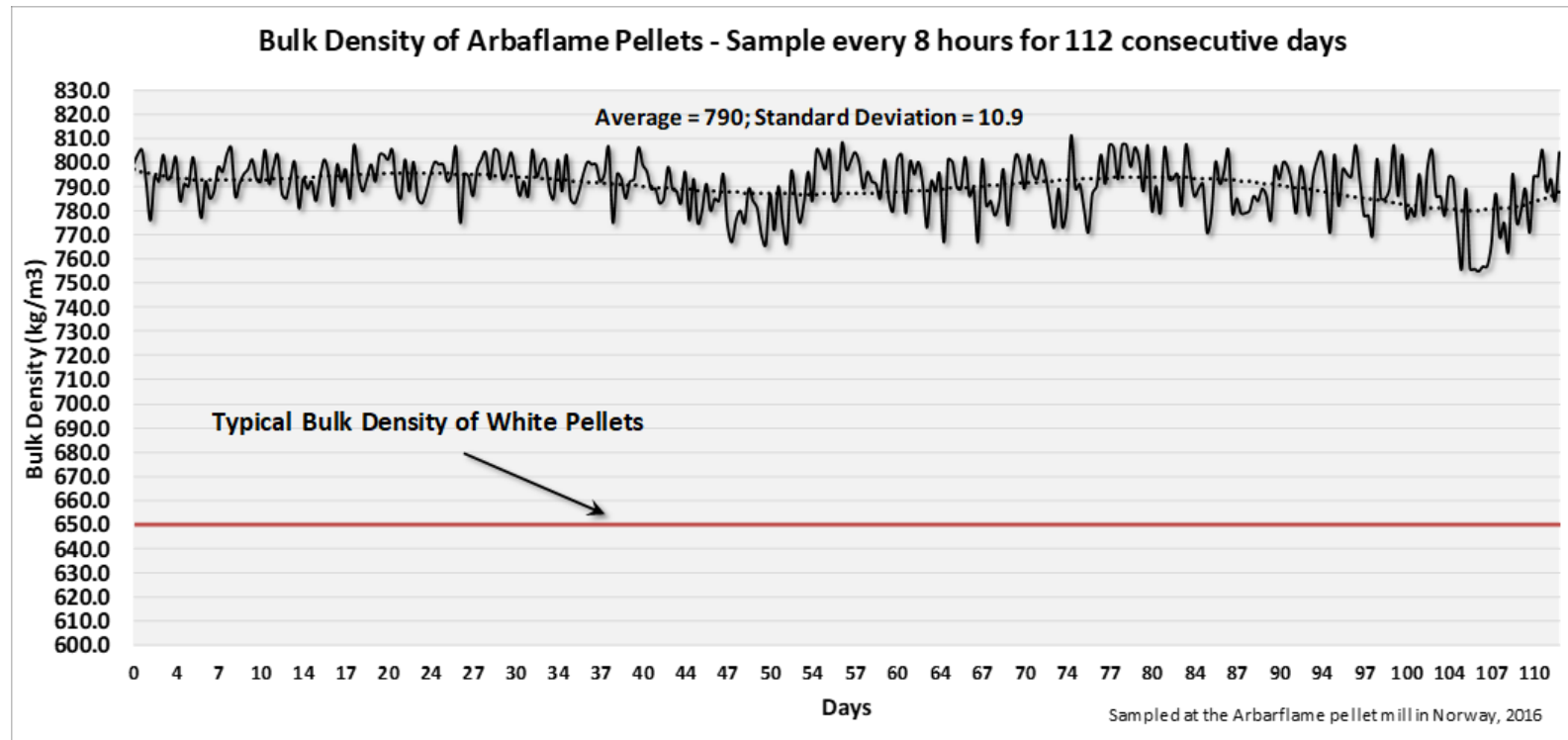
Thunder Bay Power Station
world first full conversion to SE Pellets



Impact of Higher Gigajoules per Cubic Meter

The impact of higher specific energy content in GJ/tonne (about 19.5 for SE and about 17.5 for white) and bulk density (about 790 kg/m³ for SE versus about 650 kg/m³ for white) on transportation costs per GJ delivered is another characteristic of SE pellets that gives them an advantage over white pellets.

