

A Review of Climate Change Mitigation Measures from Major Cities of United Kingdom and China

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Authors' contributions

This work was carried out in collaboration between all authors. Author MAI designed the study and wrote the first draft of the manuscript. Author SAH managed the literature searches of the study while authors EA and TB managed the final draft. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JGEESI/2015/18399

Editor(s):

(1) Zeyuan Qiu, Department of Chemistry and Environmental Sciences, New Jersey Institute of Technology, USA.

Reviewers:

(1) Antipas S. Massawe, Department of Chemical & Mining Engineering, University of Dar es Salaam, Tanzania.

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Complete Peer review History: <http://www.sciencedomain.org/review-history.php?iid=1105&id=42&aid=9588>

Review Article

Received 20th April 2015
Accepted 8th May 2015
Published 4th June 2015

ABSTRACT

The study explored new strategies and technologies being used by cities around United Kingdom and China to mitigate climate change. So as to enable other cities in the world to emulate similar strategies. Hence, the study reviewed the adaptation strategies of five cities. One of such strategies is the “sustainable Glasgow project” aimed at reducing Glasgow’s carbon emissions through improved energy management and the development of new integrated low carbon energy systems for the city. Similarly many organisations in Dundee set up a “carbon reduction targets”. The Lewisham Council established a systematic approach to energy monitoring, based on electronic data retrieval systems. China although a non-Annexe1 country, also hosted the largest number of Clean Development Mechanism (CDM) projects and also generated the largest number of certified emission reduction (CERs) in the world.

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Keywords: Climate; change; mitigation; measures; cities.

1. INTRODUCTION

Climate change is a major environmental issue in today's world. Mitigation strategies to cope with climate change are very much important to city planners and environmentalist in order to manage gas emissions and the risk associated with it. More than half of the world cities are emerging as the 'first responders' in adapting to and mitigating climate change [1-3].

Over the past two decades one of the most unexpected responses to climate change has been the growing involvement of municipal governments and other urban actors in the efforts to reduce emissions of greenhouse gases (GHGs) and increasingly to adopt adaptation measures [4]. Researchers and scholars have drawn attention to the development of urban climate governance in regards to changing geographies and politics of municipal responses.

[5] in the early 1990s an initial trend of municipal responses to climate change can be identified from the literature. When it became clear that climate change was not just another myth, Industrialised countries in Europe and North America began series of research into mitigation strategies.

In 1988 the international conference on the "Changing Atmosphere" widely regarded as a policy catalyst for the international science community and many nations, played a vital role. Although in some European countries such as the United Kingdom and Germany, had already began early development of climate change policies targeted at energy conservation and sustainable development [6,7].

Human health, being a major issue in many countries could be adversely affected by climate change [8]. Therefore, it is important to determine how communities are able to handle the impacts of climate change [9]. Decisions concerning investments need to take into account climate change. However, putting climate change into the decision making process for future investment is not an easy task, for the following reasons; [10] First, due to the rate of climate change, new infrastructure will have to be able to cope with a large range of changing climate situations, which will make the decision making process more difficult and construction more expensive. Secondly, uncertainty in future

climate makes it impossible to directly use the output of a single climate model as an input for infrastructure design, and there are good reasons to think that the needed climate information will not be available soon [11]. However, one thing is certain, future planning of infrastructure projects should be made more vigorous to enable infrastructure withstand possible changes in climatic conditions. The world's climate is changing and will continue to change into the coming century at rates projected to be unique in recent human history [12]. The risks related with these changes are real but highly uncertain. Societal vulnerability to the risks associated with climate change may aggravate on-going social and economic challenges, particularly for those parts of the societies dependent on resources that are sensitive to changes in climate. Risks are apparent in agriculture, fisheries and many other components that constitute the livelihood of rural populations in developing countries [9,13].

City planners need to link climate-change issues to broader agendas [14]. Discussions about whether to invest in a more efficient fossil-fuel power plant or renewable energy sources, for example, need to be connected to discussions about the cost of energy and localized pollution impacts of power plant operations [15].

