# Carbon Pricing in Wholesale Energy Market

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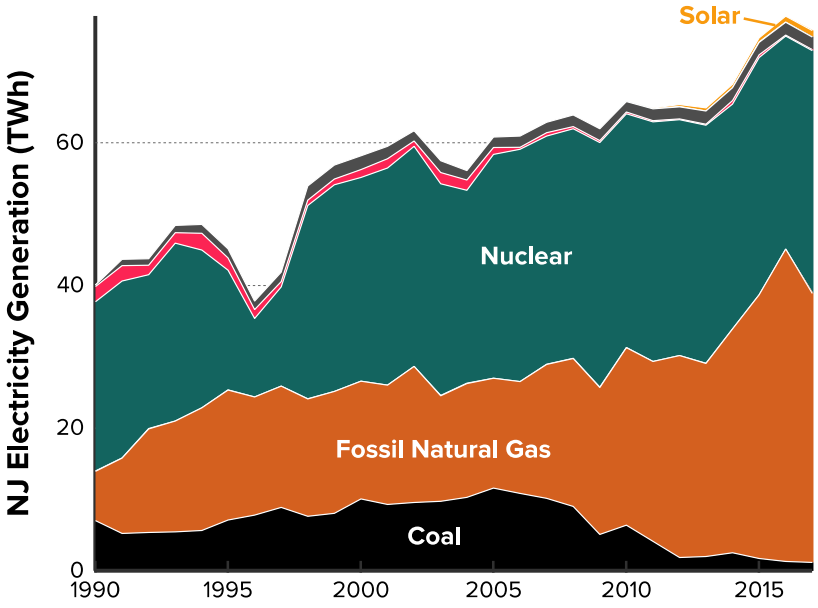
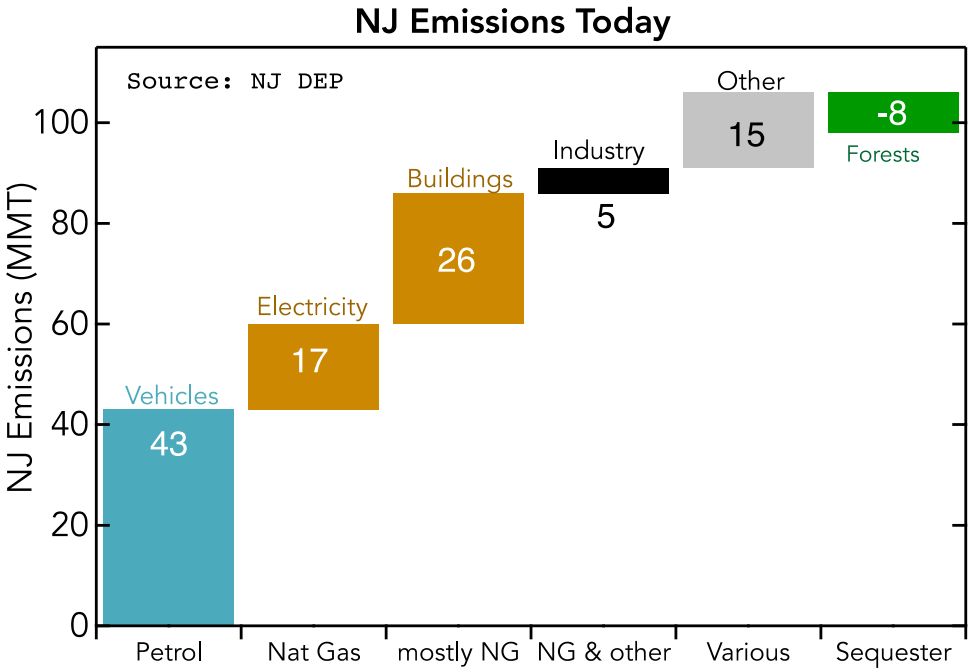
**The views expressed here are mine along and do not represent the view of the Board of Public Utilities or of Board Staff**

