

## **FIRMS' ADAPTATION TO CLIMATE CHANGE: WHAT DOES A HOTTER WORLD MEAN FOR BUSINESS?**

### **Abstract**

The extensive research in economics of climate change has been focused on mitigation and to a lesser degree on adaptation. However, even in optimistic mitigation scenarios the stabilization levels of GHG concentrations will be higher than today. To certain extent, climate change is inevitable. In addition to adaptation efforts on government and international levels, selective action shall be undertaken by individual businesses.

The paper summarizes existing research and empiric evidence of industry-specific climate change impact (including adaptation responses in Carbon Disclosure Project questionnaire) with a focus on deriving patterns of firm-level response strategies.

### **1. Introduction**

Global warming is expected to entail a complex of natural phenomena, including “gradual” changes, such as temperature growth, glacier receding, sea level rise, etc, and “extreme” changes, or natural disasters like floods, hurricanes, epidemics and others (Stern, 2006). Table 1 contains a brief summary of probable meteorological changes and geophysical processes caused by climate change.

**Table 1. Natural phenomena caused by climate change**

<b>Changes</b>	<b>“Gradual” changes</b>	<b>“Extreme” changes (disasters)</b>
<b>1. Meteorological changes</b>		
Temperature	Average temperature growth	Heat waves, cold waves
Moisture	Changes in atmospheric precipitation	Thunderstorms, hails, droughts
Wind speed	Changes in wind speed	Hurricanes, snowstorms, dust storms
<b>2. Affected geophysical processes</b>		
Lithosphere	Soil erosion	Earthquakes, volcanism, landslips
Cryosphere	Glacier and permafrost receding	Avalanching
Hydrosphere	Sea level rise, change in ocean currents	Floods, tsunami
Biosphere	Size, structure, migration of populations	Epidemics

*Source: IPCC, 2001; Stern, 2006*

To date, the extensive research in economics of climate change is focused on mitigation schemes through greenhouse gas (GHG) emissions reduction and to a lesser degree on adaptation strategies to hotter climate. However, even in optimistic mitigation scenarios the stabilization

levels of GHG concentrations will be higher than today. In this sense, climate change is inevitable and requires special efforts in adaptation to global warming.

The existing research in adaptation to climate change is concentrated on probability of damage for particular regions or key resources for some sectors of economy (Stern, 2006; Hoffman, 2006), or business awareness of climate induced risks (Firth et al, 2006; CDP Report, 2006). There are attempts to classify risks of climate change and respective vulnerabilities by magnitude, reversibility, confidence, timing, potential of adaptation (Schnellhuber et al, 2006; Klein et al, 2006). The deeper insights into the meaning of “dangerous effects” from the viewpoints of experts and society are available (Dessai et al, 2003). However the business-focused investigations of climate change impact on cross-industry level are not yet common. Most of existing studies cover single industry risks and solutions (Lloyds, 2006; Hacker et al, 2005) which can be summarized on cross-industry level.

Therefore, **the goal of our investigation is to summarize existing research and empiric evidence of industry-specific climate change impact with a focus on firm-level response strategies.** Below we classify the climate change impacts on businesses, analyze the selective climate change vulnerabilities in industrial and regional breakdown together with new business opportunities caused by global warming. After that we summarize the company-level response strategies to climate change. The empiric evidence of climate-induced challenges and response strategies include company data of EU, USA, Canada, Japan and Russia.

## **2. Impacts of Global Warming on Business**

We propose to distinguish the expected consequences of climate change for businesses into direct and indirect impact, as it corresponds to the climate adaptation strategies. **Direct impact** means that business assets, labor and other company production factors (inputs) are affected by long-term meteorological changes and shifts in geophysical processes, either gradual or extreme. **Indirect impact** reveals itself through demand-side effects on businesses, i.e. originates from company’s customers and represent a shift in demand.

In addition, climate change may produce either general or selective impact on businesses. **General impact** covers all industries within a certain region and naturally implies environment-caused changes in labor conditions and energy use. An example of such impact is industrial process interruptions due to high air temperatures, insufficient cooling capability and local electric supply failures, affecting multiple industries. Another example of general impact is the various consequences of natural disasters and economic shocks entailed. In contrast, **selective impact** affects assets and other production factors and market perspectives of selected climate

dependent businesses. For instance, global warming may affect certain assets in agriculture and electric power generation through changing the productivity of crops and hydropotential of water basins. Market prospects for certain products may also be affected through climate-induced changes in consumer behavior. The examples are changes in seasonal pattern of energy consumption, reduction in demand for winter apparel, increase in demand for insurance against climatic risks and so on.