A fully loaded 60,000 cubic meter vessel will carry about 682,000 GJ of energy with white pellets and about 924,000 GJ of energy with SE pellets.
Lower cost and lower CO₂ footprint per GJ delivered.

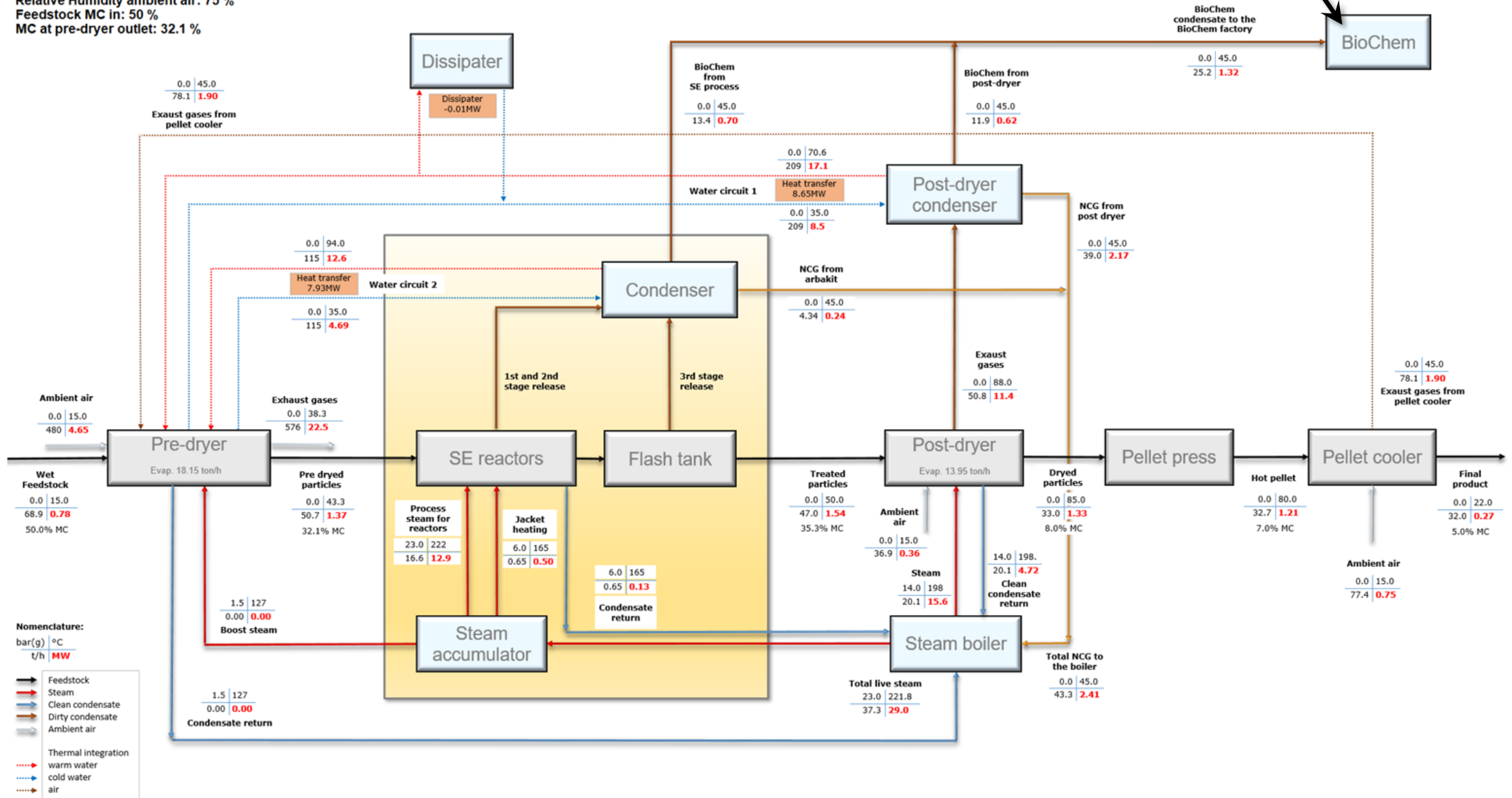


Are SE Pellets Cost Effective?