Issues such as sustainable water supplies and sewage-treatment strategies must be evaluated for their links to climate concerns [16]. Studies of the urban governance of climate change have proliferated over the past decade, as municipalities across the world increasingly place the issue on their agendas and private actors seek to respond to the issue. The study explores the new strategies and technologies major cities around the United Kingdom and China have adopted successfully in the context of climate change mitigation and/or adaptation measures that other cities in the world could emulate.

2. CASE STUDIES FROM DIFFERENT CITIES OF THE UNITED KINGDOM

2.1 Glasgow

"Sustainable Glasgow" has proposed to reduce Glasgow's carbon emissions through improved energy management and the development of new integrated low carbon energy systems for the city as shown in Fig. 1.

The Sustainable Glasgow project proposed some major integrated low carbon energy systems for Glasgow. These are highlighted in Fig. 1.

- Implementation of improved energy management systems and energy efficiency measures across all sectors.
- Creating systems to turn the city's sewage and municipal waste into biogas, this will be used in generating heat and power and in transport.
- Urban woodland should be created on the city's vacant land and the resultant biomass will be used for heat and power generation.
- Development of a district heating system for the city, starting in 5 identified zones.
- Development of highly efficient natural gas/biogas fuelled Combined Heat and Power systems.
- Restricting use of petrol and diesel vehicles.
- Increased the use of biogas and electrically powered vehicles.
- Phasing out electrical, coal, and oil heating across the city.
- Exploiting local renewable energy resources. Such as biomass, solar power, wind mills etc.

- Capturing waste heat from industries, produce energy from waste and produce biogas from sewage and municipal waste [17].

Since 2003 in partnership with Strathclyde and Central Energy Efficiency Advice Centre, Glasgow city council has targeted over 212,000 homes in Glasgow (approx. 75%) with mail drops containing information on energy efficiency and the grants that are available for home improvements such as loft insulation and the installation of central heating. This will result in the reduction of at least 5,328 tonnes of CO₂ emissions and total savings of approximately £433,580 [18].

Since the introduction of the Home Energy Conservation Act (HECA) 1995, Glasgow City Council has developed schemes and partnership arrangements to maximise the energy savings and associated benefits for the residents of the city. Thus in 8 year period CO₂ emission reduced by 458,111 tonnes. Glasgow city council has taken strategies to reduce the use of fossil fuels by replacing them with renewable sources of energy such as wind, water, solar and biomass. The council has installed many roof mounted wind turbines and plans to install a further eight units. The council is committed to reducing the traffic level of the city. Encouraging the use of

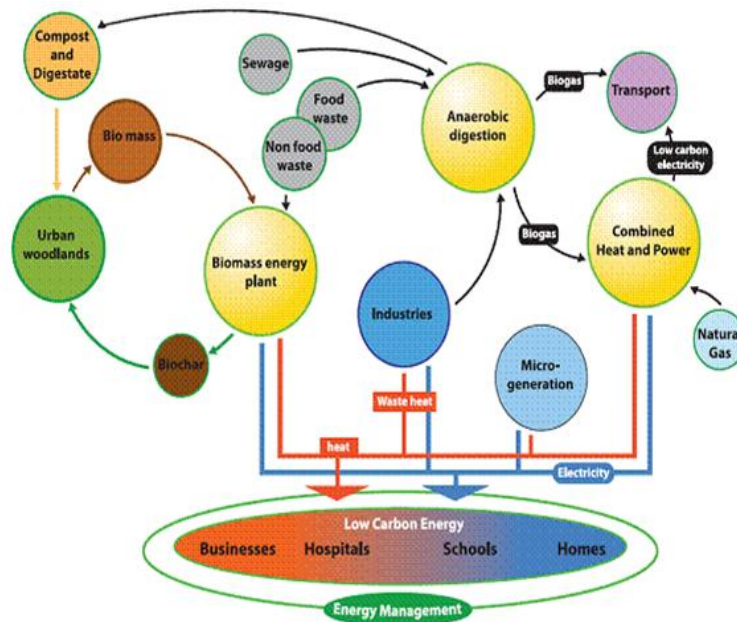


Fig. 1. Proposed integrated low carbon energy systems for Glasgow
(Source: Sustainable Glasgow, 2010)

public transport is a key concern for the council. The council has an on-going programme of vehicle emissions testing to ensure that polluting vehicles are not being used for Council business. In 2005, as part of the vehicle replacement programme, funding was secured for the trial of a number of vehicles with a selective catalytic reduction system (SCR). Through this system 70 – 90% reduction in oxides of nitrogen emissions and reduction in diesel particulate matter can be possible [17].

