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Why the South Korean Utilities May Never Engage in Long-term Offtake Agreements for Industrial Wood Pellets

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Demand for industrial wood pellets in S. Korea has grown rapidly in recent years and is expected to grow significantly over the next half decade. This brief white paper discusses why that growth is happening and is expected to continue. The paper also shows why the short-term tendering strategy that is used by S. Korean utilities for securing wood pellet fuel may remain in use for the foreseeable future despite the challenges that the absence of long-term agreements place on the supply side.

Industrial Wood Pellets – Demand is based on policy

Industrial wood pellets are used to substitute for coal in large utility power stations that use pulverized fuel systems. Almost all large utility coal plants around the world are based on pulverized coal (PC) designs. Wood pellets easily pulverize and, with relatively minor and well-established modifications, the power plant can co-fire wood pellets with coal or use 100% wood pellets and have no loss of output or reliability¹.

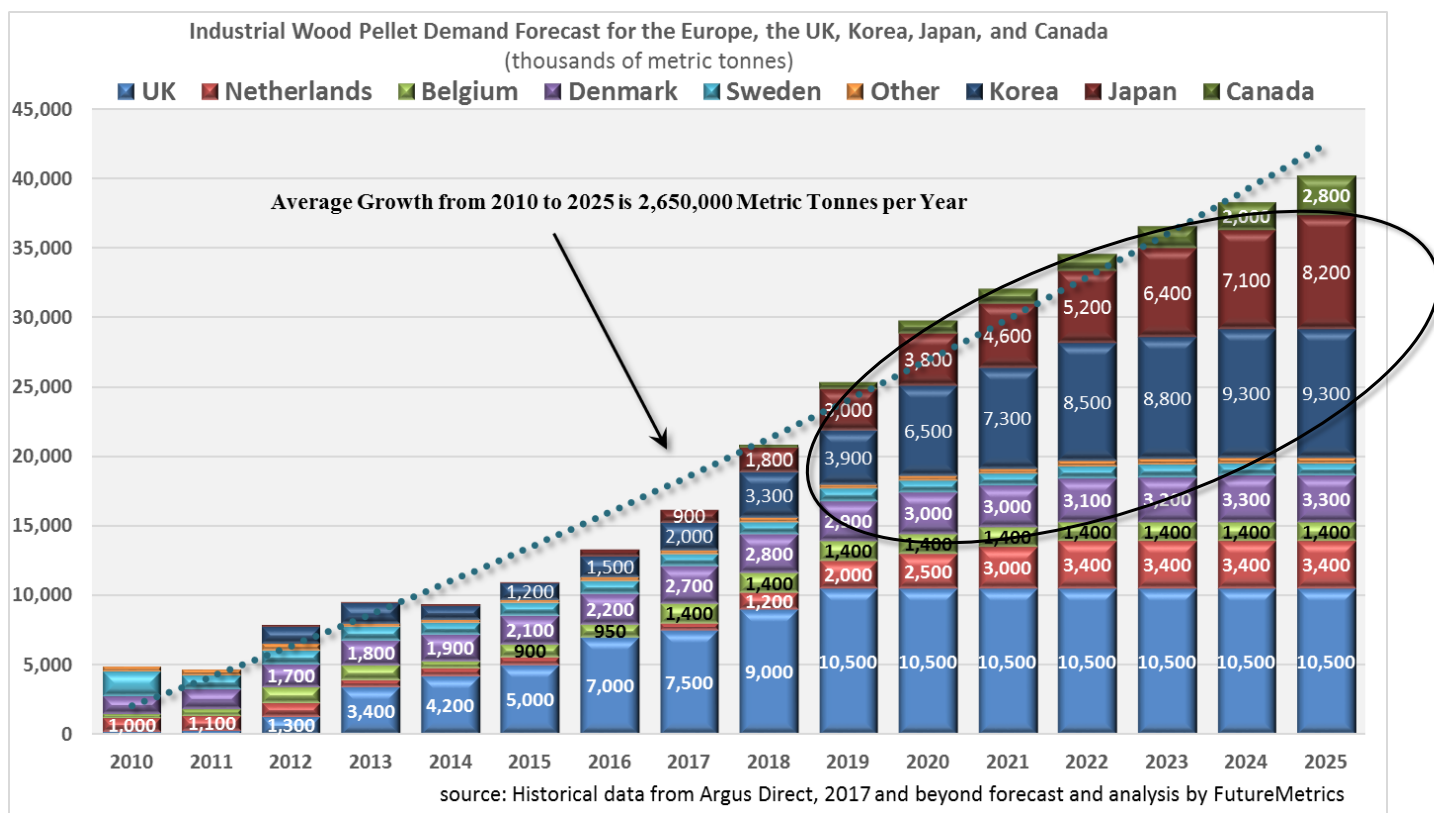
The motivation for substituting pellets for coal is to lower CO₂ emissions² and increase the proportion of power generated from renewable energy. Wood pellet fuel is costlier per megawatt-hour (MWh) generated than coal but significantly lowers CO₂ emissions. Therefore, in every country that has power stations that are co-firing or full-firing wood pellets there is policy that supports the strategy of pellets-for-coal substitution. Most policies either provide incentives for the reduction in CO₂ emissions or penalize those emissions.