# New Jersey's Carbon Mix



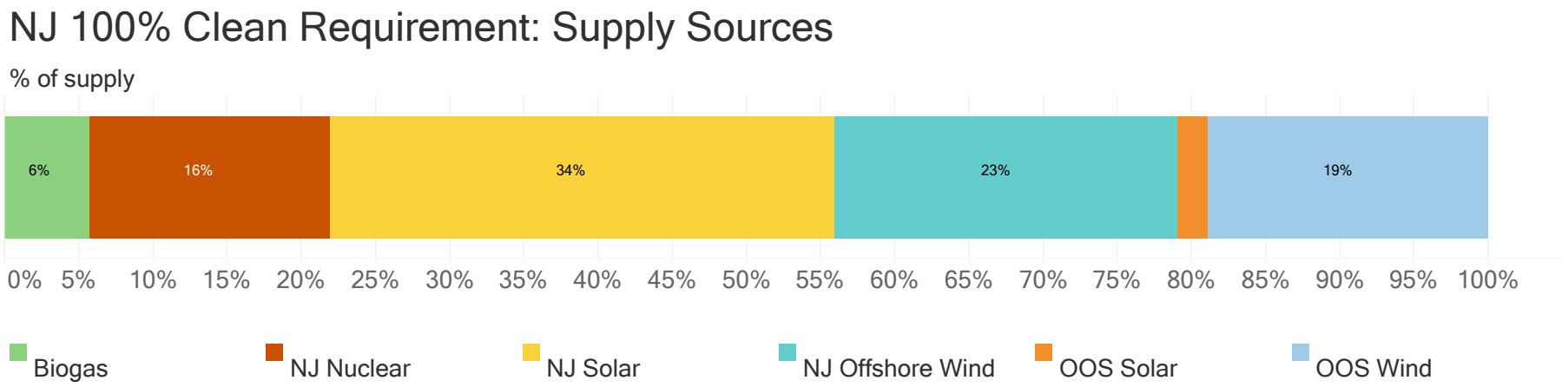

**80x50 goal**

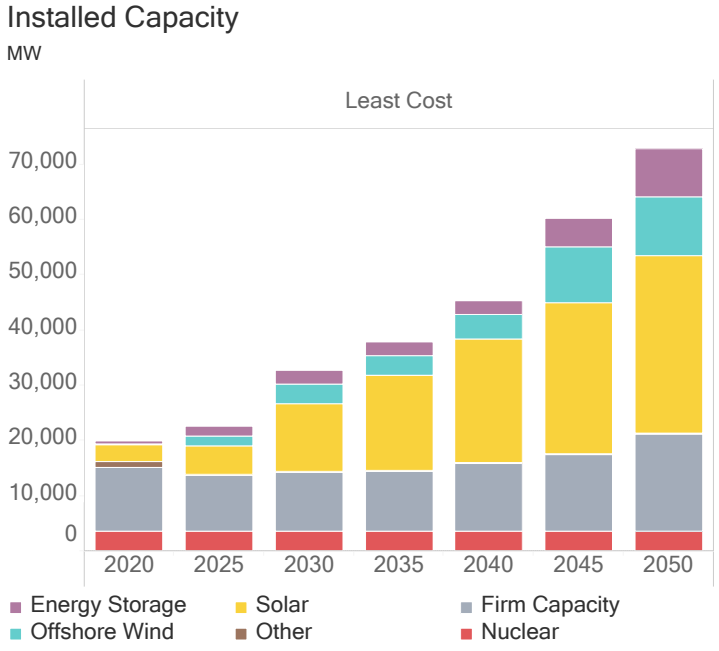
By 2050, reduce economy-wide emissions to 80% below 2006 levels

