OECD Economics Department Working Papers No. 964

Achieving the "Low Carbon, Green Growth" Vision in Korea

Randall S. Jones,

Byungseo Yoo

https://dx.doi.org/10.1787/5k97gkdc52jl-en

OECD

Unclassified **ECO/WKP(2012)41**

Organisation de Coopération et de Développement Économiques
Organisation for Economic Co-operation and Development **05-Jun-2012**

English - Or. English

ECONOMICS DEPARTMENT

ECO/WKP(2012)41
Unclassified

ACHIEVING THE "LOW CARBON, GREEN GROWTH" VISION IN KOREA

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JT03323002

Complete document available on OLIS in its original format

English - Or. English

ABSTRACT/ RÉSUMÉ

Achieving the "low carbon, green growth" vision in Korea

Korea, which has had the highest growth rate of greenhouse gas emissions in the OECD area since 1990, adopted an ambitious Green Growth Strategy in 2009. It aims at reducing emissions by 30% by 2020 relative to a "business as usual" scenario, implying a 4% cut from the 2005 level. The Strategy also includes a Five-Year Plan with public spending of 2% of GDP per year to promote green growth. Korea is planning to establish a carbon price through a cap-and-trade emissions trading scheme. Such an approach, combined with a carbon tax in sectors not covered by the scheme, is necessary to reduce emissions in a cost-effective manner and foster innovation in green technology. In addition, each sector should face the same electricity price based on production costs to promote efficient energy use. Given market failures, the government has a role to play in green R&D, particularly for basic research, in fostering green finance and in developing renewable energy resources.

This Working Paper relates to the 2012 *OECD Economic Survey of Korea* (www.oecd.org/eco/surveys/Korea).

JEL classification: Q28, Q48, Q54, Q56, Q58
Keywords: Korea; Korean economy; climate change; greenhouse gas emissions; green growth; emissions trading system; environmental taxes; energy subsidies; renewable energy; carbon tax; energy efficiency; electricity pricing; R&D; green certificates; National Strategy for Green Growth; Five-Year Plan.

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Concrétiser le projet d'une « croissance verte et sobre en carbone » en Corée

La Corée, qui affiche le plus fort taux d'accroissement des émissions de gaz à effet de serre de la zone OCDE depuis 1990, a adopté en 2009 une ambitieuse Stratégie de croissance verte. L'objectif est de réduire de 30 % les émissions d'ici à 2020 par rapport au scénario « au fil de l'eau », ce qui équivaut à une baisse de 4 % par rapport à leur niveau de 2005. La Stratégie institue également un Plan quinquennal qui prévoit les dépenses publiques correspondant à 2 % du PIB par an pour promouvoir la croissance verte. La Corée envisage de créer un prix du carbone grâce à la mise en place d'un système de plafonnement et d'échange de permis d'émissions. Une telle approche conjuguée à l'application d'une taxe carbone dans les secteurs non concernés par ce système est nécessaire pour abaisser les émissions de manière efficace et économe et stimuler l'innovation dans les technologies vertes. En outre, chaque secteur devrait se voir appliquer le même prix de l'électricité, fondé sur les coûts de production, afin de promouvoir une utilisation rationnelle de l'énergie. Compte tenu des défaillances du marché, les pouvoirs publics ont un rôle à jouer dans la R-D verte, notamment dans le domaine de la recherche fondamentale, dans la promotion de la finance verte et dans le développement des énergies renouvelables.

Ce Document de travail se rapporte à *l'Étude économique de l'OCDE de la Corée*, 2012 (www.oecd.org/eco/etudes/corée).

Classification JEL : Q28, Q48, Q54, Q56, Q58
Mots clés: Corée ; économie coréenne ; changement climatique ; émissions de gaz à effet de serre ; croissance verte ; système d'échange de permis d'émission ; taxes environnementales ; subventions d'énergie ; énergies renouvelables ; taxe carbone ; efficacité énergétique ; tarification de l'électricité ; R-D; certificats verts ; Stratégie Nationale de Croissance Verte ; Plan quinquennal.

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ACHIEVING THE "LOW CARBON, GREEN GROWTH" VISION IN KOREA

By Randall S. Jones and Byungseo Yoo[1]

1. In 2008, Korea's President proclaimed Low Carbon, Green Growth as the nation's vision to guide development during the next 50 years. Since then, the government has established the National Strategy for Green Growth and the Five-Year Plan for Green Growth and has set a target for reducing greenhouse gas emissions (GHG) (Table 1). The National Strategy has three main objectives: *i)* effectively dealing with climate change and attaining energy independence; *ii)* creating new engines of economic growth; and *iii)* raising the overall quality of life. Korea's energy intensity is about one-fifth above the OECD average and Korea was the tenth-largest energy consumer in the world. Meeting the emission reduction target of 30% relative to a business-as-usual (BAU) baseline by 2020 will thus be extremely challenging.

Table 1. The development of Korea's Green Growth Strategy

	Action	Date
Vision	The President proclaims "Low Carbon/Green Growth" as the nation's vision to guide development during the next 50 years	September 2008
	Announcement of the "National Strategy for Green Growth" up to 2050	July 2009
Institutional framework	Establishment of the "Presidential Committee on Green Growth" and its secretariat	January 2009
	Creation of the local green growth committees in each of the 16 metropolitan cities and provinces	November 2009
	Start of the monthly implementation evaluation meetings, chaired by the prime minister	September 2011
Medium-term plan	Launch of the "Five-Year Plan for Green Growth" (2009-13)	July 2009
Emission target	Announcement of a target to reduce greenhouse gas emissions by 30% relative to the BAU baseline by 2020	November 2010
	Setting reduction targets by sector and industry	July 2011
Legal foundation	Enactment of the "Framework Act on Low Carbon, Green Growth"	January 2010
	Submission of a bill to the National Assembly to create an Emission Trading Scheme	April 2011

Source: Presidential Committee on Green Growth.

1. Randall S. Jones is head of the Japan/Korea Desk in the Economics Department of the OECD and Byungseo Yoo was a senior economist on the Desk when the paper was written. He is now an Assistant Secretary to the President of Korea for Economics and Finance. This paper is based on material from the *OECD Economic Survey of Korea* published in April 2012 under the authority of the Economic and Development Review Committee (EDRC). The authors would like to thank Nicola Brandt, Anthony Cox, Andrew Dean, Robert Ford, James Greene, Reo Kawamura, Vincent Koen, Dirk Pilat, Satoshi Urasawa and Žiga Zarnic for valuable comments on an earlier draft. Special thanks go to Lutécia Daniel for technical assistance and to Nadine Dufour and Pascal Halim for technical preparation.

2. However, the shift to a green growth paradigm offers a number of benefits to Korea. *First*, it will provide new engines of growth and create jobs for an economy facing rapid population ageing and falling potential growth. Indeed, the potential growth rate, which has fallen from more than 7% to around 4%, is projected to slow further to 2% by the 2030s. *Second*, it will improve the quality of life by reversing the environmental degradation that accompanied rapid industrialisation. *Third*, it will reduce dependence on energy imports, which account for 86% of Korea's primary energy supply, and its vulnerability to the world oil market. In sum, increasing concern about the sustainability of economic growth underpins Korea's commitment to a greener model of growth.

3. The Five-Year Plan (2009-13) contains about 600 projects that cost 108.7 trillion won (10% of 2009 GDP). The major 25 programmes that account for almost three-quarters of total expenditure over the first four years of the programme are shown in Table 2. The high level of spending reflects the inclusion of large construction projects, notably the Four Major Rivers Restoration Project and railroad construction, which together account for one-third of total outlays between 2009 and 2012. The Plan also includes the construction of Songdo City on a man-made island 56 kilometres west of Seoul. The city, which is expected to reach 65 000 inhabitants by 2016, aims to limit its GHG emissions only one-third of most cities that size (OECD, 2012). In contrast, R&D spending is limited to 11% of the Plan's outlays over that period. In addition, each of Korea's 16 provinces and metropolitan cities has a "Green Growth Execution Plan". For example, Daejon province has a goal of planting 30 million trees, while Seoul is introducing electric buses (NRCEHSS, 2011). The government estimates that the Five-Year Plan will induce production worth around 20% of 2009 GDP and boost employment by as much as 10% by 2013, suggesting a relatively high fiscal multiplier of around two. However, the shift to a green growth paradigm requires changing production processes, consumption patterns and industrial structures, entailing large transition costs.

4. In addition, each of Korea's 16 provinces and metropolitan cities has a "Green Growth Execution Plan", which includes specific goals and programmes. For example, Daejon province has a goal of planting 30 million trees, while Seoul is introducing electric buses (National Research Council for Economics, Humanities and Social Sciences, 2011).

5. The Five-Year Plan is now in its fourth year, making it an appropriate time to evaluate its implementation thus far, in part as a preparation for the second plan to follow in 2014. Following up on the green growth chapter in the 2010 *OECD Economic Survey of Korea*, this paper focuses on the three objectives of the National Strategy – mitigating climate change, creating new engines of growth and enhancing the quality of life. Progress in implementing the recommendations in the 2010 *Survey*, as well as new policy recommendations in this paper, are summarised at the end in Table 10.

Mitigating climate change

6. The government estimates that GHG emissions would rise by one-third by 2020 under a business-as-usual (BAU) scenario (Table 3). The projected emission growth varies widely by sector, ranging from 45% in manufacturing to declines in primary industries and garbage disposal. In 2011, the government set reduction targets by sector and industry to achieve its overall target of cutting emissions by 30%, which implies a 4% cut from the 2005 level. The targeted reduction is relatively small compared to the 2020 targets for Japan (30%), the United States (17%) and the EU (13%). However, 30% relative to a BAU baseline is the maximum recommended by the Inter-governmental Panel on Climate Change for non-Annex 1 countries.[2]

2. Non-Annex I countries had no obligation to set a specific GHG reduction target for 2008 to 2012 under the Kyoto Protocol to the UN Framework Convention on Climate Change. The 152 non-Annex 1 countries, which are mainly developing countries, include four OECD members (Chile, Israel, Mexico and Korea).