Yes with BioChem – Mass and Energy is Not Wasted

BioChem

Project: FutureMetrics Analysis
Annual pellet production: 240,000 ton/y
Ambient air temperature: 15 °C
Relative Humidity ambient air: 75 %
Feedstock MC in: 50 %
MC at pre-dryer outlet: 32.1 %



Biochemical Recovery

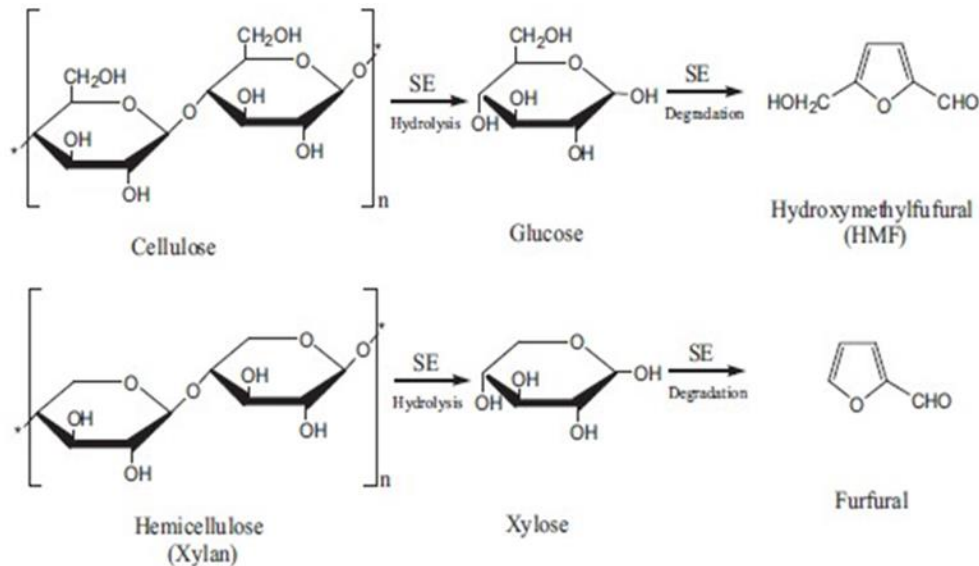
The reactor conditions are controlled such that hemicellulose hydrolysis produces furfural.

Furfural is selling for more than \$1,500 per tonne in large liquid commodity markets.

Reactor Condensate:

Water	95.86%
Acetone	0.02%
Methanol	0.62%
Ethanol	0.00%
Acetic acid	0.95%
Furfural	1.92%
Others (mostly Terpenes)	0.64%
Total	100.00%

Production of furfural adds a net equivalent of ~\$17 per tonne to the project revenue allowing the price for the SE pellets to be competitive on a \$/GJ basis with white pellets.



Perhaps the FUTURE is a facility that is an integrated SE pellet and biochemical factory.