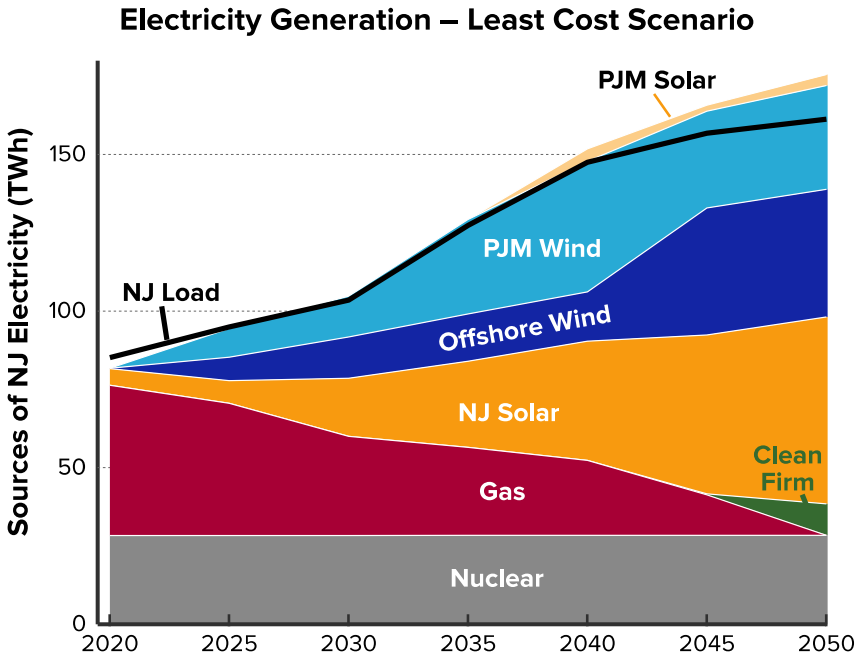
**100% Clean Energy**

NJ electricity sector is carbon-neutral by 2050

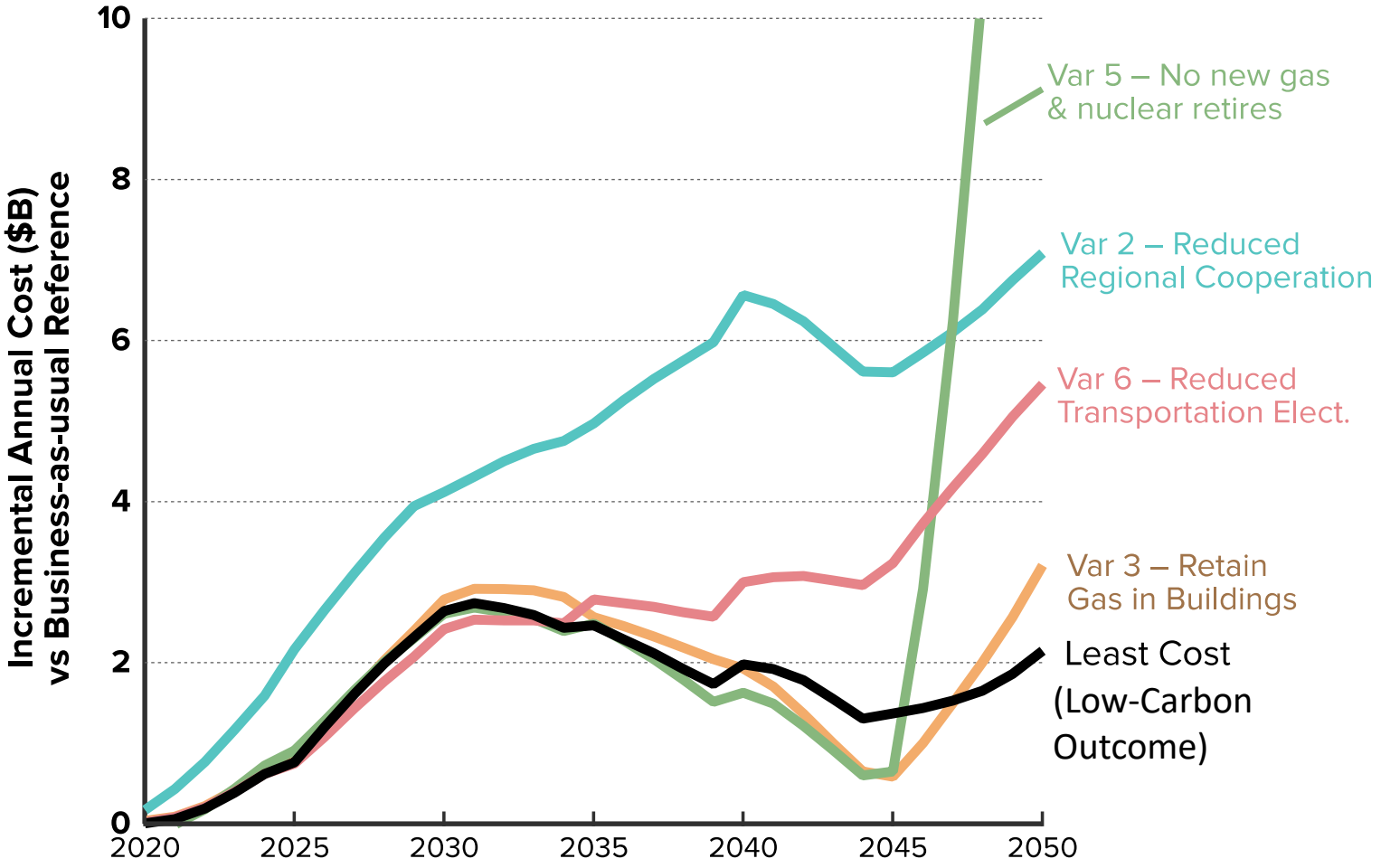
# What does a Clean Grid Look Like?