Table 2. The Five-Year Plan for Green Growth (2009-13)

Trillion won[1]

	Total	2009	2010	2011	2012	2013
Total[2]	**108.7**	**17.2**	**24.5**	**25.7**	**21.9**	**19.4**
Memorandum item: total R&D in green technology in all categories	*(13.0)*	*(1.9)*	*(2.2)*	*(2.5)*	*(2.8)*	*(3.5)*
I. Adapting to climate change & enhancing energy independence	**60.0**	**8.5**	**15.6**	**16.8**	**11.4**	**7.7**
① Effective mitigation of greenhouse gas emissions	5.0	1.0	0.9	0.9	0.9	1.3
• *Managing forests*	*2.0*	*0.6*	*0.5*	*0.5*	*0.5*	…
• *Mitigating vehicle emissions*	*0.5*	*0.1*	*0.1*	*0.1*	*0.1*	…
② Reduce fossil fuel use and enhance energy independence	16.7	2.8	3.8	3.7	3.6	2.8
• *Development of foreign oil fields*	*5.1*	*1.0*	*1.7*	*1.2*	*1.3*	…
• *Promoting renewable energy*	*3.7*	*0.7*	*1.0*	*1.0*	*1.0*	…
• *Nuclear energy development*	*1.8*	*0.3*	*0.4*	*0.5*	*0.6*	…
③ Strengthening the capacity to adapt to climate change	38.3	4.7	10.9	12.2	6.9	3.6
• *Four Major Rivers Restoration Project*	*15.4*	*0.8*	*6.4*	*6.9*	*1.3*	…
• *Improving water quality and sewage management*	*8.6*	*2.1*	*2.1*	*2.3*	*2.2*	…
• *Construction of environment-friendly small dams*	*2.2*	*0.5*	*0.6*	*0.5*	*0.6*	…
II. Securing new growth engines	**22.3**	**3.7**	**4.3**	**4.4**	**4.3**	**5.6**
④ Development of green technologies	7.3	1.4	1.5	1.4	1.4	1.6
• *R&D on energy and natural resources*	*0.8*	*0.2*	*0.2*	*0.2*	*0.2*	…
• *R&D on urban transport*	*0.8*	*0.2*	*0.2*	*0.2*	*0.2*	…
• *R&D on agriculture and fisheries*	*0.5*	*0.1*	*0.1*	*0.1*	*0.1*	…
⑤ The "greening" of existing industries and promotion of green industries	4.5	0.7	0.9	1.0	0.9	1.0
• *Support for R&D by green SMEs and start-ups*	*0.8*	*0.1*	*0.3*	*0.2*	*0.2*	…
• *Promoting recycling and other environmental industries*	*0.7*	*0.1*	*0.1*	*0.2*	*0.2*	…
• *Promoting environment-friendly agriculture*	*0.4*	*0.1*	*0.1*	*0.1*	*0.1*	…
⑥ Advancement of industrial structure to increase services	9.0	1.4	1.7	1.7	1.7	2.5
• *Promoting low-carbon broadcasting and telecom*	*1.2*	*0.3*	*0.4*	*0.3*	*0.3*	…
• *Promoting low-carbon materials and parts*	*1.1*	*0.2*	*0.3*	*0.3*	*0.3*	…
• *Promoting low-carbon medicine*	*1.0*	*0.2*	*0.2*	*0.3*	*0.3*	…
⑦ Engineering a structural basis for the green economy	1.5	0.2	0.2	0.3	0.3	0.5
• *Training human resources for the green economy*	*0.5*	*0.1*	*0.1*	*0.1*	*0.1*	…
• *Energy welfare*	*0.3*	*0.1*	*0.1*	*0.1*	*0.1*	…
III. Improving living standards & enhancing national status	**26.4**	**5.0**	**4.6**	**4.5**	**6.2**	**6.1**
⑧ Greening land and water and building green infrastructure	24.0	4.6	4.2	4.0	5.7	5.5
• *Construction of railways*	*12.9*	*3.0*	*3.0*	*2.8*	*4.0*	…
• *Managing streams and rivers*	*3.2*	*0.9*	*0.7*	*0.7*	*0.9*	…
⑨ Bringing the green revolution to daily lives	1.6	0.3	0.3	0.3	0.3	0.4
• *Developing green villages*	*1.0*	*0.3*	*0.3*	*0.2*	*0.2*	…
• *Promoting green campaigns*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*	…
⑩ Becoming an international role model for green growth	0.7	0.1	0.1	0.2	0.2	0.1
• *Green Official Development Assistance, etc.*	*0.6*	*0.1*	*0.1*	*0.2*	*0.2*	…
• *International co-operation on forests*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	…

1. Actual budgets for 2009-11 and plans for 2012-13. It includes 8.5 trillion won of investment by public enterprises.
2. For the individual programmes, the total is the sum of spending during 2009-11 and the budget plan for 2012.

Source: Ministry of Strategy and Finance and Presidential Committee on Green Growth.

Table 3. Korea's GHG emission reduction target
In million tonnes and per cent

					Emission reduction target		
Sector	**Industry**	**2007 emissions**	**2020 emissions[1]**	**Percentage increase**	**Cut in emissions**	**2020 emissions**	**Percentage Reduction[2]**
	Oil refining	12.80	17.10	33.6	1.28	15.82	7.5
	Mining	1.00	0.68	-32.0	0.03	0.65	4.0
	Steel	86.00	121.35	41.1	7.88	113.47	6.5
	Cement	42.20	41.48	-1.7	3.53	37.95	8.5
	Petrochemicals	50.70	63.47	25.2	4.77	58.70	7.5
	Paper and wood	8.70	7.73	-11.1	0.55	7.18	7.1
	Textiles and leather	11.90	9.81	-17.6	0.61	9.20	6.2
	Glass and ceramics	4.50	5.50	22.2	0.22	5.28	4.0
	Non-ferrous metal	5.40	5.02	-7.0	0.21	4.81	4.2
Manufacturing	Machinery	10.20	13.10	28.4	0.99	12.11	7.6
	Electronics[3]	9.70	12.09	24.6	0.96	11.13	7.9
	Electronics[4]	18.00	29.25	62.5	24.55	4.70	83.9
	Batteries and generators	6.30	71.65	1037.3	28.32	43.33	39.5
	Semiconductor	8.40	14.53	73.0	4.03	10.50	27.7
	Cars[3]	6.70	8.72	30.1	0.68	8.04	7.8
	Cars[4]	2.90	3.62	24.8	3.25	0.37	89.8
	Shipbuilding	1.80	3.79	110.6	0.25	3.54	6.6
	Other manufacturing	17.60	16.91	-3.9	0.29	16.62	1.7
	Foodstuffs	6.80	6.16	-9.4	0.31	5.85	5.0
	Construction	2.50	3.22	28.8	0.23	2.99	7.1
	Subtotal	314.10	455.18	44.9	82.94	372.24	18.2
Transport	Passenger & freight	87.7	107.25	22.3	36.82	70.43	34.3
Buildings	Households	70.5	87.44	24.0	23.62	63.82	27.0
	Commercial	67.6	91.52	35.4	24.44	67.08	26.7
	Subtotal	138.1	178.96	29.6	48.06	130.90	26.9
Public sector		16.2	18.85	16.4	4.70	14.15	24.9
Agriculture, forestry & fisheries		30.00	29.10	-3.0	1.52	27.58	5.2
Garbage disposal		17.1	13.83	-19.1	1.71	12.12	12.4
	Total[5]	**610.00**	**813.00**	**33.3**	**243.95**	**569.06**	**30.0**

1. Under a business-as-usual scenario.
2. Compared to the business-as-usual scenario for 2020.
3. For CO_2 emission.
4. For other types of greenhouse gases.
5. The total reduction includes 68.2 trillion tonnes from other sources.

Source: Government of Korea.

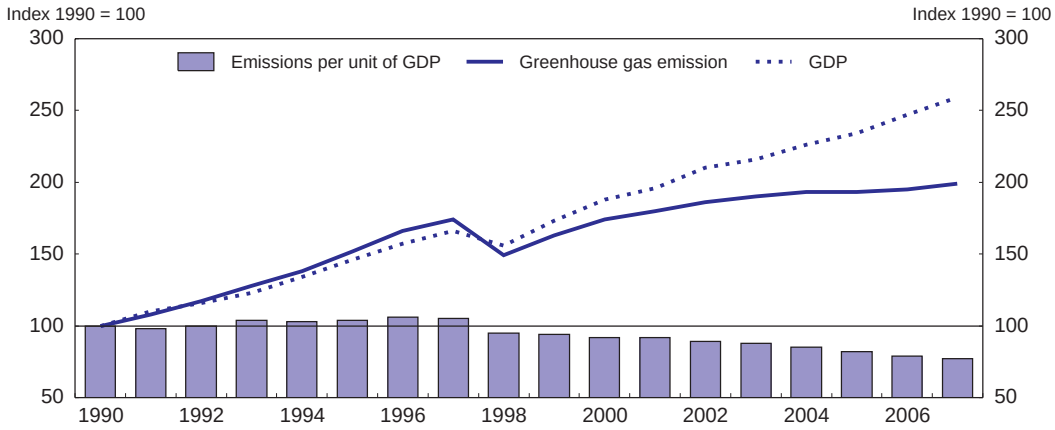
Overview of energy use and GHG emission trends in Korea

7. The doubling in GHG emissions between 1990 and 2008 far outstripped the global increase of 27% over that period, making Korea the world's 15th-largest source of emissions. Nevertheless, Korea has achieved a partial decoupling of emissions and GDP growth since the 1997 Asian financial crisis. Indeed, the ratio of emissions to GDP fell by more than a quarter by 2007 (Figure 1), thanks to the manufacturing

sector, which accounts for more than half of Korea's GHG emissions. Between 1998 and 2007, manufacturing output doubled while emissions rose by one-third, reflecting two factors (Table 4). *First*, an improvement in energy efficiency reduced emissions per unit of output by 30%. *Second*, a shift in the industrial structure away from energy-intensive activities cut emissions another 13%. These two factors, more than offset the impact of changes in the energy mix and the emissions coefficient

Figure 1. Trends in GHG emissions and GDP in Korea

1990=100



Source: *OECD Environment Database* and *OECD Analytical Database*.

