Target-aimed versus wishful-thinking in designing efficient GHG reduction strategies for a metropolitan city: Taipei

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ABSTRACT

In recent years, many national and local governments claim for a specific GHG (greenhouse gas) reduction goal targeted for many years later. In 2005, the Taipei City government announced that Taipei's total GHG emission in 2015 will reach the same level as that in 2005 and then down to 75% of that level at year 2030. However, based on the estimated energy consumption and GHG emission and the proposed emission reduction plans from the local government, it is clear that these goals are not going to be accomplished.

In Taipei, the residential and commercial sector contributes more than 78% of the total GHG emission. Thus, in a business as usual scenario, the total GHG emission in 2030 would be 79% more than that in 2005, far more than the target value proclaimed. As many key factors are uncontrollable by the local government, a target-aimed strategy designing process by looking into changes in Taipei and identifying major targets is proposed in this study. It is demonstrated that such a universally applicable approach will give more confidence to the public on working toward the expected GHG reduction goal.

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1. Introduction

As global warming becomes a key issue recently, many national and local governments are making commitments to reduce GHG (greenhouse gas) emission in the years to come. However, plans proposed by them for achieving the GHG reduction accountable are often designed according to wishful-thinking ideas. Governmental officials usually link these plans to the so-called “non-regret” policies, in which the actions taken will be environmentally and economically favorable and hence people will not feel regretful in the future (Kane and Yohe, 2000).

Taipei City is the capital of Taiwan, where commercial activities dominate its economy. In 2005, the Taipei City government has committed to the goals of reducing GHG emission in 2015 to the level of 2005 and further by 2030 pulling the emission down to the level as 75% of that in 2005. This made Taipei City be a first in Taiwan taking GHG reduction seriously and officially. However, a feasibility study of the GHG reduction plans outlined by the government suggested that only trivial reductions could be expected, which implied that the committed GHG

reduction would never be obtained under a wishful-thinking strategy (Liou et al., 2006).

In this paper, the GHG emission data of Taiwan and Taipei are analyzed. Some key issues critical for the reductions of GHG emission by the local government are identified. Based on these results obtained, practical target-aimed action plans are designed. This kind of practice is meaningful in terms of shrinking the gap between wish and reality when facing the complicated and large-scale global warming related issues.

2. Methodology and approach

Many cities in the world have proposed or announced GHG reduction plans for coping with the trend of carbon neutrality. Theoretically, any city must be located in a county or country and thus any GHG reduction goals or targets should match those in the framework of a national or upper-leveled plan. However, in some cases the city government could put forward a GHG reduction goal more ambitious than those in the national level. The case of Taipei City in Taiwan is another extreme example that a national GHG reduction goal did not even exist when the city announced its own goal in 2005. Thus, it is not surprising that the possibility of meeting the 2015 and 2030 GHG emission goals is low, if taking into account the real energy consumption and urban development

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trends. Still, wishful-thinking GHG reduction goals should be re-evaluated and checked by systematic and step-by-step examinations of all related strategies, plans, and parameters.

In this research, by taking into account the theory and practice of GHG reduction and the real situation in Taiwan, we proposed a framework for checking, evaluating, and realizing the GHG reduction goal (GHGRG) of Taipei City. Basically, the approach consists of three major processes:

- (1) check the administrative reasonability of the GHGRG;
- (2) evaluate the possibility of achieving the GHGRG; and
- (3) design and simulate the feasible scenarios for achieving the GHGRG.

This can be treated as a dynamic and interactive procedure that can serve as a “diagnosis and treatment” tool for helping the major, administrators, or citizens understand the visionaries and limitations of the existing GHGRG and then obtaining an applicable one.

In each of the processes, there exist several key tasks that need to be gone through. The following are some of these tasks:

- (1) Check the administrative reasonability of the GHGRG:
 - i. check if a national GHGRG exists;
 - ii. check if the city GHGRG can be explained within the framework of the national one; and
 - iii. check if the city GHGRG was designed based on scientific analysis and real strategies and corresponding data sets.

Fig. 1. The conceptual flowchart of checking, evaluating, and designing the city GHG reduction goal (GHGRG).