S. Korea's policy does not explicitly target CO₂ reduction. It is based on a renewable portfolio standard (RPS) that places requirements on the major utilities to generate a proportion of their electricity from renewable sources. How that policy is implemented is discussed in more detail below.

The global industrial wood pellet market had its genesis in Europe. But the growth in demand for industrial wood pellets in the EU and UK markets is nearing an end. The chart below shows the historical growth in demand and the forecast for demand to 2025.

¹ FutureMetrics works closely with Ramboll under a professional services agreement to provide information to utilities regarding coal plant modifications and conversions. Ramboll is a Danish engineering firm that has been involved in many of the modifications and conversions of PC plants for the use wood pellets in Europe and the UK. They are currently the owners engineer on the [Lynemouth power plant conversion](#) in the UK.

² FutureMetrics has written many papers about how pellets lower carbon emissions. They are available at www.FutureMetrics.com.



As the forecast shows, the expected significant demand growth after 2019 is in Japan and S. Korea.

The Korean RPS and Demand for Industrial Wood Pellets

S. Korea is guiding the power generation industry with a Renewable Portfolio Standard (RPS). The RPS program requires the 13 largest power companies (with installed power capacity larger than 500 MW) to steadily increase their renewable energy mix in total power generation over the period from 2012-2024. The table below shows the annual required proportion of power that has to be generated from renewable sources.