8. Nevertheless, Korea's energy intensity in 2007 was 19% above the OECD average and the sixth highest in the OECD area (Figure 2). Energy-intensive industries, such as steel and petro-chemicals, accounted for 12% of total value-added in Korea in 2008, the highest in the OECD area and well above the OECD average of 8%. While per capita energy use in the transport, residential and commercial sectors was below the OECD average, it was almost 50% above the OECD average in industry. Meanwhile, the share of the service sector in GDP in Korea is the second lowest in the OECD area. Energy intensity in services in Korea is less than one-third of that of manufacturing. Developing the service sector would thus reduce GHG emissions,[3] while helping to achieve the government's target of cutting energy intensity by one-third from the 2005 level by 2020, reducing it to the OECD average.

Table 4. Analysis of GHG emissions increase in Korea

The manufacturing sector, 1991=100

	Production effect	Industrial structural effect[1]	Energy efficiency effect[2]	Energy mix effect[3]	Emissions coefficient effect[4]	Total
1998	152.5	97.2	105.6	100.2	94.9	148.9
2007	312.0	84.1	73.6	103.9	101.9	204.5

1. Change in total energy consumption caused by the sum of the changes of each industry's share in total manufacturing.
2. The change in energy per unit of output.
3. The impact of changes in the composition of energy inputs by industry.
4. The carbon content per unit of energy source.

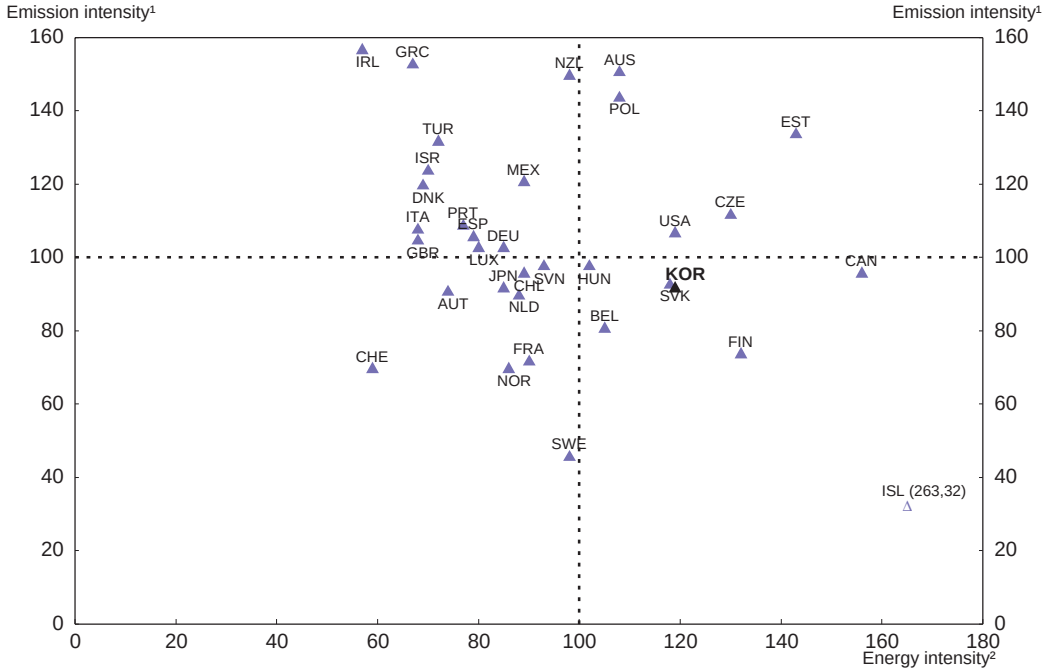
Source: Kim and Jeong (2010),

3. A long-term econometric model estimates that a significant expansion of the service sector would reduce GHG emissions (de Serres *et al*., 2010).

9. In contrast to its high energy intensity, emissions per unit of energy in Korea were slightly less than the OECD average in 2007 (Figure 2), thanks in part to nuclear energy. Indeed, Korea was the fourth-largest nuclear energy producer in the OECD area and it accounted for 17% of its total energy production. The government plans to increase its share to 28% by 2030. However, nuclear energy is associated with environmental risks and unsolved waste management issues. The government established the Nuclear Power Safety Committee as an independent organisation under the President in 2011 to upgrade supervision. Ensuring the independence of the Committee and its leadership is essential to maintain confidence in nuclear power, especially in the wake of the disaster at Fukushima, Japan in 2011.

Figure 2. The energy intensity of the economy is high, while emission intensity is about average

Unweighted OECD average = 100 in 2007



1. Emission intensity is defined as GHG emissions, excluding land-use, land-use change and forestry, divided by total primary energy supply (TPES). It is expressed in tonnes of oil equivalent.
2. Energy intensity is measured by TPES (in tonnes of oil equivalent) divided by GDP (in thousand 2000 USD using PPPs).

Source: *OECD World Energy Balances Database*, *United Nations Framework Convention on Climate Change Database* and the Korean Ministry of Environment.

Creating a clear price for carbon through market-based instruments

10. Korea's 2020 target implies that the GHG emission-to-GDP ratio would have to fall by another 44%, *i.e.* to less than half of its 1990 level (Figure 1). This calls for an appropriate policy framework that promotes cost-effective industrial restructuring. The key is greater reliance on market instruments, which equalise marginal abatement costs across emitters, thereby promoting cost-effective emission abatement. The main market instruments for internalising the social cost of carbon are an emissions trading scheme (ETS) and a carbon tax, which both put a price on carbon (Box 1). A recent study concluded that achieving Korea's 2020 emission target through an ETS would cost only 40% as much as relying on direct regulations (Lee, 2009). Furthermore, a carbon price is needed as soon as possible to kickstart private investment and innovation in greener infrastructure and technologies. Both options for carbon pricing meet the efficiency criteria, as they encourage emitters to adopt the least expensive abatement solutions that cost less than the permit price or the tax. A major difference between the two instruments is that under a carbon

tax, the price of carbon is fixed and the amount of emissions is uncertain, whereas under an ETS, the amount of emissions is fixed while the carbon price fluctuates. In practice, however, given that carbon tax rates would have to change over time to ensure that the emission targets are met, the two instruments are essentially equivalent, if properly designed and implemented. Auctioning emission permits generates revenues, as does a carbon tax. Conversely, granting permits is equivalent to recycling carbon-tax revenue to polluters.

Box 1. Designing a cost-effective set of climate mitigation policy instruments

A cost-effective set of instruments to achieve any given climate-change mitigation objective should meet three broad criteria:

- Equalise marginal abatement costs across all emission sources in order to fully exploit existing opportunities for low-cost GHG emission reductions. This requires the instrument to be cost-effective but also to be applied as widely as possible across countries, sectors and types of GHGs.
- Foster an efficient level of innovation and diffusion of GHG emission-reducing technologies in order to lower future marginal abatement costs.
- Cope effectively with risks and uncertainties surrounding both climate change and abatement costs.

While a carbon price, based on either an ETS or a tax, meets these three criteria, there are a number of market imperfections that justify complementing a carbon price with other instruments:

- The most obvious market imperfection comes from the global public good nature of the climate, which leads to free rider problems and makes it inherently difficult to achieve broad participation. This justifies having some forms of support to countries/sectors with weak incentives to participate.
- Externalities related to investment in knowledge imply that firms tend to under-invest in innovation, as they cannot fully internalize the returns on their investment. The problem is compounded in some green innovation markets by network effects, making it difficult for new entrants to compete with incumbent firms. These market imperfections justify public R&D and policies to strengthen investment and diffusion of green technologies.
- Monitoring and enforcement costs can be large for certain emission sources such as deforestation or methane emissions resulting from pipeline leakage, justifying the adoption of some regulatory standards.
- Information problems can be significant. Imperfectly informed households and firms may act inefficiently even if faced with adequate incentives. For example, the energy efficiency of buildings may be hampered by divergent incentives and asymmetric information between landlords and tenants. Some standards and information instruments, such as labeling, could help in this regard.
- Capital market imperfections may affect the ability of households and small firms to invest in profitable energy-saving equipment with high fixed costs. Some forms of subsidies can mitigate this problem (Duval, 2008).

11. Although an ETS has steep start-up costs and comes with carbon price volatility, it has a better chance of being defended by stakeholders once it is in place (OECD, 2011f). The participation of firms in the ETS creates a constituency for maintaining the system, though the authorities need to ensure that they do not impair competition by favouring existing firms, while avoiding speculation and fraud, which reduce the environmental benefits (OECD, 2011f). An ETS also has the potential to create linkages with foreign carbon markets, which could lower the cost of reducing emissions and lead to a common regional or world carbon price that would help level the playing field for energy-intensive firms, thereby helping to alleviate concerns about international competitiveness (OECD, 2010a).

12. The National Assembly approved legislation in May 2012 to create a cap-and-trade ETS in 2015 covering six types of GHGs. The first step is the creation of a "Target Management System" (TMS), which requires firms emitting more than 15 thousand tonnes annually to set targets with the government beginning in 2012. Firms emitting over 25 thousand tonnes, a threshold that included 497 firms in 2011 accounting for around 60% of total emissions, will join the ETS in 2015. Less than 5% of the permits may be auctioned in the first (2015-17) and second phases (2018-20). The system for allocating the remainder of the permits is yet to be decided. Firms with 15 to 25 thousand tonnes of emissions can enter the ETS or remain in the TMS after 2015. Firms that fail to meet their objectives in the TMS will be subject to fines. The business sector had opposed this plan. *First*, it argued that the ETS would weaken the international competitiveness of domestic industries, given that competitors in neighbouring countries do not face similar burdens. *Second*, it was concerned that the number of firms in the ETS is so small as to create the risk of considerable price instability for permits. *Third*, it argued that Korea's manufacturing sector is already energy-efficient and thus should not be required to make large emission reductions.