Glasgow City Council is a partner in the largest of the eleven designated waste management areas and is firmly committed to the “Glasgow and Clyde Valley’s area waste plan” which is intended to move towards an integrated and more sustainable system of waste management in accordance with the waste hierarchy. Currently, 93,000 households are provided with a kerbside recycling collection service for dry recyclables (e.g. paper, cans and plastics). Over 55,000 households are also provided with a brown bin for organic garden waste and the Council is working in partnership with the Waste and Resources Action Programme (WRAP) to promote Home Composting to reduce the levels of biodegradable garden waste being landfilled [17].

2.2 Dundee

Dundee area covers an area of 67 sq km. In the year 2006 the total population of Dundee city was 141,937 and the total population of Dundee metropolitan area stood at 159,522 [19].

The total carbon footprint of Dundee is 1,769,301 Tonnes. Fig. 2 which shows carbon emission by sector in Dundee reveals that the housing sector produces more carbon emissions than most other sectors in the city. Per capita carbon footprint of Dundee is 12.74 tonnes whereas the per capita carbon footprint of Scotland is 12.16 tonnes and the per capita carbon footprint of UK is 12.08 tonnes [20].

Fig. 2 shows that, the second sector responsible for most carbon footprint in Dundee is the transportation sector (22%). However, Table 3 revealed a slight reduction of CO² in the transportation sector between 2005 and 2006.

Table 1 shows the total emissions per head of population and industrial emissions as a proportion of economic output (GVA) of Dundee and other regions of Scotland.

From Table 2 we can see that, in the year 2006, Dundee city generated 4,100 kt of CO₂. That is 9% of total emissions in Scotland. 9 tonnes of CO₂ emitted in per head of population in Dundee. The industrial emissions per £1,000 GVA is 280 in Dundee whereas for the whole UK the industrial emissions per £1,000 GVA is 230 [21].

2.2.1 Carbon management plan of Dundee city council

Dundee City Council partnered with the Carbon Trust on Carbon Management programme has set a target to reduce CO₂ emission by 10% by 2013. The Council’s carbon management plans are given below:

- Continually quantify and review of annual greenhouse gas emissions from Dundee city council’s own operations.
- Identify priority areas for the reduction of greenhouse gas emissions.
- Reduce 2007/08 CO₂ emission by 10% by the year 2013.
- Reduce 2007/08 CO₂ emissions from employee travel directly related to the provision of their services by 10% by 2013.
- Encourage workforce involvement in the identification of opportunities and the implementation of action [20].

According to Dundee City Council, the Council’s carbon emissions baseline for 2007/08 was over 51,000 tonnes in Dundee.

“Business as usual emission” is a situation whereby policies and activities are maintained without any carbon reduction measures. Projections from the baseline of 2007/08 shows that the annual emissions for 2007/8 baseline (51,081 tonnes) shall increase to 52,894 tonnes by the year 2012/13. Dundee city council’s reduction target is 45,973 tonnes by the year 2012/13 that is 10% reduction from the emission of 2007/08.

To achieve the target to reduce carbon emission, Dundee city council has implemented a number of initiatives. The council has a target to reduce the overall energy consumption during this period by approximately 11.2 %, which will result in the reduction of 4100 tonnes of Carbon Dioxide (CO₂) emissions. In order to achieve sustainability in waste management and to reduce carbon emission, Dundee city council is engaged in recycling of paper, cardboards,

plastic bottles, aluminium cans, garden waste, IT equipment, furniture, fluorescent tubes and toner cartridges. In 2007, the council formally adopted an office furniture reuse strategy. To reduce the carbon and to take action for the climate change, Dundee city council frequently engage in campaigns to increase awareness in the both public and private sectors [20].