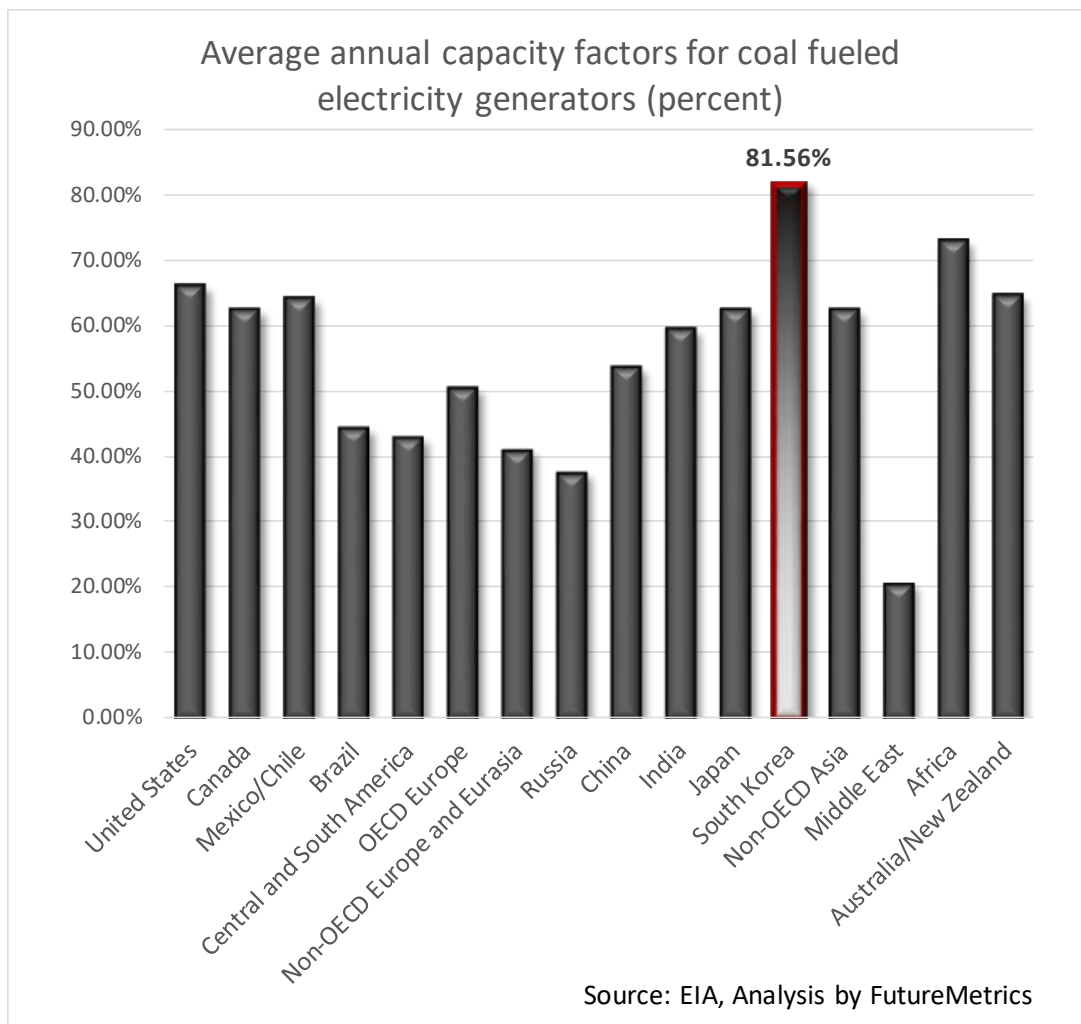
2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
2.0%	2.5%	3.0%	3.0%	3.5%	4.0%	4.5%	5.0%	6.0%	7.0%	8.0%	9.0%	10.0%

For power companies to meet their RPS targets they can:

- (1) Invest in renewable energy installations themselves and receive renewable energy certificates or RECs (RECs are issued based on the MWh's generated from renewable sources), or
- (2) purchase RECs on the market to meet their obligation.

The power companies must submit the total RECs both generated or purchased to the New and Renewable Energy Center (KNERC) on an annual basis. If the power company fails to present the required number of RECs based on the RPS mandate, KNERC applies a financial fine. The penalty is equal to 150% of the average market price of the RECs for that year.

Some of that renewable power is being generated from new wind and solar installations. However, the growth in the S. Korean demand for electricity and the relatively low cost to modify a PC power plant to use pellets has resulted in a rapid increase in wood pellet co-firing. Thermally generated power is baseload and S. Korea has a large and growing industrial base that demands 24/7 power. The chart below³ shows that S. Korea demands that its coal power stations run at very high availability⁴.



³ Data from the US Energy Information Administration, "International Energy Outlook 2016", May 11, 2016. <https://www.eia.gov/outlooks/ieo/electricity.cfm>

⁴ Capacity factor measures the number of MWh's per year that the power plant generates compared to how many it could generate if it were to run every hour of the year at full output.

But why would S. Korean generating companies (gencos) use the higher cost wood pellet fuel? What is driving the S. Korean demand for industrial wood pellets?

It is the price of producing and selling RECs and the potential cost of non-compliance.

The table below shows that the volume of RECs produced increased by almost 36% from 2015 to 2016. Yet even as supply has increased, the price of RECs has also increased. The average price from 2015 to 2016 increased by 74% to the equivalent of about \$150/MWh. This implies a significant excess demand for RECs in S. Korea.

