HEATING & COOLING

ESTIMATES GLOBAL CLIMATE IMPACT

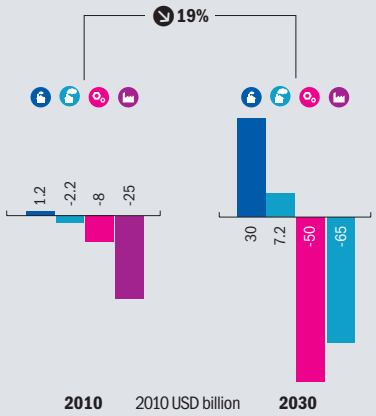
2010 EFFECT TODAY

USD **GAIN** PER YEAR **35 BILLION**

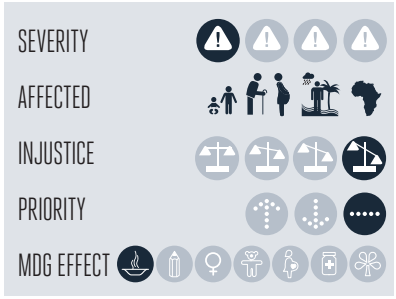
2030 EFFECT TOMORROW

USD **GAIN** PER YEAR **75 BILLION**

ECONOMIC IMPACT

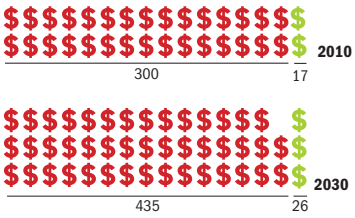


CONFIDENCE ROBUST



- The most certain outcome of global warming is rising heat
- As heat goes up, heating costs decrease and air conditioning costs rise
- In the cooler north, heating especially is mandatory and widespread, but in tropical zones, artificial cooling is not always a necessity
- Currently, the impact of rising heat on indoor space conditioning is a positive effect of climate change globally, as cost reductions in cooler countries outweigh cost increases in hotter countries
- Tropical countries still incur serious losses, and in the longer term, if climate change is not controlled, high cooling costs will overtake reductions in heating costs

RELATIVE IMPACT



HOTSPOTS

2010 $ 2030

800 **INDIA** 10,000

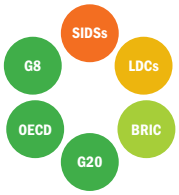
600 **MEXICO** 10,000

250 **BRAZIL** 5,000

350 **SAUDI ARABIA** 4,250

150 **VIETNAM** 3,750

GEOPOLITICAL VULNERABILITY



$ Economic Cost (2010 PPP non-discounted)

Developing Country Low Emitters

Developing Country High Emitters

Developed

Other Industrialized

$ = Losses per 100,000 USD of GDP

Change in relation to overall global population and/or GDP

$ = Millions of USD (2010 PPP non-discounted)

The heating and cooling of residential and non-residential indoor spaces are among the largest energy consumers globally (WRI, 2009). Energy demand for heating is currently ten times higher than for cooling (Isaac and van Vuuren, 2008). As a result, temperature rise is presently generating a net economic benefit for the world economy, since the lowering of heating costs due to milder winters or fewer cold days is more significant than any increase in air conditioning costs (Hansen et al., 2012). However, if climate change continues to the end of the century, rising heat and increased air conditioning demand in developing countries would generate net losses for the world (Isaac and van Vuuren, 2009). Today, the increasing costs faced by middle and lower income countries in tropical regions can represent a significant negative economic impact at a national level. As a result, cooler countries are seeing declining emissions or less growth in emissions at national levels, enabling them to better meet GHG reduction targets. In hotter countries, however, GHG emissions will be artificially inflated, making it more difficult to reduce them. In fact, meeting the rapidly growing demand for air-conditioning as incomes expand in developing countries is a significant challenge without climate change. Not meeting the challenge, including with climate change, will curtail the economic development and welfare of many lower and middle-income countries, for example through reduced productivity and greater exposure to heat related health risks (Kjellstrom et al., 2009; Akpinar-Ferrand and Singh, 2010).

CLIMATE MECHANISM

The planet's warming is virtually certain, resulting in more hot and fewer cold days and nights (IPCC, 2007). On average, winters are becoming shorter and milder, summers longer and hotter. Areas that rely on heating indoor space to maintain comfortable temperature levels will increasingly need less energy in a year as the cold wanes. On the other hand, areas that can benefit from year-round or seasonal air-conditioning to bring down indoor temperatures to comfortable levels will increasingly need more energy to maintain these levels as temperatures climb. Many industrialized countries will see benefits from reduced winter heating needs, however many of those same countries will also experience increased cooling needs (Miller et al., 2008). In the sub-tropics and tropics where most of the world's population resides, greater cooling costs far outweigh any heating fluctuations (Isaac and van Vuuren, 2008).