# Long-Term Solutions & Cost Differentials



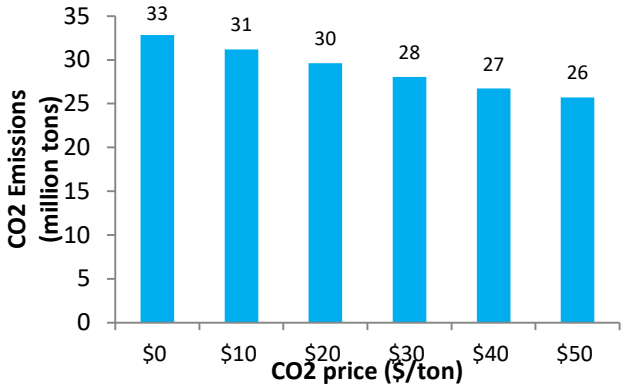
# Question #1: Can Short-Term CO2 Prices Get to 100% Clean?

**Carbon pricing in Low-Coal Systems:**

- ✓ As Coal dies, can short-term carbon drive dispatch change at sufficient scale?
- ✓ Dispatch modeling shows that progressively higher carbon prices result in, at best, only moderately lower CO2 emissions from the power sector in New England.
- ✓ In a gas-defined generation mix, there are limited marginal benefits to progressively higher carbon prices – even at 10x current RGGI prices.

**Est. Annual New England Power Sector CO2 Emissions**

*Assuming various carbon prices*

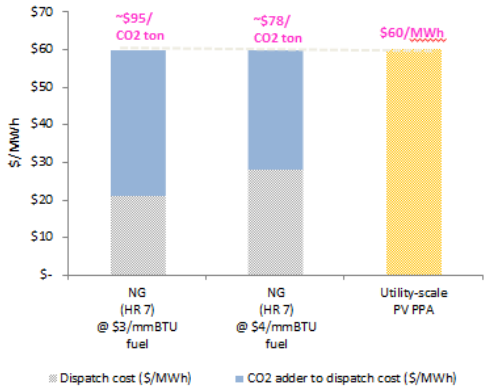



*Source: NRG Analysis*

***Illustrative values only***

- ✓ MIT's *Future of Solar Energy* study finds that in order for the levelized cost of energy (LCOE) of a utility-scale PV project to be equal to the LCOE of natural gas fired generation, "the CO2 charge would have to rise to **$104** per ton"
- ✓ The NYISO IMM found that carbon prices of between **$41 - $115** per ton are needed to incentivize new wind and solar in New York