S. Korean REC Markets				Converted to \$ at 1,130 ₩/\$	
	2015	2016	% change	2015	2016
Volume (REC)	1,932,312	2,623,819	35.8%		
Highest price (won/REC)	₩120,000	₩180,000	50.0%	\$ 106.19	\$ 164.78
Average price (won/R C)	₩96,213	₩167,834	74.4%	\$ 85.14	\$ 150.23
Lowest price (won/REC)	₩70,000	₩86,000	22.9%	\$ 61.95	\$ 82.39

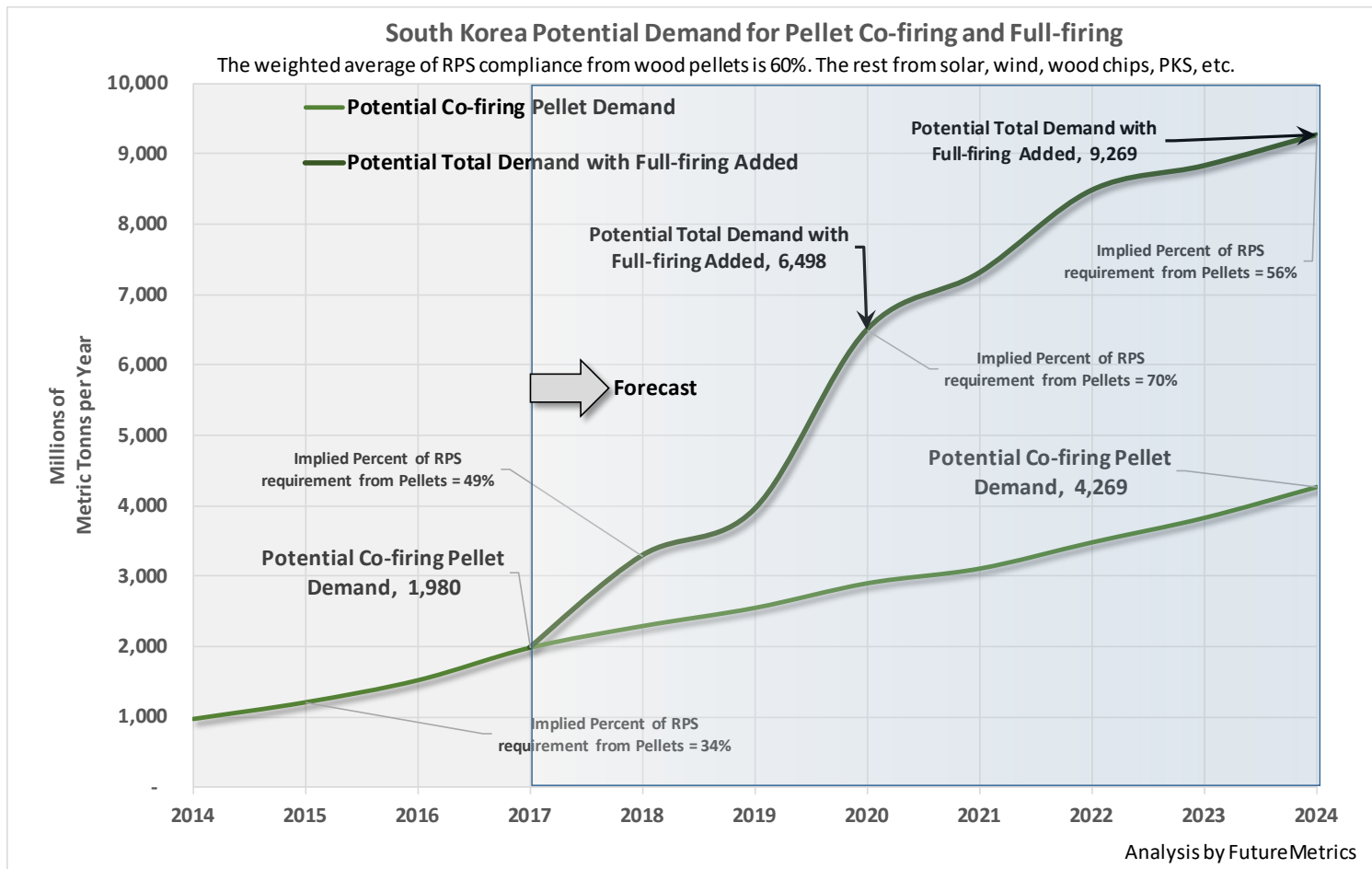
Data provided by Argus

\$150 per REC received per megawatt-hour generated from renewable fuel is a much higher rate for power sales than the spot price for wholesale electric power. Therefore, even after accounting for the higher cost of generation from using wood pellet fuel and adding in the estimated amortized cost of the modifications needed to efficiently and reliably co-fire pellets, S. Korean PC power plants can improve their bottom line by co-firing.