International competitiveness issues

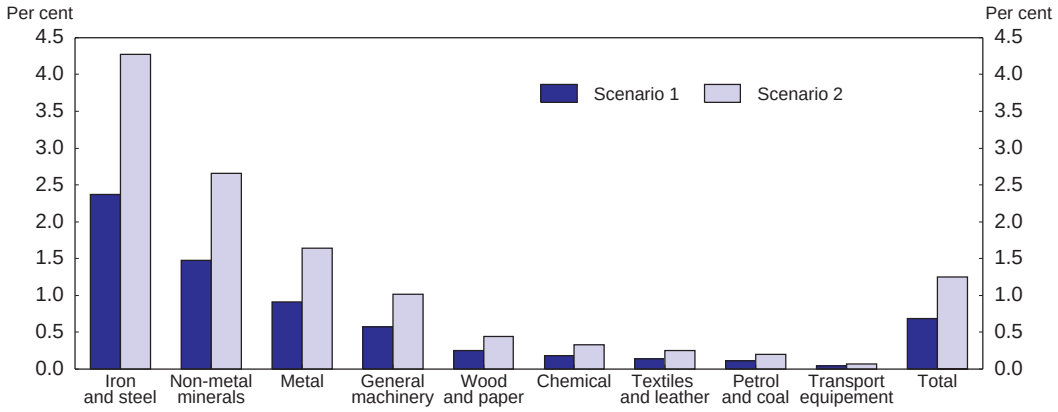
13. The overall economic cost and competitiveness issues arising from pricing emissions are likely to have only a small impact on output growth. Nevertheless, to cope with the "carbon leakage" problem, most countries with carbon pricing protect domestic industries using a variety of methods against rivals that do not face such systems. Korea's legislation to establish an ETS would allow the government to assist firms subject to negative effects from carbon leakage by providing loans, subsidies or tax deductions that defray the cost of installing GHG reduction facilities and performing green R&D. Although transitional assistance to some strongly affected industries may be appropriate, the cost of such support could be significant and needs to be carefully measured against other potential uses of government revenue. Overly generous support to maintain current production patterns would slow the transition to sustainable low-carbon technologies. It is important to provide a clear signal that they will be phased out over time (IEA/OECD, 2010).

14. Carbon leakage from an individual country depends on the extent of climate change measures adopted by other countries. An OECD study (OECD, 2009) found that if the EU were to unilaterally cut emissions by 50% by 2050, around 12% of its reductions would be offset by increased emissions elsewhere. However, if all developed countries were to act, the leakage rate would be reduced to only 2%. A study that simulates the introduction of an ETS in Korea finds that it would reduce turnover by 0.7% to 1.3% on average in nine major energy-intensive industries (Figure 3), which account for about half of the total turnover in manufacturing (Lee, 2011b).[4] Given that manufacturing turnover has risen at an annual rate of around 8% during the past decade, the impact would appear limited. However, the decline in turnover would be concentrated in particular industries, such as pig iron, where it could reach as high as 16% (Lee, 2011b). Measures to alleviate the impact in some seriously-affected industries would thus be needed. But it is very important not to exclude energy-intensive industries from climate change mitigation policies as that would increase the cost of achieving emission reductions (OECD, 2009).

4. This study, based on 2007 data, is by the Korea Economic Research Institute, which was established and is supported by the Federation of Korean Industries.

Figure 3. The estimated decline in sales in Korea following the introduction of an ETS

In nine energy-intensive industries that account for half of manufacturing output[1]



1. Scenario 1 assumes a price of $22 per tonne of GHG emissions and Scenario 2 a price of $40.

Source: Lee (2011b).

Volatility of permit prices

15. Permit prices vary with changing demand, reflecting such factors as fluctuations in energy prices, economic growth and weather conditions (Webster *et al*., 2008). In schemes implemented to date, there has been a tendency for caps to be set too high in the initial stages of trading, resulting in the collapse of carbon prices, as occurred in the EU's ETS. In addition, estimation mistakes or unforeseen changes in Korea's BAU baseline could have a dramatic effect on permit prices. Many governments have tended to overestimate emission trends, reflecting a lack of historical data on emissions, over-optimistic forecasts of baseline GDP growth, unanticipated changes in fuel prices and a tendency to underestimate the potential for abatement and innovation (IEA/OECD, 2010).

16. One remedy to reduce volatility in permit prices is to allow their banking for future use. For example, if the ETS includes a credible pathway with strict targets in the future, permits that are "surplus" today will still have value. This was the case in the EU ETS, where despite an expected surplus during 2008-12, allowances traded around €10 in anticipation of tighter targets announced for 2013-20, although the price has fallen recently. The legislation establishing a Korean ETS allows permits to be banked during the first phase for subsequent phases. The borrowing of permits has a similar stabilising effect, although there is a need for caution as firms do go bankrupt. While allowing firms to smooth their emission profiles through the business cycle by banking and borrowing permits helps to limit price volatility, it must be accompanied by adequate compliance mechanisms and long-term targets to be effective. For instance, if future emission caps are not adjusted to take account of the excess supply of permits, carrying forward excess permits would reduce the need for emission reductions in the future.

17. A long-run solution to reduce both overall costs and volatility is to link the Korean ETS to other carbon markets, thereby allowing the export and import of permits. In practice, such links will be possible only among schemes that have similar caps, rules and offset provisions (Dellink *et al*., 2010). However, even without direct linking there is likely to be some convergence of permit prices if common offsets are allowed. For example, most schemes currently accept Kyoto Protocol Clean Development Mechanism permits, whose value is driven by permit prices in the EU ETS, thus linking them to the European market. The Korean ETS legislation also allows offsets, with the conditions to be determined later.

High level of energy efficiency in manufacturing

18. A number of studies show that Korea's energy efficiency in manufacturing is high compared to other countries,[5] suggesting less scope for cutting emissions. However, this factor was taken into account in setting the 2020 GHG emission reduction target. As noted, manufacturing emissions increase by 45% in the BAU scenario, compared to 33% for the country as a whole. In addition, the reduction from the BAU scenario, which is based on the availability of abatement technologies, reduction potential and competitive conditions, is only 18% in manufacturing, well below the 30% overall reduction target. Consequently, manufacturing is the only one of the six sectors where the emissions target for 2020 is larger than actual emissions in 2007. In particular, steel, petro-chemicals and cement have reduction targets ranging between 8% and 11%, which do not appear challenging, as one study estimated the targets could be met using existing technology (Lee and Choi, 2010).

Conclusion: an ETS with auctioning of permits should be the key priority

19. Korea's mandatory cap-and-trade ETS is the first priority for climate change mitigation and green growth. The ETS should quickly shift from the allocation of permits by the government, which provides scope for windfall profits for existing firms, resulting in potentially unfair competition for new entrants, to the auctioning of permits. Auctioning is more efficient as it generates revenue that can be used *inter alia* to offset the impact of the ETS on firms and consumers, fund green investments, reduce more-distorting taxes or achieve fiscal consolidation.

20. Given that the ETS is limited to large emitters, a carbon tax should be applied to smaller and more diffuse sources of pollution, such as households, farmers, small businesses, transport and the commercial sector.[6] The government is currently considering such a tax. It is important, though, to minimise overlap and complicated interactions between an ETS and a carbon tax that would raise uncertainty about the overall outcome (OECD, 2006c). In particular, the two instruments should be set to minimise differences in the explicit and implicit carbon prices across sectors (de Serres *et al.*, 2010). For example, while Korea taxes fuel used for transport, heating and industrial processes, it provides a substantial tax exemption for fuel used in agriculture and fisheries that amounted to more than 1.9 trillion won (0.1% of GDP) in 2010 (OECD, 2011d). To ensure adequate incentives to reduce emissions in all sectors, this provision should be reviewed. Moreover, while Korea's decision to end budgetary support for coal production and rationalise support for briquette production is laudatory, greening growth requires ensuring that there is a positive price on emissions from the combustion of coal in sectors not covered by the planned ETS.

21. The taxation of transport fuels also should be re-examined, given that diesel is taxed less heavily than gasoline, even though emissions of both carbon dioxide and air pollutants are higher from a litre of diesel than a litre of gasoline. Moreover, the earmarking of environmental taxes, including the transport-environment-energy tax on gasoline and diesel, for road construction, should be ended. At present, 80% of the revenue is earmarked for transport infrastructure, primarily roads, thus encouraging GHG emissions. Once an ETS and carbon tax are in place, the TMS, which will apply to firms with 15 to 25 thousand tonnes of emissions after 2015, should be phased out.

5. An IEA/OECD analysis (2007) of a number of industries, including iron and steel, cement, chemicals, petrochemicals, paper and printing and pulp, showed that Japan and Korea have higher energy efficiency than Europe and North America. Other studies show that Korea's steel and petrochemical industries are among the most efficient in the OECD area (Lee and Choi, 2010 and Lee, 2011b).

6. In contrast, New Zealand's ETS will cover all sectors of its economy, thus eliminating the challenge of co-ordinating an ETS and a carbon tax

22. A clear price signal is a necessary, though not always sufficient, condition for efficiency, given a number of market failures resulting from externalities related to investment in knowledge, information asymmetries and market imperfections, including in capital markets (Box 1). Such market failures justify complementing market-based mechanisms with other instruments. However, the use of overlapping instruments is generally costly and, therefore, non-market-based instruments should be used only when there is a market failure that cannot be fully addressed by a carbon price. Such alternative policies cannot succeed without some form of carbon pricing (OECD, 2009).

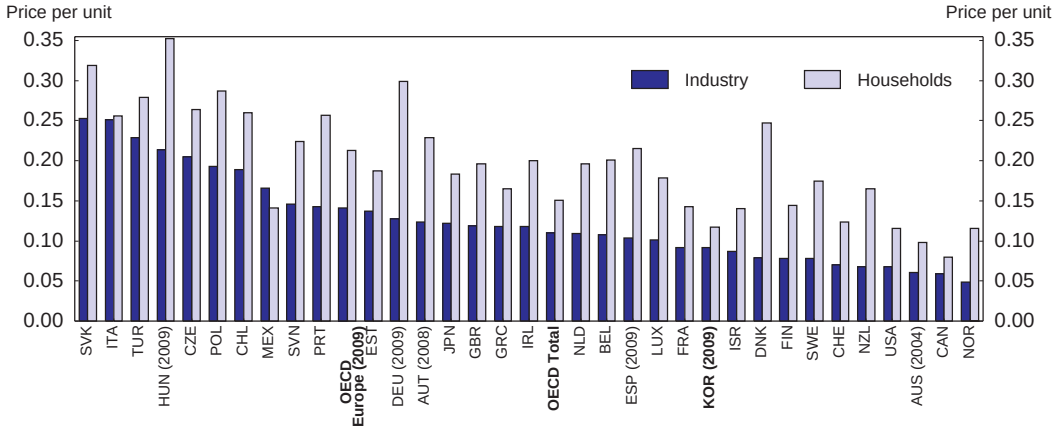
23. Convincing the public to bear the cost today of fundamentally changing what is produced and how it is produced for uncertain benefits that are spread unevenly across generations and across countries is a difficult challenge. The indispensable policy tool – a price on carbon – is unpopular politically. In contrast to Korea, a number of countries have recently backed down from measures to introduce or extend the use of pricing instruments and are instead relying on regulations and subsidies. It is important to communicate clearly the higher cost of second-best solutions (de Serres *et al*., 2011). For example, the cost of subsidies to ethanol and biodiesel by the EU to reduce CO2 equivalent by one tonne is estimated to be at least $700 and $250, respectively (Steenblik, 2007). To gain public support, the Korean authorities have emphasised the economic benefits of green growth and the scope for improving the quality of life by reducing GHG emissions. These two topics are discussed later in this paper.