Dundee city council has funded in 14 energy saving projects that will save 0.77 % of the total CO₂ attributed to their properties. Those are given below.

There are 80 energy saving measures have been identified for 21 educational properties with an

estimated cost of £500,000 with the resultant annual savings of approximately £52,000 and 442 tonnes of CO₂.

The city council has proposed 19 opportunities for investigation in the medium to long term. Those are given below.

The council has introduced two electric vehicles to its waste management fleet to reduce its carbon emissions. The two Mega electric tippers are being used by the waste management department in Dundee town centre, Lochee and Broughty Ferry [22].

Table 1. The per capita and total carbon, GHG and ecological footprint of Dundee city in 2004

Dundee city (Population 138,915)						
Total	Per Capita Foot Print			Total Footprint		
	Ecological Footprint	Carbon Footprint	GHG Footprint	Total Ecological Footprint	Total Carbon Footprint	Total GHG Footprint
	5.65	12.74	17.24	784,385	1,769,301	2,394,248
Housing	1.80	4.71	5.48	249,966	653,879	760,647
Transport	0.86	2.84	3.28	119,175	394,801	455,733
Food	1.32	1.15	2.86	182,761	160,108	397,598
Consumer	0.67	1.32	1.93	93,504	183,941	268,727
Private	0.28	0.71	1.03	38,271	98,972	143,283
Services						
Public	0.59	1.58	2.13	82,407	219,108	296,313
Services						
Capital	0.12	0.36	0.46	17,271	49,338	64,091
Investment						
Other	0.01	0.07	0.06	1,030	9,156	7,855

Themes as percentage of total			
	per capita foot print		
	Ecological footprint percentage breakdown	Carbon footprint percentage breakdown	GHG footprint percentage breakdown
Housing	32%	37%	32%
Transport	15%	22%	19%
Food	23%	9%	17%
Consumer items	12%	10%	11%
Private services	5%	6%	6%
Public services	11%	12%	12%
Capital Investment	2%	3%	3%
Other	0%	1%	1%
Placing in Scottish LA's	30/32	26/32	26/32
UK average	5.30	12.08	16.34
SCOTLAND average	5.34	12.16	16.46

Source: (Dundee City Council, 2009)

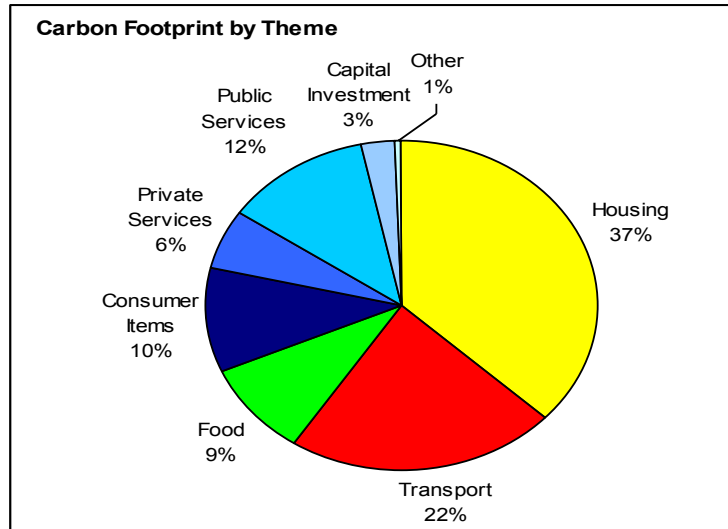


Fig. 2. Carbon footprint of Dundee by sectors
(Source: Dundee City Council, 2009)

Table 2. The CO₂ emissions in Dundee and other regions of Scotland in the year 2006

	Co ² Emissions			
	Total CO ² Emissions 2006 (kt)	% Change in CO ² Emissions 2005-2006	Total CO ² per head of population	Industrial CO ² Per £1,000 GVA
Dundee City Region	41,00	-1%	9	280
Aberdeen City & Shire	52,00	-2%	12	300
East Region	15,500	1%	10	340
West Region	15,500	2%	7	190
Scotland	43,500	1%	8	260
UK	531,700	0%	9	230