FutureMetrics has estimated the levelized cost of energy (LCOE) for a typical/hypothetical S. Korean power plant and has estimated the incremental increase in LCOE from co-firing wood pellets. The analysis shows that at current REC prices, S. Korean utilities will significantly increase the net of their average revenue over the cost of generation by increasing their co-firing rates.

This is already happening⁵. The chart on the next page shows the recent demand for pellets in S. Korea and the forecast demand. The lower line in the forecast is based on the expected ramp-up of co-firing as the RPS requirement moves from its current 4% to 10% in 2024. The upper line shows the expected wood pellet demand given the announced PC power plants that will be using 100% wood pellets.

⁵ "Some industry participants are now projecting total South Korean woody biomass demand of around 7mn-8mn t/yr by 2020, an upward revision from 5mn-6mn t previously. This growth is based on conversion projects and the addition of at least two large dedicated biomass power projects in South Korea in the coming years. Previously announced planned projects by state-controlled utilities Koen and Korea Midland Power (Komipo), as well as a joint project by construction company Hanyang and state-controlled nuclear power producer KNHP, could together create demand for 3.6mn t/yr of wood pellets when they start full operations by 2020, according to Argus calculations." (source: Argus Direct, April 17, 2017)



Note also that the chart shows the implied percent of the RPS requirement that is satisfied by using pellets in the PC power plants⁶. The rapid increase in pellet demand as the full-firing plants come online in 2019-2020 takes the estimated proportion of the RPS requirement satisfied by pellets to about 70%. In 2024, when the RPS proportion for renewables hits 10%, the estimated portion of the renewable requirement met by pellets is 56%.

REC Prices and S. Korean Demand

As noted above, the net of revenue over costs is driving the move by S. Korean utilities into the use of wood pellets for power generation. The tables below show an example of a hypothetical S. Korean PC power station's accounting⁷. The analysis below assumes that all of the renewable obligation has to be

⁶ The forecasted increase in power demand is based on data from Korea Electric Power Corporation (KEPCO).

⁷ There are many assumptions in the model including the capital cost of the coal plant, the cost of coal, efficiency of the plant and its capacity factor, the cost of delivered pellets, the wholesale price of power, etc. FutureMetrics can provide analysis with inputs specific to the conditions of any power plant and potential export source.

satisfied by the power plant. As the chart above implies, some of the RPS obligation will be satisfied by other forms of generations such as wind and solar.

The first table below shows the outcome for a hypothetical power plant that is generating with 100% coal in 2018. The 2018 proportion of power required from renewables is 4.5% and this power plant is generating zero percent from renewables. Given the assumptions in the model, the utility is paying a fine of about \$27.4 million in 2018.

South Korea RPS	
Assumed 500 MW Power Plant	
Year	2018
Percent Renewable Required by RPS	4.5%
Percent Renewable Generated	0.0%
Assumed REC Price = ₩140,000	\$122.00
MWh's Needed for Compliance	150,000
MWh's from Pellets	-
Fine (@150% of Average REC Price)	\$27,360,000
REC Income	\$0
NET Adjustment	-\$27,360,000
Net Adjustmeent per MWh	-\$8.22
Revenue/MWh	\$78.26
Estimated LCOE/MWh	\$75.30
Net/MWh before RPS Adjustment	\$2.96
Net/MWh <u>AFTER</u> RPS Adjustment	-\$5.26

This hypothetical plant would have been making a profit of about \$2.96/MWh if it were not for the fine for failing to generate or purchase RECs equal to the 150,000 needed for compliance. After subtracting the cost of the fine, the plant is in the red by about \$5.26/MWh.