Reforming electricity pricing

24. The government regulates electricity prices on the grounds that their network structure is monopolistic. However, this has not improved efficiency, as the government's pricing policy tends to focus on macroeconomic objectives, such as price stabilisation and strengthening the international competitiveness of manufacturing (Jhung and Park, 2010). Korea's electricity prices for industry and households are a little less than the OECD average and much lower than European countries on the basis of PPP exchange rates (Figure 4) – and one of the lowest in the OECD based on market exchange rates. Furthermore, its electricity price is exceptionally low relative to that of oil (Table 5). Moreover, the gap between two prices has widened significantly in Korea since 2000 while remaining fairly stable in the OECD area. Against this backdrop, Korea faces electricity shortages, which forced rolling blackouts in Seoul in 2010.

Figure 4. Electricity prices in OECD countries in 2010

Prices per kWh using PPP exchange rates



Source: *IEA/OECD Energy Prices and Tax Database*.

Table 5. International comparison of electricity price trends in the industrial sector

Relative to light fuel oil price (each year's oil price = 100)[1]

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Korea	88	88	88	77	65	57	54	57	44	63
Japan	481	467	454	413	364	269	226	219	163	301
USA	210	261	272	229	184	139	132	121	98	162
OECD Europe	151	182	191	195	177	153	158	161	142	203
OECD	207	239	243	223	200	160	155	155	131	201

1. Index is calculated by using electricity and oil prices per tonne of oil equivalent.

Source: *IEA/OECD Energy Prices and Tax Database*.

25. The low electricity price is an environmentally-harmful subsidy that boosts electricity consumption and GHG emissions and promotes an energy-intensive industrial structure. As a result, electricity consumption per unit of GDP in Korea in 2009 was 1.7 times higher than the OECD average. The overall recovery rate – the unit price as a share of the total unit cost – was 90.2% in 2010 and the price varies widely between sectors, creating significant cross-subsidies between consumers (Table 6). The recovery rate in the general category, which includes services, was 96.3%, compared to 89.4% in industry and only 36.7% in agriculture. Although the gap between some sectors has narrowed in recent years, the overall recovery rate has fallen from 93.8% in 2007 to 90.2%, indicating that electricity prices still do not cover costs. The government should raise electricity prices by replacing the sector-based price structure with a system based on voltages, which would effectively reflect production costs, thereby reducing GHG emissions and promoting efficient energy consumption. Such an approach would be in line with the 2008 National Energy Master Plan, which called for abolishing cross-sector subsidies.

Table 6. Recovery rate of electricity price by sector in 2010

	Average	General	Residential	Industrial	Educational	Agricultural
Unit price (won/kWh)	86.8	98.9	119.9	76.6	87.2	42.5
Total unit cost (won/kWh)	96.3	102.7	127.2	85.7	103.1	116.0
Recovery rate in 2010 (%)	90.2	96.3	94.2	89.4	84.6	36.7
Recovery rate in 2007 (%)	93.8	108.4	99.2	90.5	88.7	39.2

Source: The Government of Korea (2008) and Jhung and Park (2010).

Developing renewable energy

26. The electricity pricing policy also hinders the development of renewables, which are essential to reduce GHG emissions and promote green growth. Korea has promoted renewables through a Feed-In-Tariff (FIT) system, which guarantees their price through subsidies equal to the difference between the generation cost and the market price. Following the introduction of the FIT in 2002, the share of renewables in total primary energy supply (TPES) increased from 1.4% to 2.6% in 2010, leading to a large increase in the number of firms in this sector and their exports. A FIT reduces the uncertainty of investment, even for smaller generators, by guaranteeing the price, making it an effective instrument to rapidly expand renewables. Nevertheless, according to the OECD definition,[7] the share of renewable energy in TPES in Korea was only 0.7% in 2010, still far below the OECD average of 7.6%.

27. The government replaced the FIT in January 2012 with a Renewable Portfolio Standard (RPS), which obliges electricity companies to produce or buy a specified share of their electricity from renewable sources. The RPS target for renewables is 2% of total electricity supply in 2012, rising to 10% by 2022,

7. The OECD definition includes industrial waste and non-renewable municipal waste, which is excluded under IEA methodology on the grounds that they are not biodegradable (IEA/OECD, 2011).

compared to only 1.3% in 2010. The target appears feasible, given Korea's large potential in solar photovoltaics and offshore wind (IEA/OECD, 2008).

28. Under the RPS, producers of electricity from renewables receive certificates based on kilowatt-hours (kWh) of electricity produced, thereby creating a supply of certificates. The number of certificates allocated per kWh varies between sources based on generation costs, the expected impact on renewable technologies, and the environmental effect. For example, offshore wind is worth two certificates per kWh, compared to only 0.25 for "Integrated Gasification Combined Cycle". However, there is still debate over the appropriate size of the coefficients. Electricity companies need to purchase certificates when their direct production or purchases of renewables falls short of the specified share, thereby generating demand for certificates. The RPS thus creates a market, with the price of certificates depending on supply and demand and, in turn, on the size of the quota obligation.

29. Empirical studies on this issue do not provide clear conclusions on which approach is best.[8] No "one-size-fits-all" approach meets all policy objectives. Whatever policy is adopted, it must be well-designed to meet a country's specific circumstances and carefully implemented. The government offered three reasons for shifting from the FIT, a price-based instrument, to a RPS, a quantity-based instrument. *First*, it promotes competition in renewables. *Second*, it reduces the financial burden on the government as it no longer has to provide subsidies. *Third*, it makes it easier to project future supply capacity. In addition, empirical analysis shows that a RPS has a larger impact on innovation in renewables (Johnstone *et al*., 2010b).

30. However, there is a risk that a RPS, a quantity-based system, will result in excessive use of low-quality renewables, in terms of their generation costs, the expected impact on renewable technologies, and the environmental effect. To reduce this risk, Korea applies different weights to certificates between renewable sources, as noted above. Nevertheless, the government needs to closely monitor technological developments in the renewable market. In addition, potential suppliers of renewable energy face more risk in the RPS system, where permit prices tend to be volatile, than in a FIT system, which guarantees the price they will receive. But many of these risks reflect the absence of long-term contracts and are not intrinsic to the RPS (Mitchell, 2006). Tradable certificate systems tend to be more effective in promoting renewable energy if they use long-term contracts, thus reducing the risk associated with the short-run volatility of certificate prices (Agnolucci, 2007). In renewables, as in other green areas, clear and consistent policies over the long term are needed to promote private investment (Croce *et al*., 2011).

The transport sector

31. Although Korea has eleven types of taxes on car owners, covering purchase, possession and fuel, the transport sector is the second largest source of GHG emissions with 20% and its emissions have been increasing most rapidly. The number of vehicles in Korea has risen to 17 million and is rising 13% a year. In addition to GHG emissions, road transport is responsible for more than 60% of urban air pollution. Korea is taking a number of steps to reduce GHG emissions from the transport sector:

8. The European Commission (2005, 2008) compared the cost of renewable energy support schemes with the proportion of the potential renewable energy supply share achieved and concluded that well-designed FIT schemes are generally the most effective. In contrast, another study found that the German FIT scheme had encouraged inefficient wind generation in low-wind areas (Jamasb *et al*. 2008). Newbery (2010) observed that FITs for solar photovoltaic power in Spain and Germany had been set too high, raising prices excessively

- *Average fuel efficiency standard*: the five-year plan requires cars to either achieve 17 kilometres per litre or cut GHG emissions below 140 grammes per kilometre by 2015. The rules will apply to 30% of cars sold in 2012, rising to 100% by 2015.

- *Bonus-Malus system*: in 2012, Korea introduced such a system, modelled on that in France. It imposes an additional tax on cars that produce a high amount of CO2 emissions or provides a bonus to cars with low emissions.

- *Car taxes*: Korea is considering a shift in the base of taxes on purchase and possession of cars from their engine size to their amount of CO2 emission.

Creating new engines for growth

32. Green growth means fostering economic growth while ensuring that natural assets continue to provide the resources and natural environment on which well-being depends. This requires effectively using the large-scale expenditures in the Five-Year Plan and other policies to promote green investment and innovation that will underpin sustained growth and give rise to new economic opportunities. A shift to a green growth paradigm requires a framework that provides adequate incentives for greener behaviour by firms and consumers, thereby helping to jump-start the creation of new businesses and innovation (OECD, 2011f). Korean firms have been increasing investment in green industry. According to a government survey, investment by the top 30 business groups was three times higher in 2010 than in 2008 and amounted to 15 trillion won over the three-year period (1.5% of 2009 GDP). The major investment areas included renewable energy (39%), next-generation electric equipment (26%) and green cars (16%). By 2010, Korea was the world's second-largest producer of lithium rechargeable batteries and LED devices. The top business groups plan to invest an additional 22 trillion won during 2011-13, focusing on renewable energy (44%), green cars (24%) and next-generation electronic equipment (19%). However, it is still too early to assess the impact of the Green Growth Strategy on economic growth.

Green financing: channelling funds to green business

33. Access to finance is one of the key constraints on private-sector investment in green businesses and innovation at an early stage of commercial development. In particular, start-up firms can play a crucial role by exploiting opportunities ignored by incumbent firms. Financing such long-term projects through traditional mechanisms is difficult due to risks, such as information asymmetries. It takes time for markets to price such risks accurately (OECD, 2011b), making it important to improve access to financing by ensuring a legal foundation, a well-functioning certification system to determine which firms deserve green financing, and financing tools (Kim, 2011). Korea's 2010 Framework Act sets the legal foundation and requires the government to establish financial tools by developing new products, providing direct financial support for green enterprises and encouraging private investment in green infrastructure projects. In addition to a good framework, clear and consistent policies over the long term are necessary to promote private investment in green growth projects (Croce *et al*., 2011).