- (2) Evaluate the possibility of achieving the GHGRG:
 - i. examine if the city GHGRG can be interpreted according to some announced city development plans;
 - ii. examine if the data/parameters included in the baseline scenario and some other idealized scenarios practical; and
 - iii. examine if the idealized scenario(s) can be theoretically and administratively linked to the GHG reduction targets.
- (3) Design and simulate the feasible scenarios for achieving the GHGRG.
 - i. identify some sensitive parameters that are also relatively not difficult to adjust in the real world;
 - ii. re-design the baseline scenario and some idealized scenarios based on verified and calibrated data;
 - iii. carry on scenario simulations and interpret the results; and
 - iv. modify the previously reported city GHGRG if necessary.

Fig. 1 illustrates these tasks and the linkages among them. Once the City GHGRG was identified as not interpretable within the framework of existing city development plans, it would be classified as a wishful-thinking one. This means that the City GHGRG needs to be re-examined and rewritten. At last, we need to determine if the announced City GHGRG is achievable or not according to all of the judgments made. A modified version of the City GHGRG is preferable. Following this flowchart, it is likely the City GHGRG previously reported would be at least modified to some extent.

3. GHG emission in Taiwan

Taiwan's GHG emissions inventory, which covers the emissions of carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and hexafluoride sulfur (SF₆), has been monitored by the TEPA (Taiwan Environmental Protection Administration) (2006). The net CO₂ equivalent emissions reach an amount of 285 Mtons in 2006 which was increased by 104% from 1990 to 2006, and 87% of them was from the energy sector. Within the energy consumption sector, more than 53% of the CO₂ equivalent emissions were from the industry, 19% from the residential and commercial sector and 14% from the transportation sector (MOEABOE, 2007a).

The total energy supply has increased 138% from 1990 to 2006 (MOEABOE, 2007b). Petroleum, coal, natural gas, nuclear power and hydropower each contributes 51%, 32%, 8%, 7% and 2%, respectively, in 2006. The total electricity sold has increased 144% during the same period of time. Currently, 31% of total electricity is generated from the coal-burning thermal power plants, 10% from oil-burning plants, 33% from gas-burning plants, 14% from nuclear plants and 12% from hydropower plant (TAIPOWER, 2008). In recent years, wind power generators have been installed and they contribute only about 0.6% of the total electricity demanded.

By taking a linear extrapolation approach, the Bureau of Energy suggests that the demand of electricity will be increasing 3.5% annually for the coming decades (MOEABOE, 2007c). Thereafter, the government proposes to reconstruct the power generating network so that by 2020 the coal-burning thermal plant will contribute 46–47%, oil-burning 3%, gas-burning 26%, nuclear 9%, hydropower 5% and renewable energy 10–11%. Considering the total amount of electricity generated in the future, the amount of CO₂ emissions from the fossil-fuel-burning thermal plants is likely to increase at least 34% more.

In 2006, a Greenhouse Gas Reduction Act was drafted by TEPA. Once this Act in action, it will allow the government to promulgate in stages the national GHG emissions cap, to assign

reduction targets on different sectors, to develop reduction plans accordingly, to initiate carbon trading and to punish enterprises for non-compliance with the Act, etc. However, no specific reduction goal is outlined in this Act. Considering the complexity of GHG reduction, even if the Act is in action in recent years, no significant GHG reduction can be expected by 2020 unless the expected energy demand in the coming years will be reduced substantially.

Since the per capita GDP of Taiwan is about half of the mean OCED level, Taiwan can be taken as one of the developing countries, hence her continuous growth of CO₂ emission can be justified. However, from 1998 to 2006, the total growth of GDP is only about 32%, which is lower than the mean OECD growth rate of 48% (OECD, 2008). In the mean time, the total energy supply has increased by 42%, which is much higher than the mean OECD increase rate of 8%. Therefore, Taiwan is a country with moderate productivity and with deteriorated energy efficiency. Unless a dramatic improvement on the efficiency of energy consumption, the CO₂ emission in Taiwan is not likely to be reduced substantially.

4. GHG emission in Taipei

Based on the methodology outlined by IPCC (1997), the GHG emissions from the transportation, commercial and residential, industry and waste processing sectors in Taipei are estimated and plotted in Fig. 2 (Liu et al., 2008), along with an estimation of the forest sink. Among the total emission of 15.0 Mtons in 2006, the commercial and residential sector contributes 78%, transportation 18%, waste processing 4% and industry 3%. The forest sink is about –3% of the total emission and is contributed from a limited forest area on the surrounding mountains, which has been remaining the same for many years.