The next table shows the same plant; but now the plant is generating 5% of its MWh's from pellets.

South Korea RPS	
Assumed 500 MW Power Plant	
Year	2018
Percent Renewable Required by RPS	4.5%
Percent Renewable Generated	5.0%
Assumed REC Price = ₩ \$140,000	\$122.00
MWh's Needed for Compliance	150,000
MWh's from Pellets	170,000
Fine (@150% of Average REC Price)	\$0
REC Income	\$20,360,000
NET Adjustment	\$20,360,000
Net Adjustmeent per MWh	\$6.12
Revenue/MWh	\$78.26
Estimated LCOE/MWh	\$76.64
Net/MWh before RPS Adjustment	\$1.62
Net/MWh <u>AFTER</u> RPS Adjustment	\$7.73

In this case, they are paying no fine since they are producing 170,000 RECs. That is 20,000 RECs above the required amount. They are also producing revenue from selling RECs. In this example, the plant has a slightly lower net per MWh before the RPS adjustment due to the higher cost of generation from co-firing pellets. Adding the REC income, equal to about \$6.12/MWh, yields a net positive cash flow of \$7.73/MWh.

At current REC prices, there is a strong incentive to be in compliance.

In fact, at current REC prices, there is a strong incentive to go all in and full-fire at 100% pellets.

The table below shows the same hypothetical plant full-firing at 100% wood pellets in 2020.

South Korea RPS	
Assumed 500 MW Power Plant	
Year	2020
Percent Renewable Required by RPS	6.0%
Percent Renewable Generated	100.0%
Assumed REC Price = ₩140,000	\$122.00
MWh's Needed for Compliance	200,000
MWh's from Pellets	3,330,000
Fine (@150% of Average REC Price)	\$0
REC Income	\$405,290,000
NET Adjustment	\$405,290,000
Net Adjustmeent per MWh	\$121.74
Revenue/MWh	\$78.26
Estimated LCOE/MWh	\$126.10
Net/MWh before RPS Adjustment	-\$47.84
Net/MWh <u>AFTER</u> RPS Adjustment	\$73.90

Without the benefit of the REC income, the plant would be losing about \$48/MWh due to the higher cost of pellet fuel and the amortized costs of a full conversion (including sufficient dry storage). But, assuming REC prices of ₩140,000 (\$122) and with every MWh producing a REC, the net cash flow is almost \$74/MWh. Compare that to the cash flow from generating with 100% coal of \$2.96/MWh in the first table above..

S. Korean utilities that convert plants for full-firing wood pellets will be very profitable!

Future Sustained Demand for Wood Pellets Depends on REC Prices and Pellet Prices

The increase in demand that is forecast from the full-firing conversions mentioned in the footnote on page 4 and the chart on page 5 would suggest that the need for the security of fuel supply would motivate S. Korean utilities to move from the current short-term tendering strategy to a more long-term strategy of engaging in offtake agreements with terms of 7 or more years.

But there are risks to the sustainability of the cash flows that yield the outcome in the table above.

REC prices are determined by the market for RECs. As in any market, supply and demand set the market clearing price. Currently there is excess demand for RECs. As the S. Korean RPS ramps up to 10% renewables by 2024, it is likely that the market will remain in a state of excess demand.

However, it is possible that REC prices may fall. The chart on page 5 suggests that even at high pellet demand levels, the proportion of the RPS compliance from using pellet fuel in PC power stations may never exceed 100%. The chart shows that it is possible that pellet fuel will provide 70% of the RPS requirements in 2020. What is not included in the analysis is the proportion of power generated from

other renewables such as wind and solar. It is possible that at some point in the future the total RECs produced could approach or exceed the RPS requirements.

As the supply of RECs increases and demand for purchased RECs declines, REC prices will fall.

Suppose the REC price is ₩25,000 (\$22) in 2022. Our hypothetical power station using 100% pellets would have the following cash flows.