**Carbon price required to 'levelize' $/MWH cost among generators**

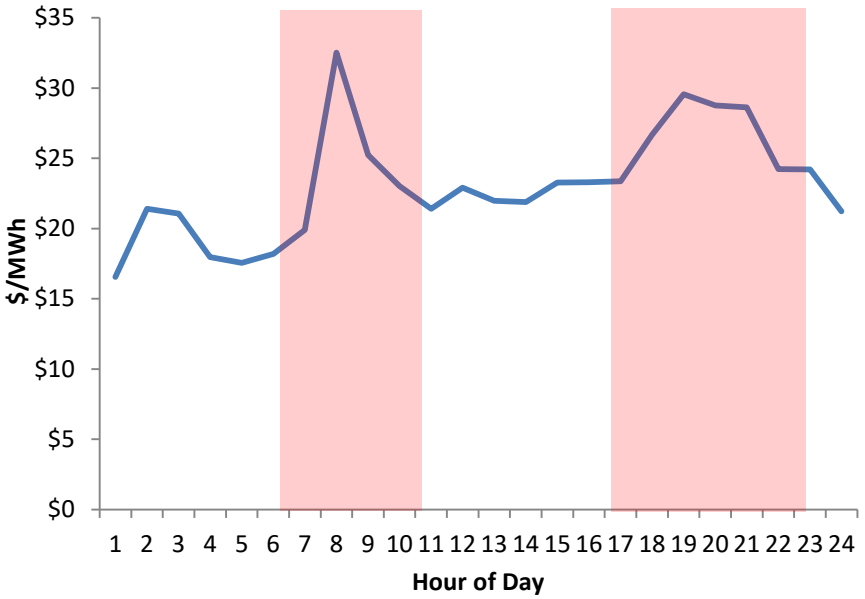



*Source: NRG Analysis of NE contracts*

# Question #2: How does Hourly CO2 Variability Change the Equation?

**ISO-New England Hourly Prices & Average Carbon Intensity**

2/14/18-2/24/18, Energy Velocity Suite




Blue line represents average carbon emissions

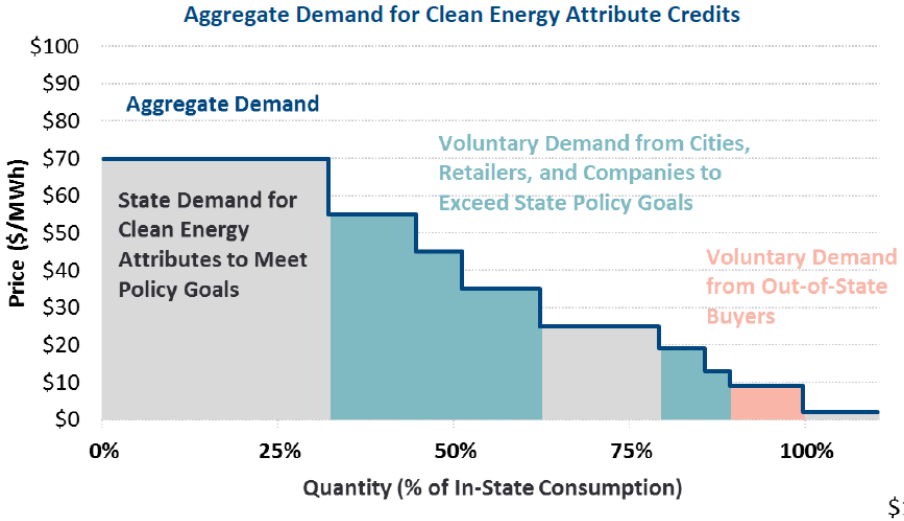
## CAISO calculated hourly GHG emission intensity (mTCO2/MWh) of May 2018