The EU has launched its biggest Research and Innovation program ever for decarbonization: – HORIZON 2020

HORIZON 2020 - €80 Billion research and innovation program



*Horizon 2020 is the biggest EU Research and Innovation programme ever with nearly
€80 billion of funding available over 7 years (2014 to 2020)*

Arbaflame has received a 19 million euro EU grant

- **The project includes the construction of a SE pellet and biochemical production unit; integrated at Engie's power plant at the Port of Rotterdam using power, waste heat, and low-pressure steam from the power station to run the new pellet/biochem factory.**
- **Engie will use the fuel, and the biochemicals will be used by industry**
- **EU will utilize the project as a showcase and promote similar conversions of about 300 CHP's in Europe that currently run on coal**

Consortium partners



Thank you

Bill Strauss – WilliamStrauss@FutureMetrics.com



Bill enjoying BC powder – March 2, 2019

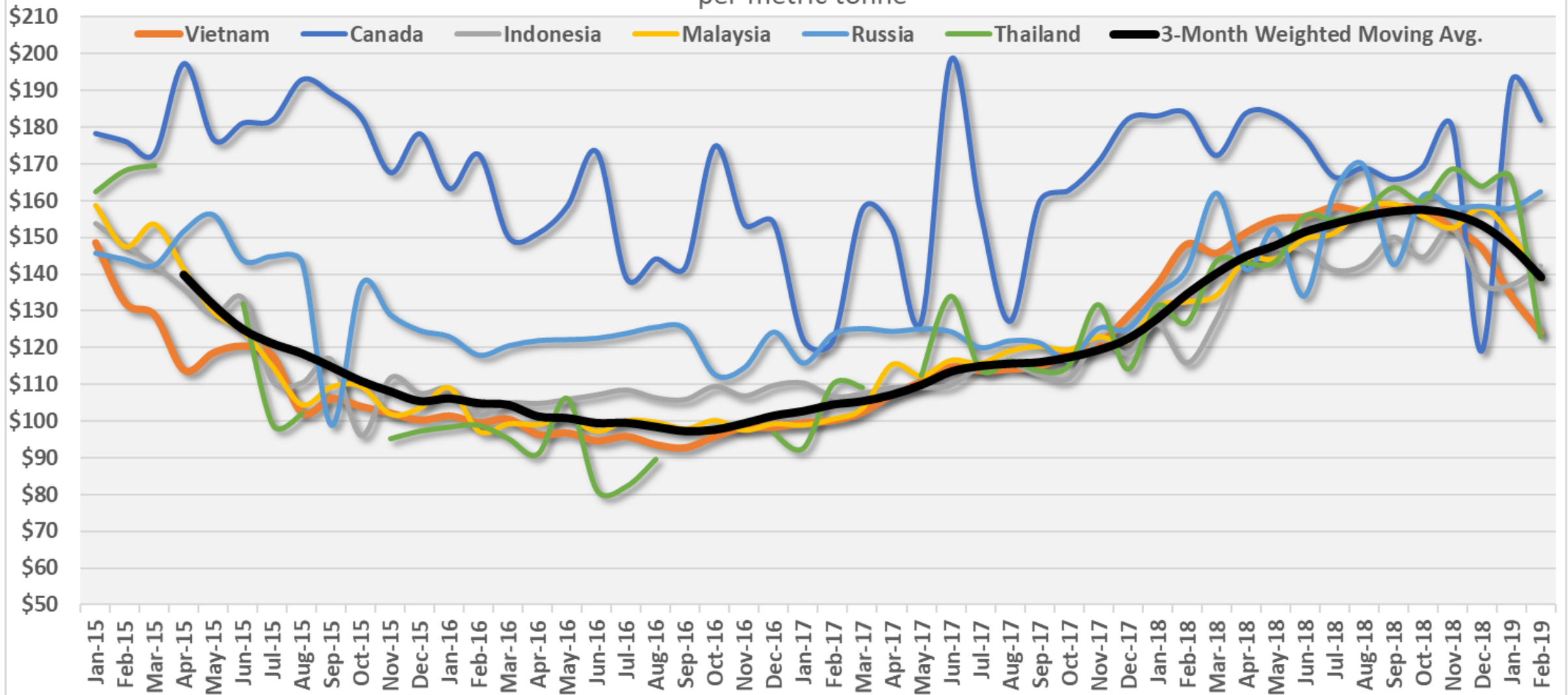
FutureMetrics - Consultants to the World's Leading Companies in the Wood Pellet Sector