IMPACTS

The global impact of climate change on heating and cooling is currently estimated to benefit the global economy by more than 30 billion dollars each year. By 2030, the costs of heating and cooling are estimated to decline slightly as a share of global GDP, but reach over 70 billion dollars. This is a signal of what lies ahead, as increased demand for cooling will gradually overtake any benefits from lower heating costs.

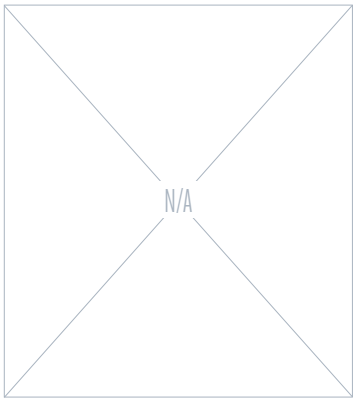
In 2010, national losses amounted to some 5 billion dollars a year in additional costs, whereas gains in countries benefitting from lower heating costs amounted to 40 billion dollars a year. By 2030, annual losses are estimated to be over 70 billion dollars and gains at 150 billion dollars. Countries with the largest losses in 2030 are India and Mexico, each with over 10 billion in annual costs. The largest gains are in the United Kingdom, Russia, China, and Germany, with benefits ranging from 10 to 20 billion dollars or more each year.

Least developed and lower-income countries in Africa, Central America, the Caribbean, and the Pacific are particularly negatively impacted, with losses reaching from 0.5–1% of GDP by 2030.

THE BROADER CONTEXT

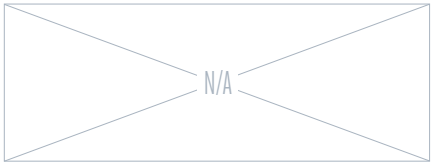
Energy demand for both heating and cooling is growing almost everywhere. Global demand for heating is expected to peak around 2030, while demand for cooling will continue to expand throughout the 21st century as incomes grow in tropical and sub-tropical developing countries (Isaac and van Vuuren, 2008). These increases and decreases would occur without climate change, since energy efficiencies are being realized in cooler countries where markets for heating and cooling equipment are saturated and population growth is slow or declining (UNECE, 2012). In developing countries air conditioning demand is far from saturated and is expected to increase rapidly as incomes rise and

BIGGER PICTURE

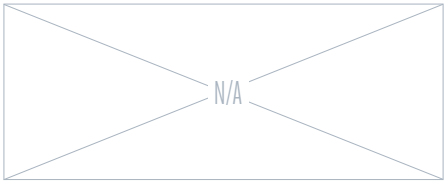


SURGE

OCCURRENCE

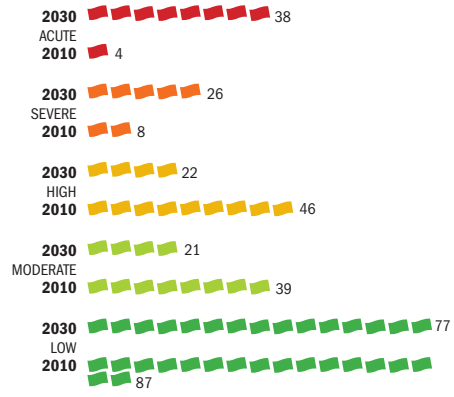


PEAK IMPACT



GENDER BIAS

VULNERABILITY SHIFT



INDICATOR INFORMATION

MODEL: Isaac et al., 2008

EMISSION SCENARIO: TIMER/IMAGE reference scenario for the ADAM project (Isaac et al., 2008)

BASE DATA: Baumert et al., 2003; Electricity price EIA 2010; Perez-Lombard et al., 2007; UNECE (2012); Zmeureanu and Renaud, 2009

= 5 countries (rounded)

Acute Severe High Moderate Low

populations grow. Urban heat islands, growing in many places as a concern parallel to these other factors, are also exacerbating energy requirements (Kolokotroni et al., 2010; Memon et al., 2011).

VULNERABILITIES AND WIDER OUTCOMES

The world's hottest countries are most vulnerable to the impacts of climate change, since they already rely heavily on air-conditioning. Africa, Asia and the equatorial zones are particularly exposed since large populations and significant amounts of economic activity are located in warm zones.