From 1998 to 2006, the total GHG emission has increased slightly from 14.6 to 15.0 Mtons, i.e. +3%. Among all studied sectors, emissions from waste processing change by –85%, transportation –2%, industry –1%, and commercial and residential +42%.

The decrease of the waste processing emission is quite impressive, which is benefited from a successful policy of collecting garbage disposal fees with garbage bags, i.e. the Per Bag Trash Collection Fee policy, in along with a promotion of waste recycling in Taipei. The total municipal garbage cleaned was reduced from 1.6 to 0.52 Mtons during 1998–2006, among them the incinerated and those buried in landfill changed from 1.1 to 0.44 Mtons and 0.5 to 0.08 M, respectively. Meanwhile, the recycled garbage was increased from 0.03 to 0.3 Mtons. Caught by such a declining trend of available garbage, the three incinerators in operation have to take turns to recess to

Fig. 2. GHG emission from different sectors in Taipei.

accommodate with this unforeseen situation. Therefore, emissions from the waste incineration and landfills have decreased 60% and 98%, respectively, from 1998 to 2006.

Methane emissions out of the waste water is also included in the waste processing sector, which has been reduced by 63% during the studied period due to an active improvement of the sewage system in Taipei. The percentage of pollution served by the wastewater treatment plants has changed from 41% to 82% between 1998 and 2006. Emissions from the waste incineration, landfills and waste water processing each contributes about 70%, 10% and 20%, respectively, to the total GHG emissions from the waste processing sector.

In the meantime, a continuous increase of the emissions from the commercial and residential sector is linked to an increase of 30% of the electricity consumption, which contributes 92% of the GHG emission from this sector. Besides, the natural gas and the liquid petroleum gas (LPG), used only for cooking and bathing, have each been consumed more by 8% and 4%, respectively, during 1998–2006. However, each contributes only about 5% and 3%, respectively, to the GHG emission from this sector.

In general, Taiwan is in the subtropical region, so none of the buildings have installed any build-in heating devices, though plug-in electric heaters are used in winter. Concrete buildings with sealed windows are basic here, for people are very concerned with their safety when earthquake or typhoon strikes. The issue of air-condition leakage has never been a problem. Electricity consumption in the commercial and residential sector has certain but limited relationship with the structure or age of buildings, but it is highly influenced by the consumption habit and the upgrade of energy-saving appliances.

As to the decrease of emissions from the transportation sector, it is linked to a mixed change of -9% , $+14\%$, $+208\%$ and -20% of the consumption of gasoline, diesel, the electricity consumed by the Taipei mass rapid transit (MRT) system and the Taiwan Railroad system, respectively, during 1998–2006. On the account of GHG emission, each of them contributes about 90%, 7%, 2% and 1%, respectively, in 1998, and then 83%, 8%, 8% and 1%, respectively, in 2006. Clearly, the enhanced consumption of electricity by MRT has been compensated by the reduction of gasoline consumption, which results in a moderate reduction of GHG emission from the transportation sector, i.e. -2% from 1998 to 2006.

In summary, a steady growth of the electricity consumption in the residential and commercial sector is now the major obstacle hindering the reduction of GHG emission in Taipei.

5. Key factors not controllable by the local government

The expected GHG emission outlined by the Taipei City Government, as shown in Fig. 3, suggests that a peak level is expected to happen in 2010, followed by a 23% and 58% reduction from the projected (i.e., business as usual, BAU) emission in 2015 and 2030, respectively. Clearly, to accomplish these goals is not an easy task (Liou et al., 2006).

About the BAU emission, it is projected that the emissions from the transportation sector will be decreasing about -4% from 2006 to 2030, the industry sector remaining a constant amount of 72% of that in 2006, the waste processing also remaining a constant amount of 91% of that in 2006, the residential and commercial sector increasing 99% from 2006 to 2030, and the forest sink remaining the same as that in 2006. The result is a near-constant linear growth of total emission.