Selection of Current and Recent Clients



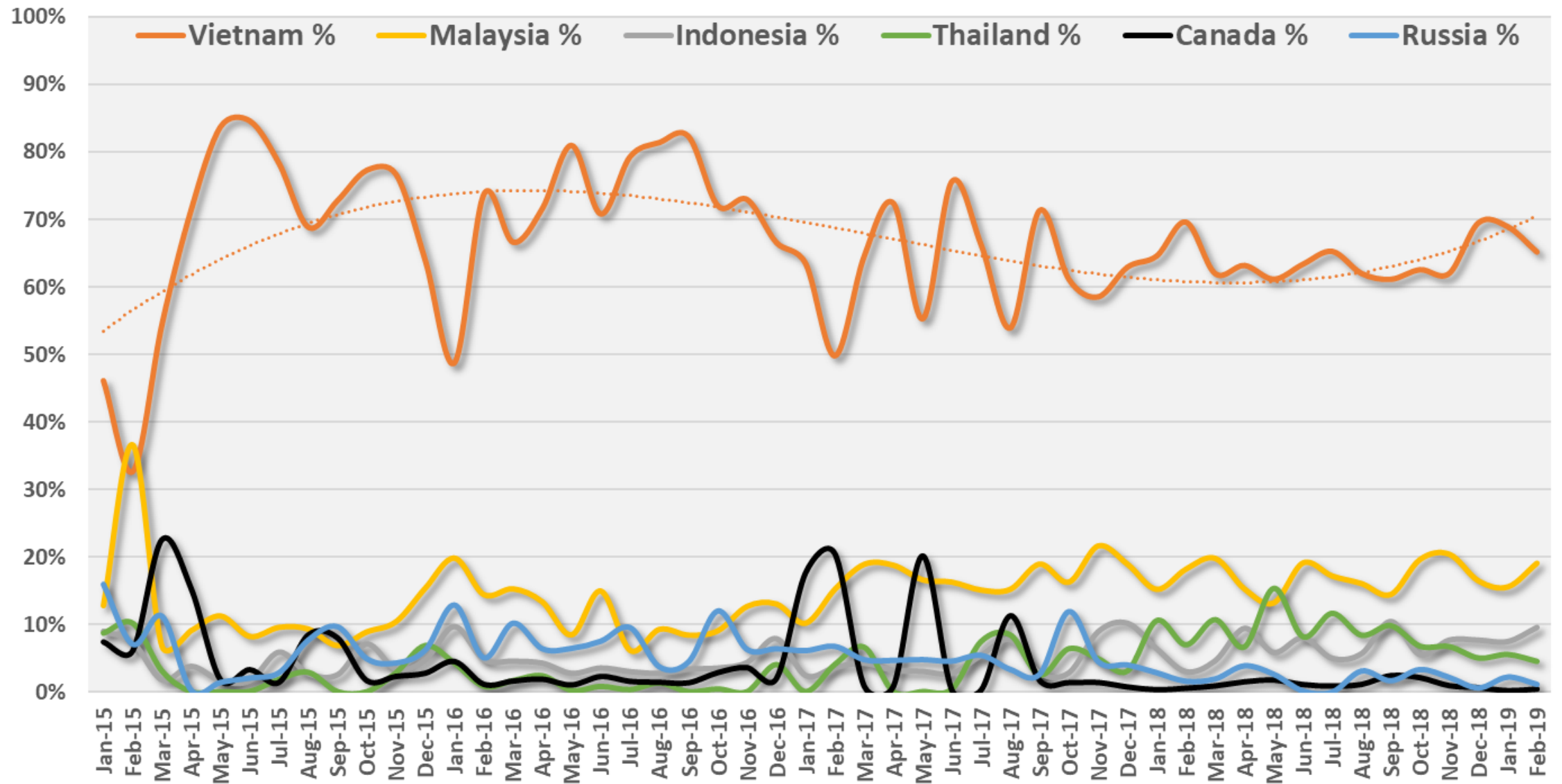
Pellet Prices Delivered to S. Korea

per metric tonne



source: International Trade Data, Analysis by FutureMetrics, April 2019

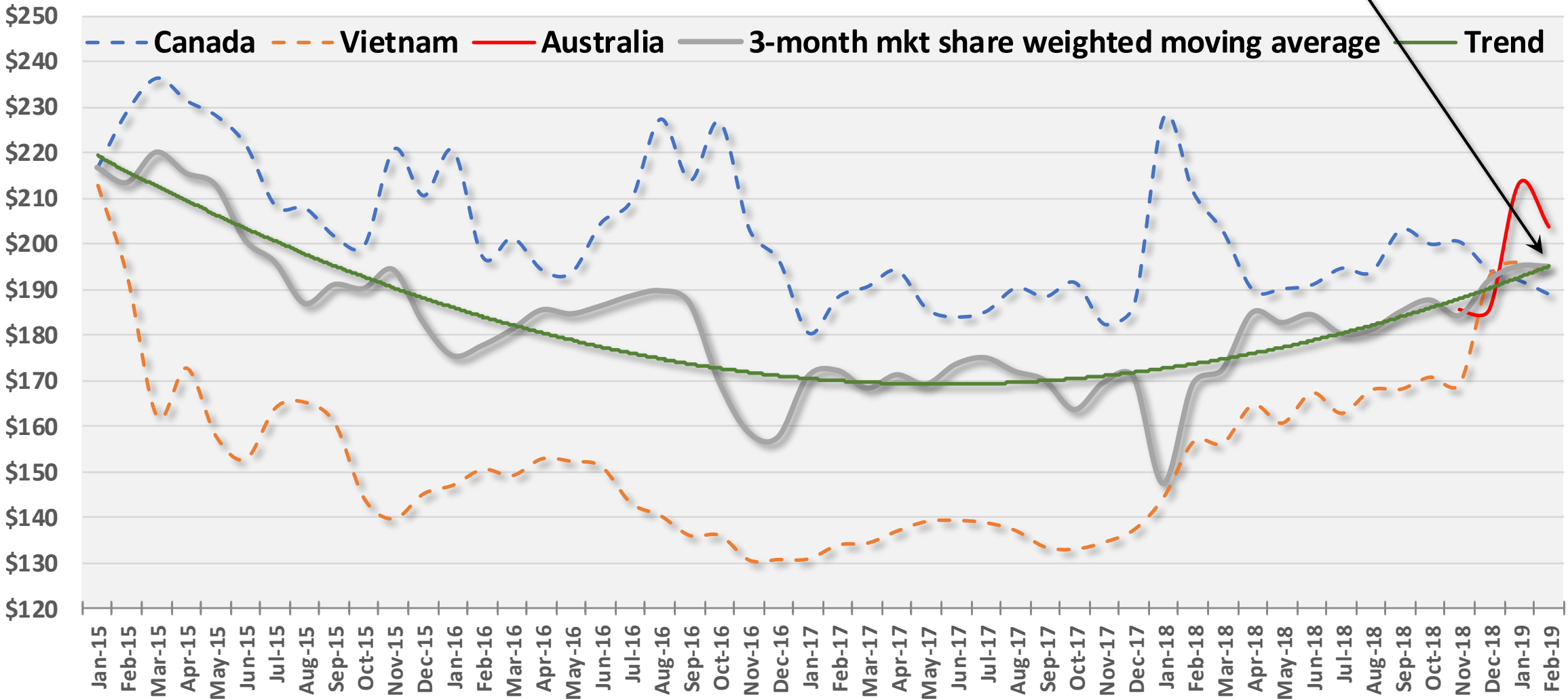