If rising heat is not compensated by additional cooling that maintains at least the same level and progress in indoor climate control, economic productivity will fall more or less predictably (Kjellstrom et al., 2009a). Human welfare will be significantly affected through additional, serious impacts to human health from cardiovascular and chronic respiratory illnesses over and above what is already noted in the Health Impact section of this report (McMichael et al., 2006). As is highlighted in this report's Ghana country study, people in the lowest-income communities are more likely to sleep outdoors on the hottest nights, increasing exposure to mosquito bites during peak vector activity periods (dusk and dawn) and promoting higher transmission rates of malaria. Heat stress also affects cognitive performance, mental stress, and depression among other psychological effects (Hancock et al., 2003; Hansen et al., 2008).

RESPONSES

Increases in heat are often offset by increased energy consumption on the part of those who can afford it, but at an additional energy cost. For those who cannot, social and economic welfare will be compromised by productivity and health effects, although it is unclear how the economic costs of lost productivity might compare with extra cooling costs (Yardley et al., 2011; Kjellstrom et al., 2009b). Since solutions for indoor space cooling are technically possible in many cases, international responses could focus on ensuring adequate indoor cooling for lower-income communities unable to do so at will, particularly in areas with high risk for malaria and vector-borne disease. Improving building insulation and energy efficiency in the tropics (not only in cold countries) to protect against heat (not only cold) would be an important, lower-emission option for adapting to the growing heat (Akpinar-Ferrand and Singh, 2010).

Heating and cooling is a clear example of a dual-focus adaptation-mitigation response area. Any mitigation project that ensures provision of cooling-related technologies to affected communities would also constitute an adaptation action. In terms of practical steps, increasing local shade-tree cover can have a positive effect on cooling buildings (Donovan and Butry, 2009). Cities could take greater advantage of the geothermal energy created as a result of the heat island effect to supply energy for cooling, since cities also heat the ground below, not only the air above. The potential energy supply has been estimated to exceed cooling demand requirements in several major cities (Zhu et al., 2010).

THE INDICATOR

The indicator maps residential/non-residential heating demand changes. It is considered robust, given the certainty of the climate science community and model convergence on the main parameter of increasing heat, although humidity levels are also important (Wang et al., 2010). High quality energy consumption data gives a reasonable indication of the phenomenon's scale, but relies on the concept of heating and cooling degree-days, which are not fully accurate in terms of all demands, since wind, cloud cover, and humidity strongly influence heating and cooling behaviour (Baumert and Selman, 2003). While the same optimal temperature is assumed for different countries, it is argued that the optimal temperature varies by region, climate, and other conditions (Dear and Brager, 1998). Though the Indicator considers several dynamic variables, floor space size changes over time are not, though are understood to have a significant impact on future energy requirement estimates (Isaac et al., 2008; Clune et al., 2012).