Source: (Scottish Enterprise, 2009)

Table 3. The comparison of CO₂ emission in Dundee in the year 2005 and 2006

Dundee city	Kt CO ²		Per capita emission (t)	
	2005	2006	2005	2006
Industry, Commercial and Public sector	502	517	3.52	3.63
Domestic	490	497	3.44	3.48
Road Transport	144	142	1.00	0.99
Land Use, Land Use Change & Forestry	6	7	0.04	0.04
Total	1,142	1,163	8.02	8.81
Scottish Average	-	-	8.47	8.50
UK Average	-	-	8.84	8.78
Placing in Scottish Local Authorities	-	-	17/32	17/32

Source: (Dundee City Council, 2009)

2.2.2 Carbon management plan of Dundee organisations

University of Abertay Dundee has set a target to reduce its carbon dioxide emissions by 25% by

2013, which will save £600,000 over five years. Dundee City Council has set target to reduce its carbon emissions by 10% by 2013, shown above in Table 4 which will save £5.25 million. NHS Tayside has set target to reduce emissions by

6,417 tonnes by 2014, which will deliver an energy bill reduction of £2.5 million in five years. These organisations are among 24 organizations in Scotland who have completed the sixth phase of the Carbon Management Programme and received a certificate from the Carbon Trust. These organisations established their current baseline emissions and assess the risks and opportunities posed by climate change and developing strategies to reduce their carbon footprints over a five to ten-year period [23]. 2010). Table 5 has shown planned/funded projects of Dundee city council.

Michelin Tyre PLC, a big car tyre manufacturing company in Dundee, has set a target of a 20% environmental impact reduction across all production sites by 2011. The company has also registered zero landfill since 2007 and reduced its energy use since 1998 by 30%. The Dundee

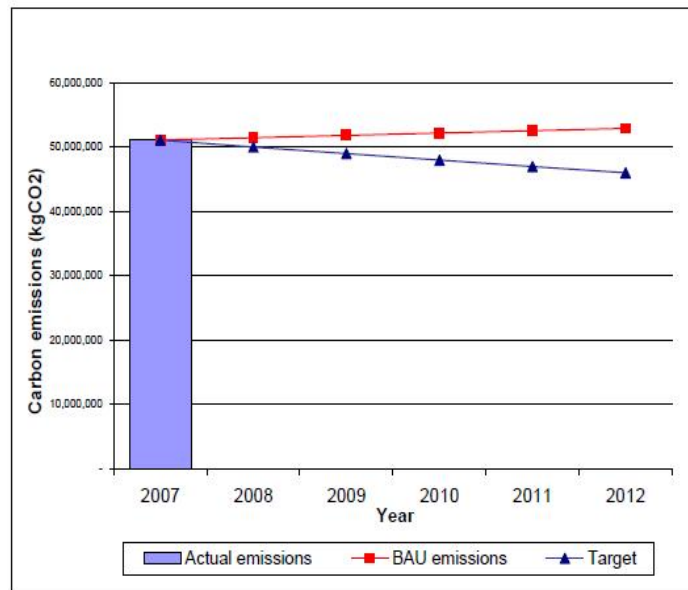
factory of Michelin manufactures over 6.5 million car tyres each year and the largest private sector employer in Dundee. The factory has opened two wind turbines at the site in 2006 and marked Dundee as the first Michelin factory in the world to embrace wind energy with two wind turbine generators.

2.2.3 Carbon reduction strategies of NHS Tayside

NHS Tayside has set a target of reducing CO₂ emissions by 20% by 2013, using 2007/08 as the baseline year mentions in Table 7 and Fig 4. This reduction will equate to 6,417 tonnes of CO₂ emissions, generating approximately £2.15 m cost savings over the 5 years. In business as usual case NHS Tayside’s CO₂ emissions over the next 5 years will increase by 1,898 tonnes with a cost of £4.36 m.