| 2018 | 5/1 | 5/2 | 5/3 | 5/4 | 5/5 | 5/6 | 5/7 | 5/8 | 5/9 | 5/10 | 5/11 | 5/12 | 5/13 | 5/14 | 5/15 | 5/16 | 5/17 | 5/18 | 5/19 | 5/20 | 5/21 | 5/22 | 5/23 | 5/24 | MAY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.281 | 0.285 | 0.255 | 0.288 | 0.315 | 0.296 | 0.278 | 0.286 | 0.277 | 0.290 | 0.266 | 0.308 | 0.265 | 0.245 | 0.261 | 0.285 | 0.263 | 0.258 | 0.242 | 0.259 | 0.259 | 0.263 | 0.274 | 0.284 | 0.275 |
| 2 | 0.282 | 0.302 | 0.251 | 0.282 | 0.321 | 0.303 | 0.267 | 0.291 | 0.291 | 0.289 | 0.264 | 0.313 | 0.260 | 0.249 | 0.256 | 0.289 | 0.250 | 0.243 | 0.237 | 0.265 | 0.263 | 0.265 | 0.277 | 0.285 | 0.275 |
| 3 | 0.273 | 0.292 | 0.253 | 0.280 | 0.322 | 0.308 | 0.265 | 0.280 | 0.298 | 0.295 | 0.265 | 0.298 | 0.254 | 0.257 | 0.259 | 0.296 | 0.259 | 0.234 | 0.242 | 0.251 | 0.263 | 0.271 | 0.281 | 0.298 | 0.275 |
| 4 | 0.265 | 0.275 | 0.267 | 0.288 | 0.316 | 0.296 | 0.268 | 0.291 | 0.300 | 0.300 | 0.269 | 0.290 | 0.262 | 0.260 | 0.257 | 0.289 | 0.262 | 0.236 | 0.248 | 0.250 | 0.264 | 0.282 | 0.289 | 0.296 | 0.276 |
| 5 | 0.265 | 0.270 | 0.271 | 0.296 | 0.317 | 0.304 | 0.271 | 0.302 | 0.302 | 0.301 | 0.277 | 0.295 | 0.262 | 0.263 | 0.261 | 0.278 | 0.263 | 0.238 | 0.251 | 0.256 | 0.270 | 0.285 | 0.290 | 0.293 | 0.279 |
| 6 | 0.265 | 0.268 | 0.270 | 0.299 | 0.306 | 0.298 | 0.266 | 0.310 | 0.294 | 0.301 | 0.284 | 0.291 | 0.256 | 0.253 | 0.264 | 0.274 | 0.260 | 0.235 | 0.250 | 0.259 | 0.272 | 0.278 | 0.289 | 0.292 | 0.277 |
| 7 | 0.267 | 0.265 | 0.270 | 0.299 | 0.298 | 0.295 | 0.270 | 0.311 | 0.291 | 0.300 | 0.280 | 0.283 | 0.244 | 0.244 | 0.260 | 0.264 | 0.254 | 0.223 | 0.234 | 0.251 | 0.269 | 0.265 | 0.290 | 0.290 | 0.272 |
| 8 | 0.237 | 0.239 | 0.226 | 0.248 | 0.233 | 0.259 | 0.226 | 0.252 | 0.241 | 0.248 | 0.236 | 0.215 | 0.186 | 0.204 | 0.214 | 0.210 | 0.202 | 0.178 | 0.178 | 0.201 | 0.226 | 0.221 | 0.239 | 0.240 | 0.224 |
| 9 | 0.202 | 0.201 | 0.179 | 0.188 | 0.179 | 0.214 | 0.180 | 0.204 | 0.183 | 0.197 | 0.175 | 0.156 | 0.153 | 0.157 | 0.161 | 0.157 | 0.156 | 0.139 | 0.121 | 0.160 | 0.209 | 0.184 | 0.198 | 0.206 | 0.178 |
| 10 | 0.191 | 0.201 | 0.156 | 0.165 | 0.165 | 0.169 | 0.166 | 0.190 | 0.156 | 0.174 | 0.149 | 0.131 | 0.132 | 0.147 | 0.148 | 0.158 | 0.147 | 0.132 | 0.098 | 0.124 | 0.179 | 0.169 | 0.187 | 0.206 | 0.161 |
| 11 | 0.181 | 0.191 | 0.148 | 0.160 | 0.157 | 0.143 | 0.161 | 0.187 | 0.147 | 0.155 | 0.121 | 0.118 | 0.114 | 0.147 | 0.141 | 0.159 | 0.146 | 0.130 | 0.086 | 0.114 | 0.159 | 0.167 | 0.183 | 0.198 | 0.152 |