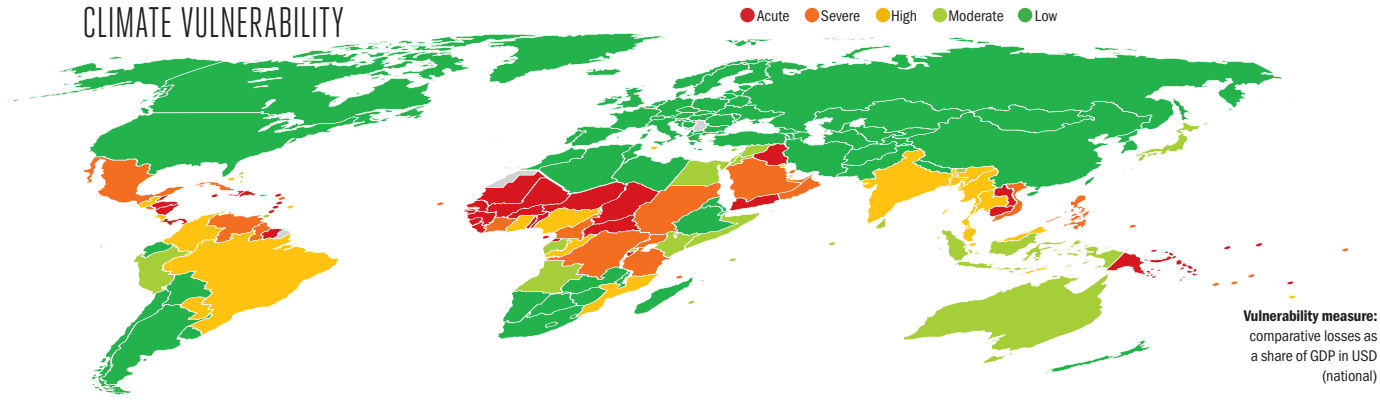
ESTIMATE COUNTRY-LEVEL IMPACT

COUNTRY	$ 2010	$ 2030	⚡ 2010	⚡ 2030	2010	2030
ACUTE						
Antigua and Barbuda	1	25	15	65	15	55
Belize	1	30	15	55	1	10
Benin	15	150	100	300	85	200
Burkina Faso	45	400	250	600	150	350
Burundi	5	55	60	150	1	1
Cambodia	25	500	200	850	200	850
Central African Republic	5	55	40	100	5	15
Chad	45	350	150	350	150	350
Dominican Republic	65	950	450	1,750	350	1,250
Equatorial Guinea	25	200	150	400	95	250
Grenada	1	15	10	40	10	30
Guinea	15	100	95	250	25	60
Guinea-Bissau	1	20	15	45	15	35
Haiti	35	500	250	950	150	550
Honduras	25	400	200	750	65	250
Iraq	100	1,500	750	3,000	550	2,250
Jamaica	20	300	200	750	100	450
Laos	10	250	100	400	1	1
Liberia	5	50	40	100	25	65
Mali	30	250	200	550	65	150
Marshall Islands		5	1	10		
Mauritania	10	70	60	150	40	100
Micronesia	1	5	5	15		
Myanmar	75	1,250	650	2,750	100	450
Nicaragua	30	500	200	750	100	400
Niger	30	250	200	550	200	550
Panama	30	500	200	750	60	250
Papua New Guinea	20	350	200	900	85	350
Saint Lucia	1	25	15	65	15	50
Saint Vincent	1	15	10	35	5	20
Sao Tome and Principe		1	1	5	1	1
Senegal	30	250	200	550	150	400
Sierra Leone	10	75	65	150	30	80
Solomon Islands	1	25	15	65	15	55
Suriname	5	50	25	100	10	35
Togo	10	85	70	200	10	30
Tuvalu		1	1	1		
Yemen	200	2,250	1,500	4,750	1,000	3,250
SEVERE						
Bahrain	15	200	100	400	60	250
Cameroon	35	300	250	650	45	100
Cape Verde	1	10	5	15	5	10
Comoros	1	5	5	20	5	15
Cote d'Ivoire	35	300	300	750	150	350
Cuba	55	850	550	2,250	450	1,750
Dominica	1	10	5	25	5	15
DR Congo	15	150	400	1,000	1	5
El Salvador	20	300	150	600	50	200
Fiji	1	35	20	90	5	20
Gambia	5	25	20	60	15	40
Guyana	5	50	25	100	20	85
Kiribati		5	5	15	5	10
Mexico	600	10,000	6,250	30,000	3,000	15,000
Oman	45	550	350	1,250	250	800
Palau		1	1	5		
Philippines	200	3,000	1,500	6,500	800	3,250
Samoa	1	10	5	25	1	10
Saudi Arabia	350	4,250	2,500	9,000	2,000	7,250
Sudan/South Sudan	80	750	750	2,000	250	700
Tanzania	40	350	450	1,250	100	300
Uganda	40	300	150	450	25	70
United Arab Emirates	150	2,000	1,250	4,250	800	2,750
Vanuatu	1	10	5	25	5	20
Venezuela	200	3,000	1,500	6,250	400	1,500
Vietnam	150	3,750	1,500	6,000	550	2,500
HIGH						
Bahamas	1	30	20	80	15	60
Bangladesh	45	650	950	3,500	550	2,000
Barbados	1	30	20	80	20	70
Brazil	250	5,000	1,500	7,500	70	400
Brunei	5	50	25	100	20	85
Colombia	-40	1,250	-300	2,500	-55	450
Congo	5	60	50	100	10	25
Costa Rica	10	150	100	400	5	15
Ghana	30	250	350	900	60	150
Guatemala	5	150	30	300	10	100
India	800	10,000	15,000	65,000	15,000	55,000
Kuwait	55	650	400	1,500	450	1,500
Malaysia	65	1,000	550	2,250	350	1,500
Malta	1	10	15	30	10	25
Mozambique	10	90	150	400		
Nigeria	85	700	2,500	6,250	1,000	2,750
Paraguay	5	150	90	500		
Qatar	40	500	300	1,000	150	550
Singapore	60	1,000	300	1,250	200	900
Thailand	200	3,000	2,000	8,500	1,250	4,750
Timor-Leste	1	10	5	20		
Tonga		5	1	10	1	5
MODERATE						
Angola	15	150	95	350	20	75
Australia	150	550	1,750	4,000	1,500	3,750
Bhutan		1	-1	15		
Cyprus	1	15	5	65	5	50
Djibouti	-1	1	-5	1	-5	1
Egypt	-150	200	-1,250	550	-700	300