34. A well-functioning certification system to determine which firms are truly green is essential. Korea's certification system is run by the Green Certification Committee, which determines which technologies, projects and firms qualify based on an evaluation by the Korea Institute of Advancement of Technology. By October 2011, 456 technologies and 12 projects had been certified (Table 7). In addition, firms in which certified green technologies account for more than 30% of sales can be certified as green firms. Only 57 firms had qualified by October 2011, given that it takes time to reach the 30% threshold. The Small and Medium Business Administration also grants green venture certificates under its venture certification system. The number of such certificates increased from 1 133 (7.4% of all venture businesses

in 2008) to 1 785 in 2010 (9.5%) (Young, 2011). Venture businesses receive a variety of benefits, including generous tax incentives and equity guarantees (OECD, 2005).

Table 7. Requests by firms for green certification

Request for:	Applications	Examining documents	Evaluation underway	Certified	Rejected
Green technology certification	1 130	357	124	456	193
Green project certification	93	62	3	12	16
Green firm certification	86	24	3	57	2
Total	1 309	443	130	525	211
Per cent of total	100.0	33.8	9.9	40.1	16.1

Source: Presidential Committee on Green Growth.

35. The government is using various channels to supply money to green businesses. Because of the high risk of green finance and its long investment horizon, credit guarantees are used to activate green lending. During the first half of the Five-Year Plan (2009 to mid-2011), credit guarantees of 14 trillion won (1.3% of 2009 GDP) were provided to green industries by two public institutions (Table 8), the Korea Credit Guarantee Fund (KODIT) and the Korea Technology Finance Corporation (KOTEC). Green industries thus account for a significant share of the 62 trillion won in outstanding guarantees, which are primarily given to small and medium-sized enterprises (SMEs). The large share reflects the priority given to green industries in deciding which loans to guarantee. In addition, the ceiling on the amount guaranteed is higher for green loans at 7 billion won ($6.2 million), compared to 3 billion won for non-green loans, and the fee for the guarantees is lower.

Table 8. Green financing in Korea

Billion won[1]

		2009	2010	First half of 2011	Total
Guarantees	KODIT	1 662	1 820	1 475	4 957
	KOTEC	2 624	3 612	2 931	9 167
	Sub-total	4 286	5 432	4 406	14 124
Bank loans[2]		5 292	8 009	4 381	17 682
Venture capital		367	527	337	1 231
(Number of firms)		215	243	133	591

1. Most of the guarantees and lending from state-owned banks are not included in the Five-Year Plan (Table 2).
2. Outstanding loans in June 2011 amounted to 16.5 trillion or 93% of the loans made over that period, indicating that only 7% of the 17.7 trillion in loans had been rolled over.

Source: Presidential Committee on Green Growth.

36. Total bank loans to green industries amounted to 17.7 trillion won between 2009 and mid-2011 (Table 8), almost 2% of banks' corporate lending. Three-quarters of the loans were provided by state-owned banks, such as the Korea Finance Corporation and the Korea EXIM Bank. Evidence from OECD countries shows no significant correlation between public financing and the amount of private financing of innovative green growth ventures (Criscuolo and Menon, 2012). Greater reliance on lending by commercial banks would improve screening and monitoring of each firm. In addition, the 14 trillion won in loan guarantees noted above covers almost 80% of lending to green industries. For most loans, 85% is guaranteed but the ratio is raised to 90% in the case of green loans. The high share that is guaranteed weakens banks' incentives to screen and monitor credit risks.

37. The capital market is an important source for green financing, particularly through venture capital investment,[9] given the immaturity of green firms and the greater perceived commercial risk. Investment in green industries through the venture capital market nearly doubled between 2009 and 2011, reaching 1.2 trillion won (0.1% of GDP) in 591 companies (Table 8), accounting for around half of total venture capital investment in Korea. Well-functioning venture capital markets and the securitisation of innovation-related intellectual property are key sources of finance for green start-ups and need to be developed further (OECD, 2011f). The financing of green start-ups is hindered by the long timeframe to develop such projects, which tends to be longer than the average life of a venture capital fund (Criscuolo and Menon, 2012). The government is mobilising public funds, which had invested 470 billion won in 83 green firms by mid-2011.

38. In sum, public financing would be better channeled through existing market-based systems and commercial institutions, rather than relying on state-owned banks and public funds (OECD, 2011f). Granting green certificates to certain firms and technologies should be done carefully, while minimising the risk of technological lock-in and lack of competition. Compared with the surge in venture business certificates during the information technology bubble in the early 2000s, the expansion of green certificates is more gradual, as it is high risk and less easy to duplicate and deploy than IT technology, thus alleviating concerns of another bubble (Lee, 2011a). While private investment matures, government policies to provide green financing and certification should advance cautiously, as policies that "pick winners" are inherently risky given the pace of innovative change and create the risk of locking Korea into a less desirable pathway.

Promoting green innovation and private investment

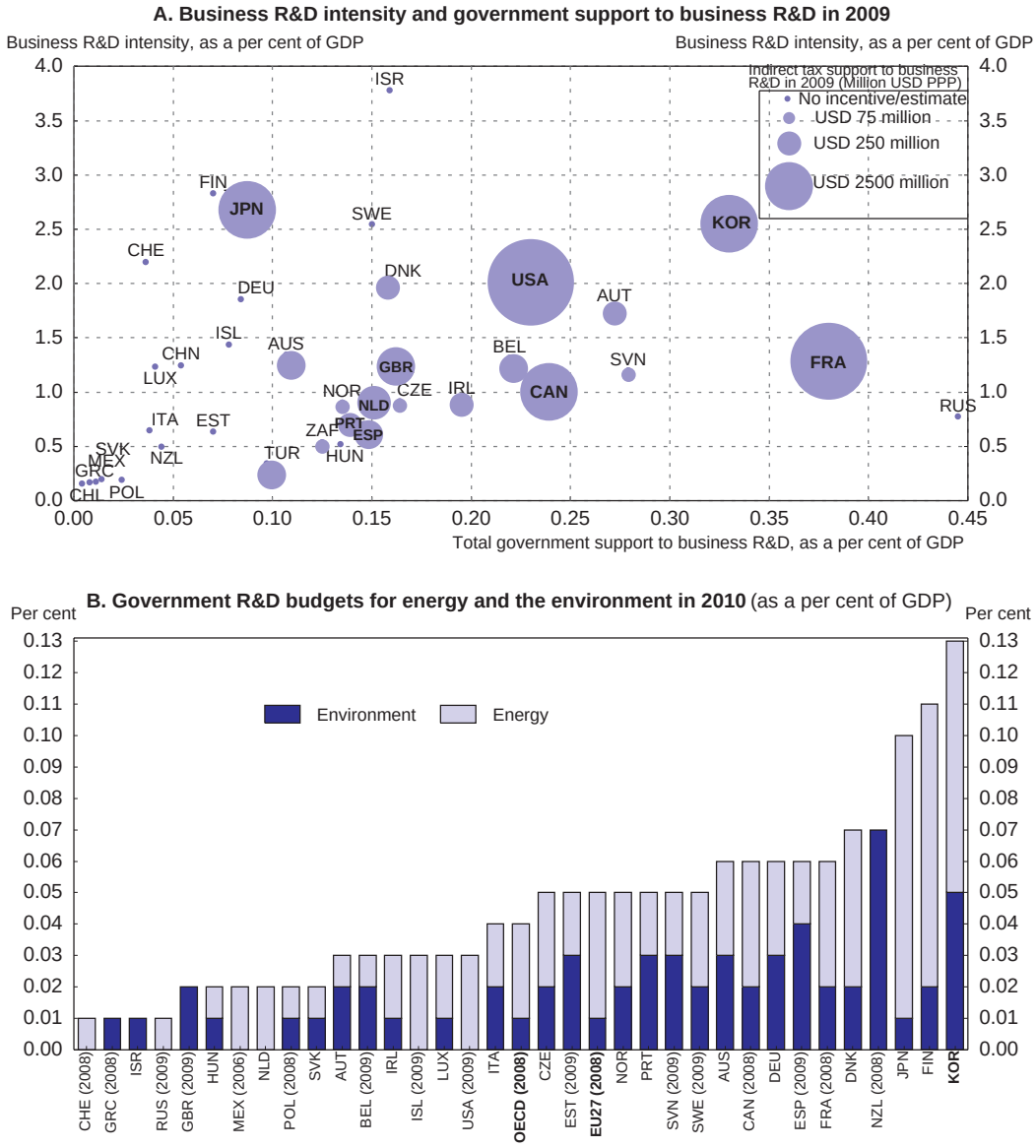
39. Innovation is an important driver of the transition to a green economy, as it develops the technologies essential to create new growth engines and jobs. The first priority, as stressed above, is to put a price on carbon to encourage green innovation. Clear and consistent price signals are needed to demonstrate the government's commitment to green growth. However, carbon pricing alone is not enough, as recent experience suggests that it does not overcome the market failures that hinder innovation, notably the difficulty for firms to fully realise the returns to their investment (OECD, 2011c). As noted above, these market failures are more prevalent in green innovation, given the high degree of uncertainty, long timescales and high fixed costs of dominant technologies (UK Committee on Climate Change, 2010). Consequently, public investment in R&D and measures to promote private R&D are needed.

40. Korea had the third-highest R&D intensity in the OECD area in 2009 with spending of 3.6% of GDP, well above the OECD average of 2.4%. The share of the business sector in R&D is also the fourth highest at 2.5% of GDP (Figure 5), financing around three-quarters of total R&D investment in Korea. Business R&D is supported by the government through R&D tax credits and allowances, tax reductions for the wages of R&D workers and accelerated depreciation of capital used for R&D. Total support amounted to 0.3% of GDP, the second highest in the OECD area after France.

41. In addition, government R&D spending, at 1.0% of GDP, exceeds the OECD average of 0.75%. For public investment in green technologies (defined as energy and the environment), Korea ranked highest in the OECD area as a share of GDP in 2010 (Figure 5, Panel B). According to the Five-Year Plan, the government will expand its green R&D from 2 trillion won in 2009 to 3.5 trillion won by 2013 (Table 2), for a five-year total of 13 trillion won (1.5% of 2009 GDP). Consequently, green R&D would rise from 16% of the government's total R&D spending in 2009 to 20% by 2013.