A comprehensive action plan was proposed in 2005 by the Taipei City Government for reaching the goals mentioned above. This plan consists of tasks in three different time periods: (1) the

Fig. 3. Projected, expected and target-aimed GHG emission in Taipei from 2007 to 2030. Real emission during 1998–2006 is also shown in the figure.

policy and regulation design phase (2005–2007), with 42 programs and 85 projects; (2) the policy implementation phase (2008–2011), with 34 programs and 47 projects; and (3) the policy verification phase (2012–2015), with 36 programs and 43 projects. Hopefully, a new plan will be proposed and executed after 2015. The programs and projects for these phases was proposed by different departments in the City Government and thus quite diversified. For example, the Department of Transportation has proposed plans to substitute traditional buses by clean-fuel ones, promote a mass transit system, set-up bicycle lanes, build more rapid transit lines, demand energy saving and higher energy efficiency, etc. However, these are wishful-thinking plans with no specific aims being pursued, in other words, no considerable amount of budget has been allocated. A preliminary estimation indicates that only a minor reduction of GHG emissions can be expected, i.e. a 11 ktons/year ($\sim 0.08\%/year$) reduction during phase I; 56 ktons/year ($\sim 0.34\%/year$) during phase II; and 86 ktons/year ($\sim 0.49\%/year$) during phase III (Liou et al., 2006).

In order to establish a more efficient strategy, key issues crucially important to an effective GHG reduction have to be identified, so as to understand the limitation that a local government faces.

One of the most important issues is whether a major switch of the power generation system from fossil-fuel based to renewable-energy based is going to take place. A steady and rapid increase in oil prices in recent years has driven a number of newly operated power plants to burn coal instead of gas or oil in Taiwan. Therefore, the carbon intensity, i.e. carbon emission per power generated, has increased from 0.62 to 0.69 kg CO₂-e/kW h from 1998 to 2006 (MOEABOE, 2007a). Based on the projection given by the Bureau of Energy, the contribution of coal-burning thermal plants on the total electricity generation will be increasing from 31% in 2006 to 46% in 2020, while the total contribution of fossil-fuel-burning plants remain the same. Clearly, the carbon intensity is going to be increasing instead of decreasing, even though the renewable energy plants will contribute 10–11% of total electricity generated in 2020. This future development is unfortunately beyond the control of a local government for the power company and the power market are 100% controlled by the central government.

Another issue is a minor change in the electricity price in the last decade. It has been 7.7–7.9 US cents/kW h for the regular charge and 5.5–5.8 US cents/kW h for the TOU (time of use) charge. Clearly, this condition poses no constraint at all on the steady increase of demands of electricity consumption. Nationwide, the electricity sold by TaiPower has increased by 42% during 1998–2006, while in Taipei, after subtracting those used by MRT and the railroad system, increased by 32%. The price of electricity is controlled 100% by the central government.

The other key issue is whether an increase in energy price will compel citizens to be concerned with energy saving as theoretically it could work. From 1998 to 2006, the price of the local brand No. 95 unleaded gasoline sold by the Taiwan Petroleum Company has increased by 53%, which is accompanied with a 9.2% reduction in gasoline sold in Taipei during the same period of time. However, it is noted that the gasoline price soared only after 2001 while the gasoline sale dropped significantly by 7.2% during 1998–2001. This is because the availability of the Taipei MRT system has, since 1996, changed the commuters' traveling habit and hence reduced the consumption of gasoline. With more lines available for use, the total number of commuters traveling with MRT increased from 0.12 billion in 1998 to 0.58 billion in 2001 and to 0.77 billion in 2006. After 2001, the gasoline sale has started to increase until 2005 and then drop in 2006. In the meantime, the total number of motor vehicles in Taipei (excluding motorcycles) has increased by 7.4% during 1998–2006. It is widely believed that citizens are taking the advantage of MRT system in daily commute but still purchase new vehicles for two-day weekend traveling. The effect of the gasoline price increase on the consumer's behavior cannot be concluded yet.

There is one thing noticeable that the drop of gasoline consumption in Taipei City has been compensated by an increase in electricity consumed by the MRT, which increased by 208% from 1998 to 2006. By transferring the electricity consumed to a unit of oil-equivalent energy amount, Liu et al. (2008) have pointed out that the increase in energy consumed by MRT is close to the amount of energy conserved with the reduction of gasoline consumption. In other words, the MRT system has successfully changed the commuters' traveling habits and therefore reduced air pollution. However, in terms of GHG reduction, the MRT is not effective enough, as only changes in GHG sources happened.

All of the issues discussed in this section are beyond the capacity of a local government as they are related to either the national energy policies or the international energy markets. When proposing any GHG reduction goals, these facts must be taken into account and scenario simulations ought to be conducted to reduce the uncertainty.