Table 4. CO2 emission of Dundee city council in 2007/08

	Total	Buildings and street lights	Transport	Water
Baseline CO ₂ emissions (tonnes)	47,469	41,528	5,796	145
Baseline cost (£)	£9,494,829	£5,716,801	£2,521,199	£1,256,829



	2007/08	2008/09	2009/10	2010/2011	2011/12	2012/13
BAU scenario total (tCO ₂)	51,081	51,439	51,799	52,161	52,526	52,894
Reduced emission scenario (tCO ₂)		50,016	48,973	47,952	46,952	45,973
Reduction since year 1		2%	4%	6%	8%	10%

Source: Dundee City Council, 2009

Table 5. Planned/funded projects of Dundee city council

Ref	Project	Lead	Cap'l	Rev'ue	Res, ce	Fin	CO ² tonnes	Pay back Years	Year
08/001	Replace existing lamps with low energy lamps in 5 properties	EEO	£4,960	-	-	£5,201	37.0	0.9	2008/9
08/002	Install automatic lighting controls in 2 properties	EEO	£11,250	-	-	£2,471	18.0	4.6	2008/9
08/003	Fit photo electric cell switching internal and external lighting and extract fans in properties	EEO	£4,960	-	-	£621	4.0	3.4	2008/9
08/004	3 properties Modify control system to utilize free cooling when ambient temperature is below 14 Deg C	EEO	£18,00	-	-	£1,396	8.0	1.3	2008/9
08/005	Insulate valves and flanges in the boiler house of 2 properties	EEO	£800	-	-	£826	2.0	2.45	2008/9
08/006	Central library fit draught stripping	EEO	£4,960	-	-	£621	4.0	3.4	2008/9
08/7/8/9/10/11	Install 5kw electric to 12kw Gas CHP unit in 5 properties	EEO	£500	-	-	£172	0.40	7.17	2008/9
08/012	Craigie House RHE Install CHP unit 5kw estimated load	EEO	£17,000	-	-	£1,405	11	2	2008/9
08/014	Turriff House RHE Install CHP unit 5kw estimated load	EEO	£17,000	-	-	£1,405	11	12	2008/9
08/015	fit draught stripping in 5 properties	EEO	£1,900	-	-	£349	2.00	5.8	2008/9
08/016	Install Insulation to valves and flanges in the boiler house of 10 properties	EEO	£5,000	-	-	£922	5.0	5.4	2008/9
08/017	Lochee swimming pool and library install heat recovery system	EEO	£3,500	-	-	£628	4.0	5.5	2008/9
08/018	Replace existing fluorescent tubes and fitting with a new lighting scheme in 8 properties	EEO	£67,000	-	-	£7,847	105	8.6	2008/9
08/019	Install automatic lighting controls to switch off lighting when not occupied in 3 properties	EEO	£9,200	-	-	£1370	8.0	6.8	2008/9

Source: (Dundee City Council, 2009)

To reduce CO₂ emission, NHS Tayside's strategies are given below:

- Achieve target of 20% CO₂ reduction by 2013.
- Produce Energy Performance Certificates for buildings that meet the criteria under the Energy Performance Building Directives in 2009.
- Raise the profile of energy efficiency and environmental management throughout NHS Tayside by means of regular report updates to the Board and both Clinical and Non Clinical Departments.
- Promote staff awareness, influence and change behavioural practices on environmental and energy efficiency through campaigns.
- Encourage staff to consider using public transport.
- Promote the use of IT facilities such as teleconferencing to reduce the need for travel to meetings. Reduce the use of paper in day-to-day activities.
- Ensure that sustainability is one of the core elements in any design, construction and refurbishment project. The potential for renewable energy technology applications must be considered for all new and refurbishment projects.
- Work in partnership with other governmental bodies such as Carbon Trust, Local Authorities and Universities to support and develop common environmental objectives [24].
- CO₂ emissions of NHS Tayside from different sources are mention below in Fig. 3.

Many energy savings projects are already taken by NHS Tayside. Those are given below in Table 6.

- Installation of high efficiency heat exchangers in Ninewells Hospital, which will save CO₂ of 228 tonnes annually.
- Replacement of pipe street lighting with energy efficient light fittings with sensors.
- NHS Tayside invested £410,000 on central energy efficiency projects which implemented from 2007 to 2009 and saved 1,360,000 kg CO₂ [24].