South Korea RPS	
Assumed 500 MW Power Plant	
Year	2020
Percent Renewable Required by RPS	6.0%
Percent Renewable Generated	100.0%
Assumed REC Price = ₩25,000	\$22.00
MWh's Needed for Compliance	200,000
MWh's from Pellets	3,330,000
Fine (@150% of Average REC Price)	\$0
REC Income	\$72,370,000
NET Adjustment	\$72,370,000
Net Adjustmeent per MWh	\$21.74
Revenue/MWh	\$78.26
Estimated LCOE/MWh	\$126.10
Net/MWh before RPS Adjustment	-\$47.84
Net/MWh <u>AFTER</u> RPS Adjustment	-\$26.10

With all the inputs unchanged, including the price of pellets that was used in the 2018 analysis, the same power plant switching to 100% coal would have the cash flows shown in the table on the next page.

South Korea RPS	
Assumed 500 MW Power Plant	
Year	2022
Percent Renewable Required by RPS	8.0%
Percent Renewable Generated	0.0%
Assumed REC Price = ₩25,000	\$22.00
MWh's Needed for Compliance	270,000
MWh's from Pellets	-
Fine (@150% of Average REC Price)	\$8,690,000
REC Income	\$0
NET Adjustment	-\$8,690,000
Net Adjustmeent per MWh	-\$2.61
Revenue/MWh	\$78.26
Estimated LCOE/MWh	\$75.30
Net/MWh before RPS Adjustment	\$2.96
Net/MWh <u>AFTER</u> RPS Adjustment	\$0.35

This analysis in the table above is not completely accurate because the fine is not based on spot REC prices but on the average REC price over the preceding 12 months. Assuming an average REC price of ₩100,000 (\$87) over the prior year, the fine will be higher and the net cash flow per MWh will be lower. However, it is still not as low as when firing 100% pellets as shown in the chart on the previous page.

South Korea RPS	
Assumed 500 MW Power Plant	
Year	2022
Percent Renewable Required by RPS	8.0%
Percent Renewable Generated	0.0%
Assumed REC Price = ₩25,000	\$22.00
MWh's Needed for Compliance	270,000
MWh's from Pellets	-
Fine (@150% of Average REC Price)	\$34,750,000
REC Income	\$0
NET Adjustment	-\$34,750,000
Net Adjustmeent per MWh	-\$10.43
Revenue/MWh	\$78.26
Estimated LCOE/MWh	\$75.30
Net/MWh before RPS Adjustment	\$2.96
Net/MWh <u>AFTER</u> RPS Adjustment	-\$7.47

This analysis assumes that delivered pellet prices remain unchanged. It is likely that as S. Korean demand for wood pellets increases, the price for delivered pellets will also increase. If that happens, the utilities will be further challenged if REC prices fall.

Conclusion

This analysis reveals a difficult problem for the S. Korean market. Most pellet producers and project lenders/investors will not commit to the capital expense of a new pellet plant without a long-term offtake agreement to guarantee that most of the plant's production will be sold at known volumes and prices. To date, S. Korean utilities have not engaged in long-term offtake agreements. But demand growth has been sufficient to spur rapid growth in production capacity in Vietnam that satisfies S. Korean tenders⁸. But as demand ramps up and demand significantly exceeds Vietnam's capacity to produce low cost pellets from furniture manufacturing residuals, it is difficult to conceive of how pellet production capacity matching the expected S. Korean demand can be deployed without long-term agreements.

Yet with the risk of falling REC prices, how can S. Korean utilities engage in long-term agreements? Or conversely, how can a producer have the confidence that their S. Korean counterparty will be able to afford their product over the terms of the offtake agreement?

Perhaps there will be change in policy in S. Korea. That is a distinct possibility. Without a policy change, there is currently no long-term guarantee to the revenue per MWh from the S. Korean RPS.

All other nations that have a developed pellet co-firing or full-firing power markets have policies that support and de-risk long-term pellet supply agreements.

The evolution of the S. Korean policies and their demand for industrial wood pellets will be most interesting to monitor...

⁸ Vietnam pellet production has been primarily based on residual materials from Vietnam's large and growing furniture manufacturing sector. Those residuals are already dry and in most cases already at a particle size that allows pellets to be produced without feedstock drying or hammermilling. Therefore, capital costs and production costs are significantly lower for Vietnam pellet producers.