9. In Korea, there have been no issues of green bonds. In the global bond market, green bond issuance to date amounts to only 0.01% of total capital (OECD, 2011e).

Figure 5. R&D spending and green technologies



Source: OECD (2011e), *OECD Science, Technology and Industry Scoreboard 2011*.

42. Three-quarters of the public investment is to be allocated to the 27 core green technologies selected by the government in 2009 (Table 9). In 2011, the government assessed progress in these technologies, based on patent data and appraisal by experts. It found that Korea's overall level of technology had increased from about one-half of the most advanced countries in 2009 to around two-thirds in 2011. In six technologies, including CO2 capture and storage, smart grid and green cars, the gap had been reduced by more than 20 percentage points. Moreover, five technologies, including LED and green IT, silicon-based solar cells and light-water reactors, reached at least 80% of the cutting-edge technologies in advanced countries. The government is revising the roadmap for green technology development in 2012. Pursuing stable and consistent green growth policies is essential, as this has been found to promote patent applications in environmental technologies in OECD countries (Johnstone *et al*., 2010a).

Table 9. Level of technology in the 27 core green technologies

As a per cent of the most advanced countries in 2011

Sector	27 core green technologies	Technology level[1]
Climate change	1. Monitoring and modelling for climate change	55
	2. Climate change assessment and adaptation	55
Energy source technology	3. Silicon-based solar cells	80
	4. Non-silicon based solar cells	60
	5. Bio-energy	60
	6. Light water reactors	95
	7. Next-generation fast reactors	70
	8. Nuclear fusion energy	60
	9. Hydrogen energy R&D	60
	10. High-efficiency fuel cells	60
Technologies to improve efficiency	11. Plant growth-promoting technology	65
	12. Integrated gasification combined cycle	60
	13. Green cars	80
	14. Intelligent infrastructure for transport and logistics	65
	15. Green city and urban renaissance	60
	16. Green buildings	70
	17. Green process technology	50
	18. High-efficiency light-emitting diodes/green IT	80
	19. IT-combined electric machines	90
	20. Secondary batteries	40
End-of-pipe technology	21. CO_2 capture, storage and processing	84
	22. Non-CO_2 processing	70
	23. Assessment of water quality and management	40
	24. Alternative water resources	60
	25. Waste recycling	70
	26. R&D in monitoring and processing for hazardous substances	40
R&D in virtual reality	27. Virtual reality	70

1. Relative to advanced countries, based on patent data and appraisal by experts.

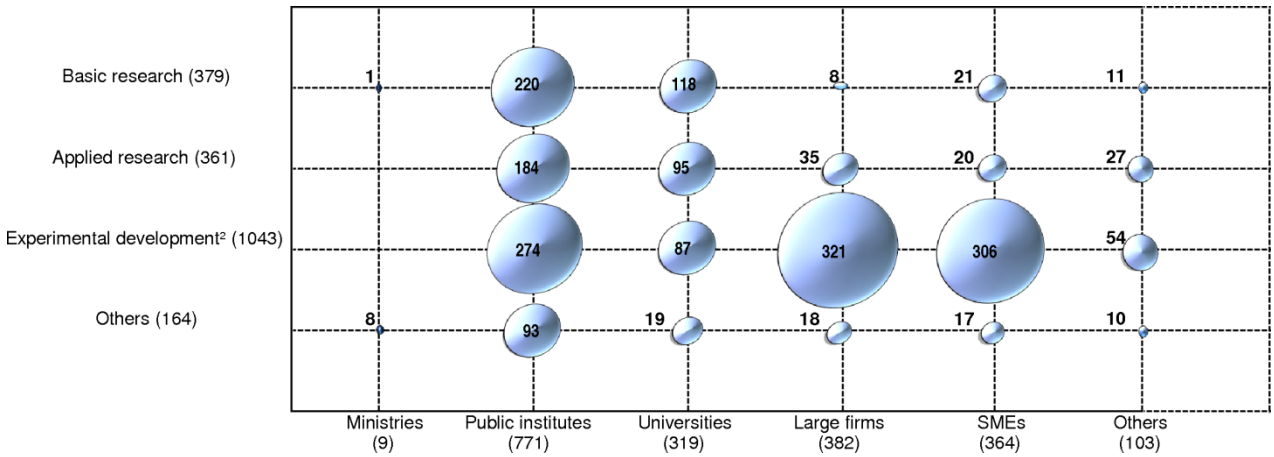
Source: KISTEP (2011).

43. More than half of total public R&D outlays in green technology were for experimental development research (Figure 6), with about 60% of it being performed in private firms. However, OECD research suggests that public R&D investment should focus on basic research, where social returns and spillover effects are potentially the greatest (OECD, 2011c). In 2009, only 20% of public investment was in basic research, although this was up from 15% in 2008. The government should follow through on its plan to raise its share to 35% in 2012, given that such research has a public good character and is unlikely to be undertaken by private firms. Regarding more commercially-oriented research, public investment should focus on general-purpose technologies and infrastructure to avoid picking winners and aim at technology neutrality (OECD, 2011c).[10]

10. More targeted support may be necessary to achieve certain climate goals, such as developing renewable energy through an RPS scheme.

Figure 6. Public R&D expenditure on green technologies by research stage and sector in 2009

In billion won[1]



1. The numbers in parentheses show the total amounts by type of research and by type of institution. The total is 1 948 billion won (0.2% of GDP).

2. Experimental development is defined as systematic work, drawing on knowledge gained from research and practical experience that is directed to producing new materials, products and devices; to installing new processes, systems and services; or to improving substantially those already produced or installed.

Source: KISTEP (2010).

44. Given that core technology development requires expertise in a range of engineering and scientific fields (KISTEP, 2010), co-operation and linkages are critical to achieve breakthroughs. It is thus encouraging that more than three-quarters of the 4 732 projects carried out in 2009 involved co-operation between government, university and business research institutes. Moreover, private firms were involved in 63% of the projects, although their financial contributions amounted to only 8% of the total, meaning that the projects were almost entirely financed by the government. Broader involvement and greater financial investment by business enterprises are needed to advance green research and make it a driver of private-sector innovation. Greater participation by universities, which employ around 70% of all doctorates but account for only 10% of total R&D spending, is also a priority. The government needs to encourage closer co-operation between government research institutes, universities and firms by facilitating joint projects, enhancing the mobility of researchers and expanding access to the research of government institutes. Reducing barriers to imports of products important for climate change technology would also promote innovation. A recent OECD study found that Korea's trade barriers in this regard are high compared to those in the EU, Japan and the United States (Steenblik and Kim, 2009).

The impact of green growth on employment and income distribution

45. The impact of the Green Growth Strategy on output growth is uncertain. It is clear that GDP is currently overestimated, as it does not take into account the depletion of natural resources. By pricing environmental externalities, Korea can become more productive, even if that were not to show up in traditional measures of output, and create a solid foundation for long-term, sustainable growth.

46. Green growth will promote employment in such sectors as renewable energy, recycling, public transport, buildings and forest management. One estimate is that expanding renewables alone could increase labour demand by 20 million worldwide by 2030 (UNEP/ILO/IOE/ITUC, 2008). In addition, the Europe Renewable Energy Council estimates that achieving the EU target of boosting renewables to 20% of total energy consumption by 2020 could increase labour demand by more than 2 million (Renner *et al.*, 2009). These gains would be partially offset by losses in energy-intensive areas, though

these employ a small portion of the workforce. Indeed, the most intensely-polluting industries in OECD countries, accounting for 82% of CO2 emissions in the nonagricultural sector in 2004, employed only 8% of the total workforce (OECD, 2011f). Moreover, a number of studies have found that the shift towards renewables will generate more jobs per megawatt of power installed, per unit of energy produced, and per dollar of investment, than fossil fuel-based energy (OECD, 2011f). Shifting to green growth is likely to increase employment although it depends on how the revenues from an ETS or a carbon tax are used:

- An OECD study estimates that GHG emission reduction policies would boost employment by 1% if permit revenues are used to cut taxes on labour (OECD, 2011f).

- Achieving Korea's 2020 GHG emission reduction target would expand employment by 0.3% compared to the baseline (Kim and Lim, 2010). The estimate assumes that the renewable industry expands to 0.9% of GDP and that half of the revenues from the ETS is spent by the government. Job gains in renewables would offset losses in energy-intensive industries, which would bear 80% of the projected fall in manufacturing output.

47. However, the shift to green growth implies significant transition costs to achieve the long-term benefits. Changing production processes, consumption patterns and industrial structure will be expensive and time-consuming. To mitigate the transition costs, labour market policies should ensure that workers and firms are able to adjust quickly. The *OECD Reassessed Jobs Strategy* (OECD, 2006b) cites the importance of employment mobility and labour training to reconcile the "creative destruction" of green growth with a high level of employment, thereby achieving a smooth transition.

48. Korea needs improvement in both of these areas (2012 *OECD Economic Survey of Korea*). *First*, employment protection is a problem, given the heavy reliance on non-regular workers, most of whom have temporary contracts. Moreover, Korea needs greater mobility of workers across occupations and sectors to facilitate the shift to a green economy. *Second*, public expenditure on labour training programmes as a percentage of GDP in Korea is one of the lowest among OECD countries. Expanding public training expenditures is essential to avoid skill gaps and shortages that could hinder the progress of green firms. In addition to more spending, stronger industry involvement in training programmes should be encouraged to meet relevant labour demands. Creating a map of skill requirements for green jobs would be an important first step for upgrading the training system. Over the medium term, similar efforts should be made to improve the vocational education system.

49. Labour market policies need to be accompanied by measures to ensure that green growth is not achieved at the cost of increased income inequality (2012 *OECD Economic Survey of Korea*). A successful Green Growth Strategy should thus take account of its distributional impact. Concerns regarding distributional effects relate to the competitiveness impact on firms, as discussed above, and the welfare effect on households. Households are affected by the regressive nature of environmental taxes, including carbon taxes, and the negative income effect of phasing out environmentally-harmful energy subsidies. A study by the Korea Environment Institute confirms that a carbon tax in Korea would have a regressive impact, as it increases the burden on low-income households, which spend a higher proportion of their income on energy (KEI, 2010). Expanding renewable energy sources in electricity production would also increase electricity prices. Such policies would increase the burden on low-income households, which spend a higher proportion of their income on energy. The government should analyse the overall impact on income equality from the transition to a greener economy and incorporate comprehensive counter-measures into the strategy.