3. LEWISHAM

Lewisham is a district in south London. Lewisham Council was awarded Beacon Status in 2005/06 for work on sustainable energy. The Lewisham Council has established a systematic approach to energy monitoring, based on electronic data retrieval systems. This monitoring system analyses energy use to identify the worst performing buildings, enabling energy saving improvement works to be targeted where they are needed most and where they will deliver the greatest cost savings. The council has taken future programme for the building of schools which is creating new school buildings across the borough and will include renewable energy technologies. Each has a target to generate 20% of its energy use from renewable features. The council has set priority to buy environmentally friendly vehicles. The council is using renewable solar power for some street lighting, which is reducing CO₂ emissions as well as energy consumption. The Council's Waste Strategy is based on the waste hierarchy of reduce, reuse, recycle and compost, energy recovery and disposal. The Council has established an environmental award for business organizations. This award recognises and celebrates businesses that have developed sustainable business practices. The council has taken strategic planning and policy framework for establishing the conditions that will shape energy consumption now and in future years through planning, transport and housing policies. The council is empowering local people and communities to come together to create their own local proposals for reducing energy use and consumption. From 2008 the council developed a programme whereby all social housing providers are required to produce an Energy Performance Certificate (EPC) prior to the renting out of each property. All new developments over 1000m² floor-space or comprising 10 or more dwellings should meet the Council's target of 20% on-site renewable energy generation [25].

4. CASE STUDIES FROM DIFFERENT MAJOR CITIES OF THE CHINA

4.1 Beijing and Shanghai

[26] Discussed the carbon reduction strategies in large commercial buildings in China. China as a non-Annexe1 country had hosted the largest number of Clean Development Mechanism (CDM) projects and also generated the largest

number of certified emission reduction (CERs) in the world. In large commercial buildings in Beijing and Shanghai, carbon reduction strategies arise from improvements in the way energy is used. Energy consumption can be reduced into two categories:

Table 6. Medium to long term projects

Proposal number	Proposal	Proposed lead
1	Identify unauthorised electrical devices by obtaining reports from the portable appliances testing contractor	TL
2	Install night watch software to switch all computers off at a pre-set time	EEO
3	Wind turbines/Solar (p.v) panels to provide lighting in the parks/ other spaces	TL
4	Investigate the use of hydro-power	EEO
6	Pilot project for the installation of voltage optimization to the city square complex	EEO
7	Install reflective street lighting furniture	Director of Planning & Transportation
8	Carry out fleet driving training workshops	Director of Dundee contract services
9	Implement more controls of staff travel	Director of Planning & Transportation
10	Suitability of staff for certain geographical locations	DoED
11	“Roll out” of fleet management review conclusions	Director of Dundee contract services
12	Bulk purchase low emission/ electric/hybrid cars for staff use on pool basis	Director of Planning & Transportation
13	Free up space in underground car park for pool car electric/hybrid	Director of Planning & Transportation
14	Future encouragement for car sharing including reduced car parking fees	Director of Planning & Transportation
15	Encourage site visits on way to or from work	Director of Planning & Transportation
16	Investigate the re-structure car lease scheme and mileage rates to encourage staff to lease/buy low emissions vehicles and improve management of pool/lease cars	Director of Planning & Transportation
17	Extend recycling network to all suitable properties and provide shower facilities for bike users	Director of Planning & Transportation
18	Encourage use bus for travel meetings within council boundaries	Director of Planning & Transportation
19	Locate reuse/shop facility at recycling centres	Waste Management

Source: Dundee City Council, 2009

Table 7. NHS Tayside’s CO₂ emissions for baseline year 2006

	Total	Co ₂	Buildings and street lights	Waste and Water
Baseline CO₂ emissions (tonnes)	4,015	1,918	1,777	321
Baseline Cost (£)	£802,116	£128,322	£673,794	£-