$ Additional economic costs due to climate change (million USD PPP) - yearly average

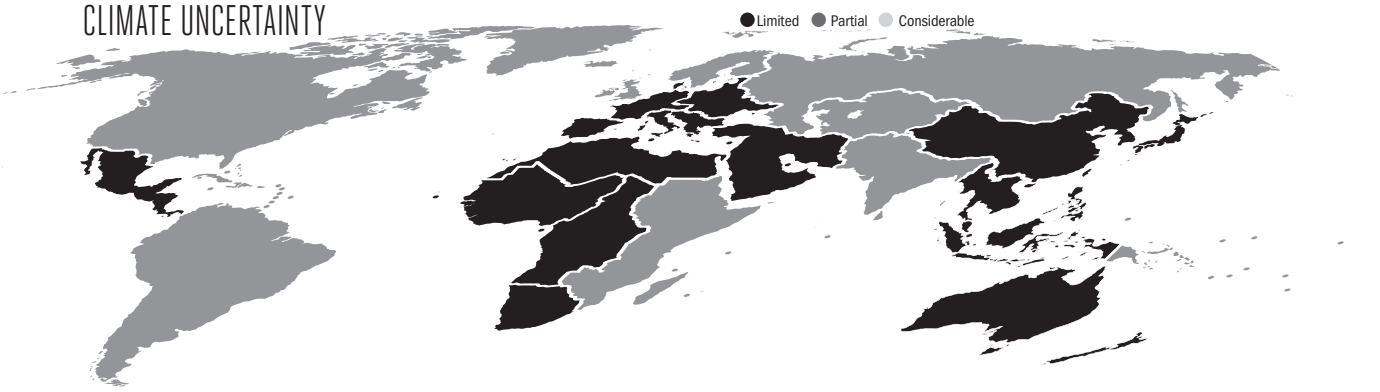
⚡ Additional/reduced energy load due to climate change (GWh) - yearly average

CLIMATE VULNERABILITY



Vulnerability measure: comparative losses as a share of GDP in USD (national)

CLIMATE UNCERTAINTY



COUNTRY	2010	2030	2010	2030	2010	2030
Gabon	5	35	30	70	5	15
Indonesia	150	1,750	2,250	7,000	1,750	5,750
Israel	5	150	55	400	45	300
Japan	250	750	1,250	2,500	550	1,000
Jordan	-5	45	-50	95	-30	55
Kenya	-10	15	-60	35	-25	15
Maldives		5	-1	25	-1	20
Mauritius	1	20	20	45	10	30
Peru	5	450	35	900	10	200
Rwanda	-1	5	-15	10	-5	1
Seychelles		1	5	10	1	5
Somalia	-1	1	-10	5	-5	1
Sri Lanka	5	100	150	600	70	300
Syria	-25	55	-200	100	-100	70
Trinidad and Tobago	1	40	100	400	75	300
LOW						
Afghanistan	-30	-150	-650	-800	-150	-200
Albania	-20	-100	-95	-150	-1	-1
Algeria	-300	-1,750	-3,000	-4,500	-1,750	-2,750
Argentina	-65	-350	-3,000	-3,750	-1,000	-1,500
Armenia	-25	-150	-200	-300	-20	-40
Austria	-500	-1,500	-2,500	-4,750	-450	-850
Azerbaijan	-35	-200	-250	-400	-150	-250
Belarus	-350	-2,250	-1,750	-3,500	-1,500	-2,750
Belgium	-600	-1,750	-3,000	-5,250	-700	-1,250
Bolivia	-100	-800	-900	-1,750	-350	-650
Bosnia and Herzegovina	-85	-500	-450	-800	-350	-600
Botswana	-5	-30	-70	-100	-90	-150
Bulgaria	-250	-1,500	-1,250	-2,250	-800	-1,500
Canada	-550	-1,500	-6,750	-15,000	-1,250	-2,250
Chile	-400	-2,750	-2,000	-3,750	-850	-1,500
China	-2,750	-20,000	-60,000	-80,000	-50,000	-65,000

