Feedbacks on the consultancy document for HK's climate change strategy and action agenda.

Background

The Hong Kong MARKAL-MARCO (HKMM) model was used to examine three scenarios for the mitigation analysis quantitatively. Hence, the suggestions in the Consultation Document are based on the results of HKMM. From the document (Agreement No. CE 45/2007 EP) released in December 2010, we found that there were one reference scenario and three proposed scenarios "run" with HKMM for the scenario selections and reported that only Scenario 3 can reach the emissions reduction target. The proposed scenarios mean that different policies were imposed for emissions reduction and use of new energy saving technologies. One of the important policies is "energy-mix" in the power generation sector. In p.B-54, it was mentioned that the mitigation policies and measures proposed in this study are defined with **fixed market penetration**, energy targets, or market shares.

Feedbacks – we are going to present three contradiction results and the reasons of these contradictions

(1) First contradiction
Abnormal result - the more emissions reduction we achieve, the more energy we use.

Table 1 is the summary of the results of all scenarios in 2010. The second column is the emissions reduction amount and the third to fifth columns are the energy demand and electricity output respectively.

From	Table 3.2 Million Tonnes CO2-e reduction	Table 3.5 Final Energy Demand (TJ)	Table 3.6 Primary Energy Demand (TJ)	Table 3.9 Electricity Output (TJ)
Base Case	46.1	396,211	744,786	232,152
Scenario 1	3.1	374,187	697,134	209,169
Scenario 2	4.2	375,817	700,716	***211,274***
Scenario 3	16.6	401,857	725,402	***231,747***

Table 1. Summary of 2010's results

Electricity demand is abnormally overestimated!

Electricity accounts for 60% in the total energy demand. Electricity demand is highlighted here because the fixed fuel-mix strategy was employed in the electricity generation sector in Scenario 2 and 3. Hence, the amount of the Final and Primary Energy Demands are dominated by the increase of electricity demand. The overestimated result is the consequence of employing the "fixed fuel-mix strategy" while using HKMM. The reason will be given later.

In Scenario 2, 21,1274 TJ electricity is required to produce when achieving the goal to reduce 4.2MtCO2-e .

In Scenario 3, 23,1747 TJ electricity is required to produce when achieving the goal to reduce 16.6MtCO2-e .

The difference in CO2-e reduction between Scenario 2 and 3 is 12.4MtCO2-e (16.4 - 4.2). A decrease in 12.4MtCO2-e requires an increase in electricity demand of 20,437 TJ (23,1747 – 21,1274) between Scenario 3 and 2.

(2) Second contradiction
Unreliable results - Price elasticity of electricity demand

From page 42 of the Consultation Document, we have the cost ranges of electricity generation by fuel type. Since the major difference between Scenario 2 and 3 is the percentage of fixed fuel-mix of the electricity generation sector, we can use this percentage to calculate the average costs of the electricity generation for Scenario 2 and 3. Moreover, since the costs are given in range, Average and High scenarios are used and the results are shown in the third and fourth Table 2.

	Electricity Output	Average Cost of electricity (cents/kWh)	
	TJ	Average	High
Scenario 2	***211,274***	64.21031	71.96579
Scenario 3	***231,747***	62.5807	67.52976
Elasticity		***-3.59552***	***-1.45319***

Table 2. Price elasticity of electricity demand in 2020.

We also copy the electricity demand from Table 1 to the second column of Table 2. We can easily calculate the price elasticity of electricity demand in 2020.

Note that it is well-known that elasticity of demand is generally inelastic (elasticity > -1) for electricity especially when the power company is a monopoly (government regulated monopoly). However, the above **elasticity results shown in the consultant report are contradicting the reality! The model results of the report as a result are totally unreliable.**

(3) Third contradiction
Huge Marginal Abatement Cost

Figure 3.13 showed that with Scenario 3 (the proposed one in the consultation document), the highest marginal abatement cost (5000HK$/Tonne Carbon) was incurred for reducing around 16.6 MtCO2-e in 2030. However, the emission reduction level found in Scenario 3 is 18 MtCO2-e in 2030 (see Table 3.2). That is, if we would like to achieve the reduction target 18 MtCO2-e in 2030, the marginal abatement cost must greater than 5000HK$/Tonne Carbon. Note that 5000HK$/Tonne Carbon is the highest historical and projected record of the marginal abatement cost (or prices of carbon credits) traded in the international market.

It is another contradicting result that while we are proposed to use more "cheap" and "clean" nuclear electricity, we need to pay record-breaking huge marginal abatement cost.

(4) Why we have these unreliable and contradicting results?

An analogy (using a wrong approach with a right tool to resolve the problem): We are going to use a claw hammer for pounding nails. However, we use the extracting-nails end of the hammer to pound nails. The nails (our results) were screwed up! **The results in the consultant report are totally unreliable.**

To answer the above question, we need to understand the foundation of the HKMM model which may be too harsh to readers. Instead, I will sum up some important features as below.

The first **M** of HKMM is the MARKAL model (a type of bottom-up engineering model) which allows a detailed description of existing and alternative energy technologies and of existing and alternative paths of energy carriers from their source -- through different conversion technologies - until the point of final energy use.

The second **M** of HKMM is the MACRO model which is a macroeconomic model with an aggregated view of long-term economic growth. The basic input factors of production are capital, labor and individual forms of energy. The economy's outputs are used for investment, consumption and inter-industry payments for the ***cost of energy***. Investment is used to build up the stock of capital. The model clearly distinguishes between autonomous and price-driven conservation.

Hence, HK MARKAL-MACRO is a synthesis between the bottom-up engineering model MARKAL and a top-down macroeconomic model called Macro described above.

The original purpose of the integration of M and M:
One of the important features is ***price-induced conservation*** by lowering the marginal productivity of capital and labor. That is, if there is a rise in energy costs, the production function allows us to adapt by substituting more capital like more energy efficiency machines in place of energy. In short, we have a single and asymmetric price elasticity of energy demand built in M-M. However, it may not be true that if there is a decrease in energy costs, the production function encourages us to use more energy and less capital according to keep the same level of output.

Wrong uses of fixed fuel-mix:
1. Fixed fuel-mix (i.e. % of nuclear & natural gas was fixed) was used as an input instead of output in the M-M model
2. This "wrong" input of fuel mix will lead to a lower energy price compared to other scenarios (the energy cost of Scenario 3 is cheaper than that of Scenario 2, see p.B-46)
3. The lower energy price will provide a false signal to the model to over-estimate the future energy demand under the same production function in HKMM as mentioned above.
4. Indeed, percentage of fuel mix is one of the outputs that is determined by the MM model

5. To pre-set the percentage of fuel mix will abuse the normal calculation of MM model and contradict the important feature: price-induced conservation.

(5) Conclusion and suggestions

ENB should **really** follow the normal procedures of application to make use of the HKMM models for different scenario settings.

According to the M-M literatures, for CO2-e emissions studies, M-M can provide primary results to rank the mitigation scenarios, in terms of cost-effectiveness as well as the cost of reducing CO2-e (value of carbon rights) and implications for the economy by imposing emissions constraints to the model. M-M should NOT be used to select the scenarios by trial-and-error in order to fulfill some pre-set conditions.

Since the proposed Scenario 3 highly relies on the imported nuclear power (~50% of electricity demand), a multi-regional MM model is required as mentioned on p.B-57. Under the MM-model's assumption, more emissions will happen in other Pearl River Delta (PRD) regions and finally lead to a significant increase in the overall emissions in both Hong Kong and PRD regions.

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