Table 1
Statistics about changes noted in Taipei during 1998–2006

Item	Change during 1998–2006	Description
Population	–0.3%	Negligible change
Total # of household	+8.2% $\approx$ +1.02%/year	Increase steadily
Total # of buildings	–1.3% $\approx$ –0.16%/year	All buildings take about 57% of the total city area in 2006
Total # of buildings with ≤ 6 stories	–6.0% $\approx$ –0.75%/year	
Total # of buildings with > 6 stories	+15% $\approx$ +1.9%/year	
Total area of buildings	+5.7% $\approx$ +0.71%/year	
Total # of housing units	+7.7% $\approx$ +0.96%/year	
Total # of electricity customers	+7.0% $\approx$ +0.87%/year	
Total # of factories	–34% $\approx$ –4.5%/year	All factories take about 0.65% of the total city area in 2006
Total area of factories	–43% $\approx$ –5.4%/year	
Total length of road	+1.9% $\approx$ +0.23%/year	All roads take about 7.7% of the total city area in 2006
Total area of road	+3.4% $\approx$ +0.45%/year	
Total # of cars	+7.4% $\approx$ +0.93%/year	Increase steadily

6. Target-aimed policy design

Based on the discussions in the previous section, it seems that there are relatively limited actions that can be taken by the local government to achieve the long-term emission reduction goal. From 1998 to 2006, Taipei City has changed in some perspectives. Key parameters have been collected and analyzed so that more effective suggestions can be proposed. The data are listed in Table 1.

In general, many old factories are moving out of Taipei and many low-rise buildings are demolished in order to allow for the construction of high-rises (buildings with more than six stories) as a process of urban renewal. During 1998–2006, this change has led to a steady increase in the total number of housing units by 7.7% and provided the ground for a steady increase in the total number of households by 8.2% and also the total number of Taipower customers by 7%, even though the total population has actually decreased. Clearly, social trends toward moving in a newly built modern building and forming more individual families are the driver of these changes, which also leads to a favorable condition for more electricity consumption.

Under BAU, the residential and commercial sector will contribute about 89% of the total GHG emission in 2030, the transportation sector 10%, the waste processing 2%, and the industry sector 1%, while the forest sink accounts only for –2% of emissions with an assumption of constant forest area. The waste processing and the industry sectors are clearly negligible and some government officials are even optimistically projecting “zero waste” and “zero industrial plants” in the near future.

Since the electricity consumption contributes the most of the GHG emissions in Taipei, certain targets must be set up before useful policies can be designed. The first one is to control the total number of housing units so as to control the increase of households, which may be accomplished by controlling the total floor area of all buildings. The second one is to make each housing unit energy-saving by creating persuasive incentives.

To transfer the idea into practice, we suggest planning executable projects by setting targets of zero growth in the total number of housing units and a 1%/year reduction of electricity consumption for each household after 2010, with other sectors remaining the same as the business as usual scenario. Both of these targets are practical to reach.

Taipei has a considerably high population density of 9680 people per square kilometer (which ranks about the 20th among all major cities in the world) (City Mayors, 2007) and is experiencing a gradual decrease of the total population, a freeze of the total number of housing units is actually a reasonable policy to pursue. Mainly, Taipei is a three-hundred old city with a modernized MRT system extending from the city center to outskirts. More and more new generations are taking the advantage of the efficient public transit system to live at suburban areas with lower living expenses while working in the busy Taipei. In the meantime, the economic growth rate has been lower than the averaged OECD level. Therefore the demolishment of old buildings for high-rises is mainly for provoking the local housing market, rather than being demanded for the improvement of living standard. Furthermore, the current city reform movement is heading toward an idealized ecological city with a policy to increase the total area of city parks and open spaces so as to enhance the city ventilation and to reduce the urban heat-island effect. A freeze of the total number of housing units is favorable toward this movement. With proper arrangement this is going to be an all-win policy for all stockholders. Certain limited budget may be needed to make this policy successful.

In the meantime, means such as installation of “smart meters” (Wood and Newborough, 2003), elimination of electric utility

customer charges (Pearce and Harris, 2007), implementation of local energy savings certificates (Vine and Hamrin, 2008), setting-up criteria to improve the efficiency of end-use electricity (Blok, 2005), providing economic incentives to demolish old buildings (Georgopoulou et al., 2006) and cutting down energy losses from buildings (Ürge-Vorsatz and Novikova, 2008) are all feasible and ready to be deployed in the near future. These means, along with the education and promotion of citizens' awareness on energy saving, makes it reasonable to pursue for a one percent per year reduction of electricity consumption per household and thus effectively reduce GHG emission.