S. Korea Pellet Suppliers Market Share



source: International Trade Data, Analysis by FutureMetrics, Aprilh 2019

About \$195/tonne

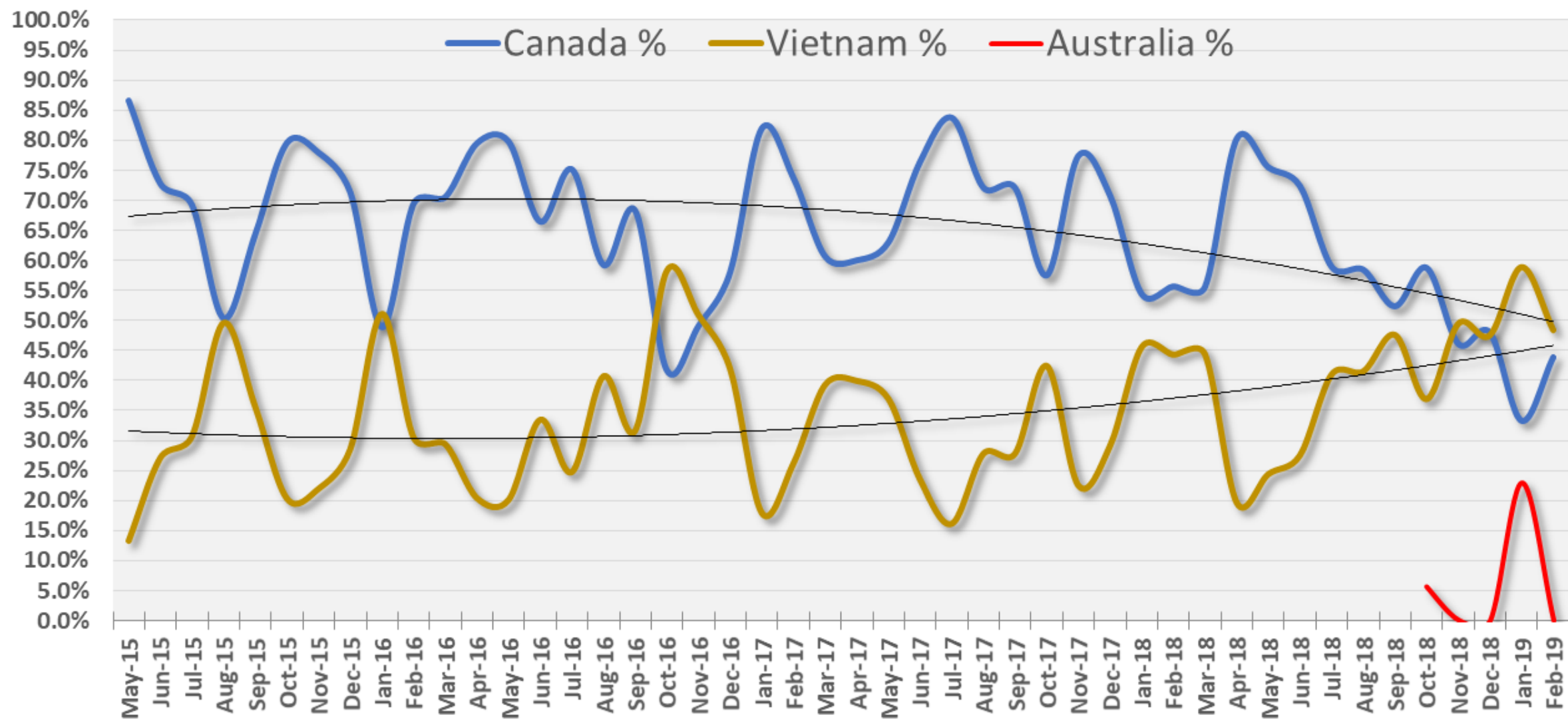
Estimated CIF Prices For Pellets from Canada, Vietnam, and Australia to Japan
(US\$ per metric tonne)



source: International trade data; April 2019; Analysis by FutureMetrics

Market Share in the Japanese Market

(three-month moving average and trend lines - other very low volume countries not included)



source: International trade data; April 2019; Anaysis by FutureMetrics