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Painting a Picture of Carbon Neutrality

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Japan is aiming for carbon neutrality in 2050. However, the path to achieving this goal remains unclear. There is a quantitative picture that covers concepts such as the economic outlook and energy and supply demand structure for FY30's target (a 46% reduction compared to FY13), but 2050's picture remains to be seen. This is most likely due to the fact that when considering the long-term, it is difficult to envisage so far into the future with such a high degree of uncertainty. Still, a quantitative blueprint will need to be drawn up at some point so that we have a roadmap to lead us toward achieving this goal.

To quantitatively envision future scenarios, we can use the "econometric model." To put it simply, this model is based on the equation Y=a+bX, where the future Y can be predicted by setting the future X, and where a and b are calculated using statistical methods based on past performance, etc. Depending on the size of the model, these equations often consist of tens, hundreds, or even thousands of equations. If we want to calculate future CO_2 emissions, for example, we can substitute equations repeatedly to get a linear equation, which can theoretically be expressed with the following single equation:

$$CO_2 = a_0 + b_1X_1 + b_2X_2 + b_3X_3 + \cdots$$

$\{X_i\}$ are the various factors that affect CO_2 emissions (economic and social activities, level of implemented low-carbon technologies, price and cost, policies, etc.), and $\{b_i\}$ is the degree to which each factor affects CO_2 emissions. Once all future values of each $\{X_i\}$ element are determined, we can then calculate future CO_2 emissions accordingly. Essentially, this is the forecast approach.

The backcast approach, on the other hand, begins with CO_2 emissions already set. So if we want carbon neutrality, each $\{X_i\}$ variable will need to be set so that $CO_2 = 0$. There will of course be an infinite number of $\{X_i\}$ combinations which could lead to $CO_2 = 0$. We could paint a number of different pictures, such as $\{X_i\}$ with 100% renewable energy, $\{X_i\}$ with fossil fuels + CCS, or even $\{X_i\}$ with extensive use of carbon removal technologies such as DACCS, but we cannot tell which is the best picture. $\{X_i\}$ is usually set by experts in each field, but there is a lot of room in terms of the analyst's subjectivity when it comes to how they arrive at an appropriate number. What's more, some impractical or unfeasible elements can creep in if the ultimate goal is difficult to achieve.

We will need to use a completely different model if we want to objectively extract the correct combination. One such model is the "optimization model," where the indicators to be optimized are cost (minimization) or profit (maximization). There are many analyses performed in the energy and environmental sector aimed at minimizing costs as the optimal technology choice for achieving goals. When searching for combinations that will result in $CO_2 = 0$, the goal (generally with the help of computers) is to find $\{X_i\}$ with the lowest total cost associated with implementing technology.[1] However, this model can produce some extreme solutions, such as recommending the implementation of all technologies for the sake of saving one yen.[2]

Even when using the backcast approach, the methods differ between the econometric model and the optimization model, and as such, the combinations of $\{X_i\}$ will be completely different. With the econometric model, the variables $\{X_i\}$ are set based on the analyst's perception of economic, social, technological, and geographic feasibility (acknowledging that while it may be difficult to achieve, it is not impossible). However, with this method, it is difficult to set appropriate long-term targets objectively, and analyst subjectivity must be minimized as much as possible, which can be done, for example, by obtaining a consensus from multiple experts. On the other hand, with the optimization model (cost minimization model), the variables $\{X_i\}$ are set in terms of cost. Still, what is "optimal" is based on only one criterion, so it may not necessarily be optimal when viewed in light of other criteria. Essentially, we would have a clear picture in terms of cost-effectiveness, but the picture would be unclear when viewed from any other perspective. While economic theory assumes that rational decisions are based on cost, we know that the real world is not driven by cost alone. In the real world, products are chosen for a variety of reasons, including high cost, ease of use, durability, and style. Then from a national perspective, there is also the issue of national security. It should be noted that the

[1] In practice, economic and social activities, prices and costs, etc., are a given, and a combination of the amount of technologies implemented (and their utilization rate) is the only thing sought. Therefore, particularly when it comes to the cost setting of each technology, there is the potential for analyst subjectivity.

[2] There are measures which can be taken to avoid unrealistic solutions, such as setting upper and lower limits in the amount of technologies implemented (implementation potential, etc.), but even with such measures in place, there is still of course the potential for analyst subjectivity.

results of the optimization model may provide some guidance, but the results will not be "optimal" under all perspectives.

The road to “carbon neutral by 2050” will be drawn up using a backcast approach, but with a high level of uncertainty, particularly in regard to technological trends, it will be difficult to come up with an objective and optimal picture no matter which model is used. With this in mind, perhaps there is no need to focus on just one picture. It may be a good idea to come up with a number of different scenarios for achieving carbon neutrality and gradually integrate them through the PDCA (Plan, Do, Check, Action) cycle. Of course, it would be ideal to charge headfirst from the outset with unwavering commitment, but considering the high level of uncertainty, the risks are too high. Regardless of the approach taken, the goal should be to paint a picture that strikes a balance and has a broad appeal.

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