Source: NHS Tayside, 2009

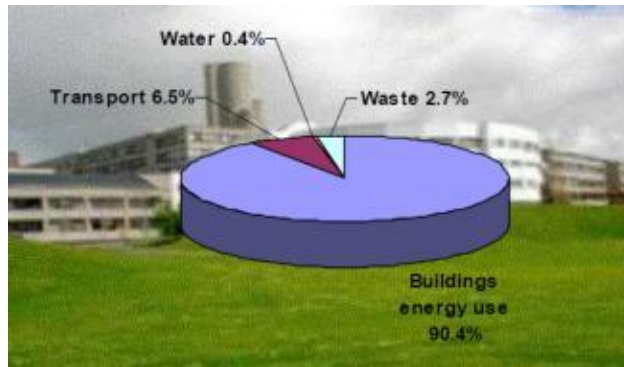


Fig. 3. CO₂ emission source of NHS Tayside in the year 2007/08
(Source: NHS Tayside, 2009)

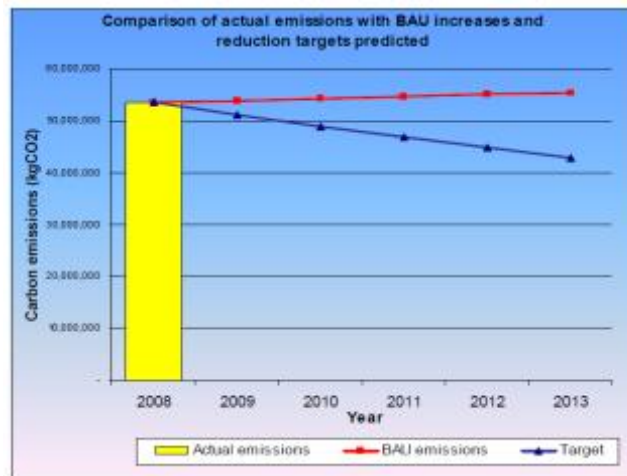


Fig. 4. The comparison of business as usual CO₂ emission and reduction target of NHS Tayside;
(Source: NHS Tayside, 2009)

4.1.1 Intrinsic energy use

To a large extent, the intrinsic energy requirements will be independent of the activities taking place. For that reason a similar thermal environment will be required for buildings in which the primary function is for laboratory work, office work or for meeting space. In some situations like in a sport hall or warehouse, the internal temperature requirements may be different and these differences will affect energy consumption. The intrinsic energy will normally be under the direct control of the energy management company in large commercial buildings.

4.1.2 Functional energy use

Functional energy is consumed as a result of activities in the building. The building

management company will have little control of these activities in the sub-areas of let space in a large commercial building. Thus in the same physical space, the energy used in an office full of computers will be much higher than that of the same space used as a meeting area.

The approach for the baseline determination will depend on the refurbishment and updating of an existing building or the construction of a new building. For existing large commercial buildings, the determination of the baseline emissions will need to separate the intrinsic and functional energy uses within a building. For functional energy use, a sufficiently long baseline monitoring period such a year may be adequate as long as external influences can be identified. For new buildings, the intrinsic energy consumption baseline should be determined according to the heating and cooling

requirements of a building of identical size but specified by the insulation levels specified in the relevant building standards and climatically normalised to the latest long-term average climatic data [26].

5. CONCLUSION

Dundee, the fourth largest city of Scotland, living around 142,470 people, emits a good number of carbons each year. Most of the CO₂ emit from the sectors like housing, commercial industries and transport. Many organisations in Dundee have set their carbon reduction targets. The Dundee city council and large businesses in Dundee are adopting new technologies and strategies to reduce carbon emissions. Dundee city council, NHS Tayside and University of Abertay Dundee are among 24 organizations in Scotland who have completed the sixth phase of the Carbon Management Programme and received a certificate from the Carbon Trust. 9 tonnes of CO₂ emitted in per head of population in Dundee, whereas the per head CO₂ emission in whole Scotland is 8 tonnes. The big organisations and people of Dundee should reduce their carbon footprint to make Dundee a sustainable modern city. The new strategies and technologies Glasgow, Dundee, Lewisham and Chinese major cities offer for others to emulate in the context of climate change mitigation and/or adaptation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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