| 12 | 0.182 | 0.175 | 0.142 | 0.159 | 0.154 | 0.141 | 0.158 | 0.183 | 0.149 | 0.153 | 0.121 | 0.123 | 0.103 | 0.140 | 0.127 | 0.158 | 0.143 | 0.128 | 0.082 | 0.110 | 0.153 | 0.167 | 0.175 | 0.195 | 0.148 |
| 13 | 0.186 | 0.171 | 0.136 | 0.161 | 0.160 | 0.139 | 0.158 | 0.182 | 0.154 | 0.154 | 0.123 | 0.119 | 0.096 | 0.138 | 0.117 | 0.151 | 0.140 | 0.126 | 0.084 | 0.095 | 0.148 | 0.165 | 0.165 | 0.177 | 0.145 |
| 14 | 0.183 | 0.180 | 0.138 | 0.165 | 0.174 | 0.149 | 0.153 | 0.190 | 0.165 | 0.156 | 0.122 | 0.120 | 0.092 | 0.145 | 0.116 | 0.144 | 0.135 | 0.130 | 0.078 | 0.084 | 0.138 | 0.172 | 0.157 | 0.166 | 0.145 |
| 15 | 0.183 | 0.194 | 0.145 | 0.173 | 0.182 | 0.159 | 0.146 | 0.190 | 0.160 | 0.155 | 0.123 | 0.114 | 0.092 | 0.149 | 0.108 | 0.142 | 0.124 | 0.124 | 0.074 | 0.090 | 0.125 | 0.159 | 0.150 | 0.159 | 0.144 |
| 16 | 0.187 | 0.187 | 0.154 | 0.186 | 0.194 | 0.182 | 0.150 | 0.179 | 0.173 | 0.157 | 0.129 | 0.116 | 0.099 | 0.155 | 0.109 | 0.138 | 0.122 | 0.102 | 0.079 | 0.093 | 0.128 | 0.167 | 0.154 | 0.157 | 0.147 |
| 17 | 0.203 | 0.186 | 0.168 | 0.206 | 0.221 | 0.215 | 0.167 | 0.191 | 0.184 | 0.171 | 0.152 | 0.128 | 0.120 | 0.153 | 0.130 | 0.139 | 0.133 | 0.104 | 0.077 | 0.131 | 0.140 | 0.177 | 0.162 | 0.163 | 0.161 |
| 18 | 0.215 | 0.184 | 0.189 | 0.235 | 0.248 | 0.243 | 0.187 | 0.212 | 0.209 | 0.212 | 0.182 | 0.156 | 0.144 | 0.170 | 0.153 | 0.151 | 0.148 | 0.139 | 0.119 | 0.174 | 0.151 | 0.182 | 0.188 | 0.181 | 0.184 |
| 19 | 0.260 | 0.233 | 0.237 | 0.286 | 0.301 | 0.273 | 0.243 | 0.252 | 0.256 | 0.260 | 0.251 | 0.210 | 0.210 | 0.223 | 0.228 | 0.210 | 0.194 | 0.189 | 0.183 | 0.227 | 0.194 | 0.223 | 0.235 | 0.222 | 0.234 |
| 20 | 0.283 | 0.270 | 0.296 | 0.320 | 0.332 | 0.288 | 0.294 | 0.287 | 0.289 | 0.280 | 0.298 | 0.265 | 0.250 | 0.282 | 0.294 | 0.281 | 0.267 | 0.251 | 0.254 | 0.278 | 0.260 | 0.277 | 0.290 | 0.279 | 0.282 |
| 21 | 0.297 | 0.278 | 0.304 | 0.325 | 0.326 | 0.295 | 0.303 | 0.292 | 0.296 | 0.293 | 0.301 | 0.292 | 0.272 | 0.297 | 0.312 | 0.298 | 0.291 | 0.270 | 0.273 | 0.292 | 0.284 | 0.294 | 0.318 | 0.299 | 0.296 |
| 22 | 0.299 | 0.273 | 0.301 | 0.314 | 0.318 | 0.294 | 0.304 | 0.281 | 0.298 | 0.291 | 0.305 | 0.287 | 0.273 | 0.288 | 0.307 | 0.291 | 0.290 | 0.266 | 0.274 | 0.290 | 0.283 | 0.294 | 0.311 | 0.301 | 0.293 |
| 23 | 0.286 | 0.268 | 0.287 | 0.309 | 0.311 | 0.288 | 0.288 | 0.267 | 0.290 | 0.281 | 0.303 | 0.273 | 0.268 | 0.280 | 0.299 | 0.272 | 0.282 | 0.251 | 0.277 | 0.283 | 0.269 | 0.278 | 0.290 | 0.287 | 0.283 |
| 24 | 0.278 | 0.261 | 0.278 | 0.307 | 0.274 | 0.279 | 0.274 | 0.263 | 0.295 | 0.279 | 0.309 | 0.264 | 0.253 | 0.268 | 0.289 | 0.263 | 0.273 | 0.247 | 0.262 | 0.267 | 0.262 | 0.272 | 0.284 | 0.283 | 0.275 |