COUNTRY	2010	2030	2010	2030	2010	2030
Croatia	-75	-450	-700	-1,250	-250	-400
Czech Republic	-700	-4,250	-3,500	-6,500	-2,500	-4,750
Denmark	-900	-2,500	-2,250	-4,000	-1,250	-2,500
Ecuador	-30	-10	-350	-20	-95	-5
Eritrea	-20	-100	-150	-300	-100	-200
Estonia	-40	-250	-150	-300	-150	-300
Ethiopia	-35	-200	-900	-1,500	-100	-150
Finland	-550	-1,500	-3,000	-5,500	-1,000	-1,750
France	-2,250	-6,250	-15,000	-25,000	-1,250	-2,000
Georgia	-1	-5	-5	-10	-1	-1
Germany	-8,000	-20,000	-30,000	-55,000	-15,000	-30,000
Greece	-25	-45	-250	-250	-200	-200
Hungary	-350	-2,250	-1,500	-2,750	-750	-1,250
Iceland	-40	-100	-150	-300		
Iran	-100	-350	-2,000	-2,000	-1,250	-1,250
Ireland	-300	-850	-1,250	-2,000	-500	-900
Italy	-2,000	-5,250	-6,500	-10,000	-3,250	-5,750
Kazakhstan	-150	-850	-2,500	-4,750	-2,500	-5,000
Kyrgyzstan	-10	-75	-250	-400	-20	-40
Latvia	-150	-950	-600	-1,000	-100	-200
Lebanon	-10	-15	-85	-30	-65	-20
Lesotho	-1	-10	-20	-35		
Libya	-55	-200	-500	-450	-500	-450
Lithuania	-300	-1,750	-1,250	-2,000	-950	-1,750
Luxembourg	-35	-100	-150	-300	-70	-150
Macedonia	-40	-250	-200	-350	-200	-300
Madagascar	-40	-150	-150	-200	-50	-60
Malawi	-1	-10	-80	-100	-10	-10
Moldova	-65	-450	-350	-650	-250	-500
Mongolia	-40	-450	-350	-750	-500	-1,000
Morocco	-200	-1,000	-1,750	-2,500	-1,250	-1,750
Namibia	-15	-70	-100	-200	-25	-40

COUNTRY	2010	2030	2010	2030	2010	2030
Nepal	-15	-80	-250	-450	-1	-1
Netherlands	-1,250	-3,500	-5,250	-9,500	-2,500	-4,500
New Zealand	-65	-200	-400	-750	-65	-150
North Korea	-150	-1,250	-1,250	-2,250	-650	-1,250
Norway	-350	-1,000	-2,250	-4,250	-35	-65
Pakistan	-65	-75	-1,500	-400	-700	-200
Poland	-1,250	-8,250	-6,750	-10,000	-7,000	-15,000
Portugal	-150	-400	-700	-1,250	-300	-550
Romania	-200	-1,250	-1,750	-3,250	-1,000	-2,000
Russia	-2,250	-15,000	-20,000	-45,000	-15,000	-25,000
Slovakia	-300	-1,750	-1,250	-2,500	-400	-750
Slovenia	-100	-650	-550	-1,000	-200	-400
South Africa	-200	-1,000	-3,250	-5,500	-3,000	-5,250
South Korea	-150	-1,250	-1,750	-3,500	-950	-2,000
Spain	-500	-1,250	-2,500	-4,000	-800	-1,250
Swaziland	-1	-15	-30	-50	-1	-1
Sweden	-1,250	-3,250	-5,000	-9,000	-150	-300
Switzerland	-400	-1,250	-2,750	-5,000	-20	-30
Tajikistan	-5	-15	-95	-90	-1	-1
Tunisia	-100	-550	-1,000	-1,500	-600	-850
Turkey	-550	-1,250	-3,250	-5,250	-1,750	-2,750
Turkmenistan	-5	-25	-100	-150	-100	-100
Ukraine	-1,250	-8,000	-6,250	-15,000	-3,000	-5,750
United Kingdom	-4,250	-10,000	-20,000	-35,000	-9,000	-15,000
United States	-650	-1,000	-5,750	-5,750	-3,500	-3,500
Uruguay	-40	-200	-250	-300	-60	-85
Uzbekistan	-40	-150	-750	-850	-500	-550
Zambia	-1	-5	-55	-45		
Zimbabwe	-30	-150	-250	-400	-150	-250

Additional CO_2 generated/reduced for heating and cooling due to climate change (Kt CO_2) - yearly average