50. Managing the equity consequences is essential for the success of the green growth strategy by gaining public support and ensuring fair outcomes. Korea starts from a low level of social protection; only around one-third of unemployed workers receive unemployment benefits. In general, the negative equity

effects of green growth can be best addressed by policies such as cutting personal income taxes, providing tax credits and increasing social benefits, rather than by exempting low-income households from environmentally-related taxes, which would reduce their incentives to use energy more efficiently (OECD, 2011e). Given that only around half of workers pay personal income taxes in Korea and that income tax rates are low, expanding the earned income tax credit, an in-work benefit, should be a priority to compensate the poorest households that will be most strongly affected. Revenues from auctioned permits and environmental taxes should be used in part to strengthen the social safety net.

Improving the quality of life through green growth

51. One of main benefits of green growth would be improved environmental conditions by cutting air pollution, reducing exposure to various pollutants and increasing access to basic environmental services, in particular clean water (OECD, 2011g). One study found that air pollution would be dramatically reduced if GHG emissions were cut by 50%, resulting in substantial gains in life expectancy (Bollen *et al*., 2009). Using an index of economic welfare that combines changes in GDP per capita and the value of living longer, an OECD study estimates that the gains in life expectancy would halve the cost associated with climate change mitigation measures (de Serres and Murtin, 2011). One of the greatest non-market benefits from green growth in Korea would be an improvement in the capital region's air quality, which is one of the worst in the OECD area. Indeed, emissions of nitrogen dioxide (NO2) and sulfur dioxide (SO2) were almost double that in Paris, London and Tokyo in 2008 (Jun, 2010). The high level of NO2 is due to private vehicles, which are responsible for nearly three-quarters of air pollution in the capital region (Kamal-Chaoui *et al*., 2011). The social costs of air pollution in Korea are estimated at 5% of GDP (OECD, 2006b).

52. The government's objective is to boost air quality in the capital region to the OECD average by 2014, primarily through the emission cap-and-trade programme introduced in 2008 covering NO2 and SO2 from large-scale emitters in the capital region.[11] The system was extended in 2010 to mid-size emitters, covering a total of around 300 factories in the capital region. The objective is to reduce annual emissions by nearly 30% between 2008 and 2012. At present, permits are allocated by grandfathering based on average emissions during the past five years. Thus far, however, average emissions were only about 60% of the target, indicating that it is too high. The target could therefore be gradually reduced to further improve air quality. As with an ETS, auctioning permits would enhance efficiency. The expectation of continued allocation through grandfathering weakens incentives to reduce emissions and acts as an entry barrier for new firms.

53. While the trading system applies to fixed sources of emissions, vehicles are a major pollution source in the capital region, making it important to diminish road traffic volume and enhance the energy efficiency of vehicles. Achieving the target to increase the share of public transport from 50% to 65% by 2020 requires improvement in its accessibility and convenience. Greater use of bicycles would be one alternative by offering public rentals and expanding bike paths. Another priority is to improve fuel efficiency of individual vehicles. The government introduced mandatory standards for vehicle GHG emissions and average fuel efficiency in 2012, at a level similar to that in the United States. Such standards will help Korea prepare for the introduction of a price on carbon.

Conclusion

54. The priority should be to establish a framework that will promote the transformation to a low-carbon economy while sustaining economic growth. *First*, it is essential to establish a price for carbon

11. During 2008-10, the number of transactions under this system reached 114 for 3 858 tonnes, only 1.5% of the total amount of permits, reflecting the fact that emissions were only 60% of the amount of permits.

through an ETS in 2015 as planned and a carbon tax, thereby encouraging R&D and innovation in green technology by households and firms. It should be made clear that the cost of achieving Korea's GHG emission reduction target through regulation would be more than twice as expensive as introducing a carbon price (Lee, 2009). *Second*, given market failures, there is a role for the public sector, notably in R&D and in promoting renewable energy. *Third*, the shift towards a low-carbon economy requires the reallocation of capital and labour resources across sectors, making it important to ensure adequate financial support for green industry, labour market flexibility and effective training. *Fourth*, the distributional impact of the Green Growth Strategy should be taken into account and mitigated through comprehensive remedy measures to ensure fair outcomes. Such a framework would minimise the cost of achieving Korea's GHG emission target while promoting the continued convergence of living standards to the high-income countries. Specific policy recommendations to improve Korea's green growth framework are provided in Table 10.

Table 10. Taking stock of structural reforms in the area of green growth

Recommendations in the 2010 *Survey*	Actions taken or proposed by the authorities	Summary of recommendations for Korea's green growth strategy in the 2012 *Survey*
	Mitigating climate change	
Introduce market-based instruments as soon as possible to achieve the 2020 GHG emission target in a cost-effective way by ensuring that abatement costs are equal at the margin across all options.	The government submitted a bill to create an emissions trading scheme (ETS), which will begin in 2015, to the National Assembly in April 2011. It was approved by a subcommittee in February 2012.	Achieve final approval of the bill to create an ETS, preferably before the end of the current session of the National Assembly in May 2012.
Put a price on carbon emissions by creating a mandatory and comprehensive cap-and-trade ETS, which provides a clear price signal to enable market participants to make appropriate investments.	The cap-and-trade ETS in the bill will cover six types of GHGs and firms with more than 25 thousand tonnes of annual emissions.	Achieve final approval of the bill to create an ETS before the end of the current session of the National Assembly in May 2012.
Auction ETS permits.	Less than 5% of the permits in the proposed ETS may be auctioned in the first and second phases.	Announce a schedule to phase out grandfathering and expand the auctioning of permits.
Allow ETS permits to be banked for the future and, perhaps, borrowed.	In the proposed legislation, banking and borrowing would be allowed in the first phase.	Allow banking and borrowing to reduce price volatility.
Introduce a carbon tax in areas not covered by the ETS.	No action taken.	Introduce a carbon tax to reduce emissions in sectors not covered by the ETS.
Accelerate the phasing out of environmentally-harmful energy subsidies and ensure that energy prices in each sector reflect production costs.	The Coal Production Security Fund, which made up the difference between the cost of coal production and its sales price, was abolished in 2010.	Reform the electricity pricing system by raising prices to reflect unit costs in each sector and replacing the sectoral price structure with electricity prices set by voltage to effectively reflect costs.
Stop earmarking environmental taxes for transport construction, especially roads.	No action taken.	Stop earmarking environmental taxes for transport construction, especially roads.
Encourage the development of renewable energy resources by removing non-economic barriers and establishing a predictable and transparent support framework with incentives that decrease over time.	The Renewable Portfolio Standard (RPS) was launched in 2012, with an aim of increasing renewables' share of the total electricity supply from 2% in 2012 to 10% by 2022.	Monitor the market for renewables to avoid excessive reliance on low-quality options, while promoting long-term contracts to stabilise prices.
		Phase out the Target Management System, once the ETS and the carbon tax are in place.
	Creating new engines for growth	
Ensure that spending in the Five-Year Plan (2009-13) is implemented in a transparent and effective manner to address market failures, while	The government started monthly implementation evaluation meetings, chaired by the Prime Minister, from September 2011.	Effectively use the large-scale expenditures in the Five-Year Plan to promote green investment and innovation that will underpin sustained growth and

avoiding outlays designed to boost specific industries.		give rise to new economic opportunities.
Promote green innovation by increasing its share in public R&D, focusing on basic research, particularly in areas related to large-scale private-sector projects and in technologies still too far from commercial viability to attract private investment.	Green R&D is to rise from 16% of the government's total R&D spending in 2009 to 20% by 2013, while the share of basic research in total R&D is to rise from 15% to 35% between 2008 and 2012.	Focus more on basic research in green technologies in public research institutions, emphasising technology-neutral approaches, and attract more involvement from industry and academia.
Improve the overall innovation framework by spending more on basic research, closely linking government research institutes, universities and industry and reducing the mismatch between human resources and research spending in universities.	Three-quarters of the total number of green R&D projects were carried out by co-operation between research institutes in different sectors. However, the financial contributions of private firms amounted to only 8% of the total.	Encourage closer co-operation between government research institutes, universities and firms by facilitating joint projects, enhancing the mobility of researchers and expanding access to the research of government institutes.
Design the green certificate programme and the green finance initiatives carefully to limit the risk of bubbles.	The professional organisations of each technology sector are responsible for evaluation, and a two-step evaluation procedure, including an on-site inspection and document review, is required.	Channel necessary funds to green businesses through the existing market-based systems and private firms rather than directly through public institutions.
Ensure good framework conditions, including openness to foreign investment and a strong competition framework, to facilitate entry of new firms and the exit of firms in declining industries.	The government relaxed 28 market entry regulations, primarily in services, and simplified the approval process for FDI in 2009-10.	Continue to foster green financing for firms, while enforcing rigorous certificate criteria and limiting the inherent risks of "picking winners".
Enhance flexibility in the labour market and ensure adequate training of workers to facilitate the transition toward a greener economy.	The government introduced free training programmes for non-regular workers in 2009 and expanded them in 2010.	Enhance labour market flexibility and expand effective training systems for skills needed for green growth.
		Incorporate social measures, such as expanding the EITC and the social safety net, in the Green Growth Strategy to offset its adverse distributional impacts.
Improving the quality of life through a better environment		
Gradually reduce the level of emissions allowed under the cap-and-trade programme covering NOx, SOx and TSP in the capital region to improve air quality to the level in advanced OECD countries.	The target was set to reduce annual emissions by nearly 30% between 2008 and 2012.	Continuously reduce overall emission caps under the cap-and-trade programme to improve air quality and shift from allocation through grandfathering to an auction scheme to enhance efficiency.
Increase the Average Fuel Efficiency standards to reduce NOx emissions, notably in the capital region.	The government enacted mandatory standards for vehicle GHG emissions and average fuel efficiency in April 2010. This regulation will be applied to 30% of all sales in 2012 and expanded to 100% by 2015.	Improve the accessibility and convenience of public transport, promote the use of bicycles and raise the Average Fuel Efficiency standards for vehicles to reduce pollution, notably in the capital region, until a price on carbon is introduced.

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