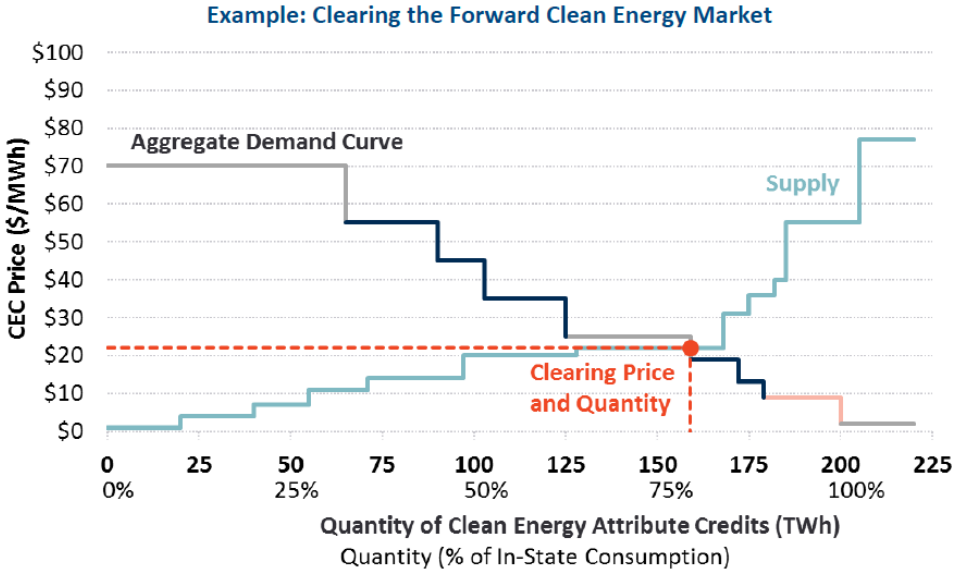
Note: The hourly GHG emission intensity (mTCO2/MWh) is calculated based on total generation plus net import.

- ✓ As the grid decarbonizes, will CO2 pricing have less effect on energy prices?
- ✓ Will CO2 prices need to rise substantially to maintain any support for merchant renewable investment?

# Question #3: Does Moving the CO2 Price Signal into the Planning Horizon Work Better?




Driving investment in zero carbon resources is a *different* policy objective from minimizing short-term emissions



# Mad Scientists and Economists Wanted!

*"The bigger task is to redesign power markets to reflect the new need for flexible supply and demand…. Bills could be structured to be higher or lower depending how strongly a customer wanted guaranteed power all the time—a bit like an insurance policy.* ***In short, policymakers should be clear they have a problem and that the cause is not renewable energy, but the out-of-date system of electricity pricing.*** *Then they should fix it."*

*-- The Economist, February 25, 2017*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