Worldwide, the building sector contributes about one-third of energy-related CO₂ emission. According to Ürge-Vorsatz et al. (2007), appliance standards, building codes, tax exemptions and voluntary labeling are found to be the most effective policy instruments for reducing emissions from buildings. Among them, the Taipei government can certainly activate voluntary reduction plans, while other instruments are in the control of the central government.

By assuming that the local government will need to pay at least half the price of installing one smart meter at each house unit, which is about US\$100 in Taiwan, so as to persuade each unit to reduce one per cent per year the electricity consumption, which is going to be 19% total from 2010 to 2030. It is estimated that the total cost will be about US\$47 million, and the resulted reduction of carbon dioxide is about 12 Mtons, which makes the cost of each ton reduced about US\$3.9. The government probably needs a few years to complete this task, and this is quite a reasonable expense.

The line marked as “target-aimed” in Fig. 3 indicates that the total emissions will be reduced, after adopting policies toward a freeze of total housing units and a 1%/year reduction of electricity consumption per household, by 16% from the projected values in 2015, which is about 9% away from the goal level. Furthermore, emissions will be reduced by 46% from projected values for 2030, which is about 28% away from the expected level. It is clear that a dramatic reduction can be obtained by adopting such simple and reasonable target-aimed strategy.

Under the “target-aimed” scenario, the residential and commercial sector will account for 79% of the total emissions in 2030, the transportation sector 18%, waste processing 4%, and the industry sector 2%, while the forest sink accounts for −3% of emissions.

Still, there is one major drawback with the current strategy. That is the carbon intensity will be increasing instead of decreasing based on the plan proposed by the Bureau of Energy. If this is truly going to happen, all efforts done by the local government will be probably going in vain. For this reason, all local governments in Taiwan favor the Greenhouse Gas Reduction Act to be in force as soon as possible, so as to push the Ministry of Economy to change policies related to the industry development and energy consumption.

7. Conclusion

In this study, a framework for checking, evaluating, and realizing the GHG reduction goal (GHGRG) of Taipei City has been proposed and exercised. The GHG emissions in Taiwan and in Taipei are presented to illustrate the difficulty faced by the local government and the crucial contribution of electricity consumption by the residential and commercial sector in Taipei. The social trends of moving in newly built modern buildings and forming more individual families are the major drivers of a steady increase in electricity consumption and, hence, the GHG emission.

In the meantime, the wishful-thinking plans proposed by the Taipei City government for reducing local GHG emissions toward a

specific target have been criticized by Liou et al. (2006) as useless because they can generate only negligible effects on the total emissions.

A study indicates that some key factors are uncontrollable by the local government, such as an increase of coal consumption for power generation and the low electricity price set by the central government. These factors are unfavorable for an efficient reduction of GHG emission. Under such constraints, the key question is then: what kind of strategy should a local government take in order to secure a future emission reduction goal?

In this paper, we have demonstrated a target-aimed strategy-designing process by looking into changes in Taipei and identifying major targets to tackle. It turns out that a freeze of total housing units and a drive toward a one percent per year reduction of electricity consumption per household after 2010 will result in a significant reduction of the total GHG emissions to be close enough to the stated reduction goal. The remaining tasks are then to persuade the residents that it is necessary to strive toward the targets and to explore the means that lead to the desirable conditions. Clearly, such an approach will give more confidence to the public on working toward the expected GHG reduction goal.

Furthermore, if the idea condition of “zero waste” and “zero industrial plants” is fulfilled by 2030 in the near future. Also, the emission from the transportation sector reduces about 20% instead of 4% by 2030 and the forest areas have doubled by then. The target-aimed emission in 2030 will be about 13% away from the expected value, which indicates that the emission from the residential and commercial sector will be cut down to be about 90% of the level in 2006. Further reduction to the expected target will then depend on the participation of the central government.

One note to emphasize is that the bottom-up initiatives from local governments may lead the central government to enact more aggressive mitigation policies (Lutsey and Sperling, 2008). Also, the potential of the innovative energy technologies development (Schumacher and Sands, 2006) and the availability of renewable energy sources to cut down carbon dioxide emission in the future may minimize the remaining differences between the target-aimed and the expected GHG emissions.

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