Combination of the above mentioned types of climate change impact brings out a simple matrix typology of climate change impact on business (Table 2).

**Table 2. Types of climate change impact on business**

	<b>Direct impact (business assets and inputs)</b>	<b>Indirect impact (demand-side effects)</b>
General impact (all industries)	<ul style="list-style-type: none"> <li>▪ Changes in labor conditions</li> <li>▪ Damage from natural disasters in affected regions</li> </ul>	<ul style="list-style-type: none"> <li>▪ Changes in total productivity of economy</li> <li>▪ Economic shocks caused by natural disasters</li> </ul>
Selective impact (selected industries)	<ul style="list-style-type: none"> <li>▪ Assets and inputs of climate dependent industries (agriculture, forestry, tourism, etc)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Shifts in demand for selected goods and services (electric power, insurance, etc)</li> </ul>

Existing research (Hoffman, 2006; Klein et al, 2006) stress the industrial dimension of climate induced vulnerabilities and unequal adaptability of various industries to climate change. At the same time, most of attention is now paid to the general impact of climate change, with a focus on estimating the expected changes in overall economic performance and possible damage in result of natural disasters. The selective impact of climate change on cross-industry level is less investigated. The existing works (Schnellhuber et al, 2006; Lloyd’s, 2006; Hacker et al, 2005) are focused on certain industries which are highly exposed to climate induced risks – insurance, construction and energy supply.

An important step in understanding of selective climate change impact, either direct or indirect, is provided by Carbon Disclosure project (CDP, 2006; Firth et al, 2006) on company level, including cases in oil and gas production, metallurgy, electricity generation, banking and insurance, etc. We used this information together with companies’ data to summarize the examples of selective vulnerabilities, opportunities and response strategies to climate change on company level<sup>1</sup>.

<sup>1</sup> Further development of investigating climate-induced risks for industries and regions is undertaken in UK through the announced “A Changing Climate for Business” project, to be completed in 2008. (UKCIP, 2007)

### 3. Selective Impact of Climate Change: Key Challenges for Business

Selective impact of climate change produces an industry-specific effect on business assets, other production factors and demand. For business unit, the sensitivity to this kind of climate change impact can be different, depending on assets it employs, goods or services it produces and geographic location it operates. Consequently, the capacity of business unit to adapt to this impact can be also different<sup>2</sup>.

The selective impact of climate change contains 2 major challenges for business. The first is to adjust existing operations and facilities to the new hotter environment, i.e. to respond to the threats of climate change and become less vulnerable to it. The second challenge is to find and employ the new business opportunities arising from the climate change. These opportunities can be in the form of emerging new markets, increase in demand, and new possibilities in exploring natural resources.

To summarize the existing threats and opportunities on cross-industry level, we grouped the information concerning possible business threats and opportunities in accordance with ISIC industry code. The sources of information are company responses to the Carbon Disclosure Project questionnaire and other publicly available company data. The results are presented in Appendices 1 and 2.

About 20 industries (out of 60 groups on the “upper level” of ISIC) can be considered potentially vulnerable to the industry-specific climate change impact. The potential vulnerabilities can be divided into 2 parts – vulnerability of assets and inputs (which represents the direct impact of climate change) and vulnerability from the demand side (i.e. indirect impact of climate change). In short, one can select industries with climate dependent assets, or climate-dependent demand, or both.

Business units with the most climate dependent assets are the companies directly exploiting the natural resources. In most cases, they belong to agriculture, forestry and logging, fishing, extraction of crude petroleum and natural gas, mining, hydropower generation and recreational services (tourist resorts). A number of manufacturing businesses might experience the so-called “second-order” climate dependency of assets and inputs due to the buyer-supplier relations with producers of raw materials. The examples of such kind of climate dependency are manufacture of food and beverages, wood, cork and paper products, manufacture of basic metals, machinery and equipment and other goods.

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<sup>2</sup> Noteworthy, the business units potentially affected by selective climate change impact are also exposed to the general impact of climate change, like all other business units. As the result, the adaptation to climate change for such companies is further complicated.

A lot of companies supplying consumer goods and services have climate dependent demand. The most vulnerable in this case might be electricity and water supply, insurance sector, healthcare and social services, construction. In most cases, the climate dependency of demand means it's restructuring in time (if seasonal pattern of consumption is changed) or in composition of "consumer basket" (some goods are less demanded and the other are more demanded instead).

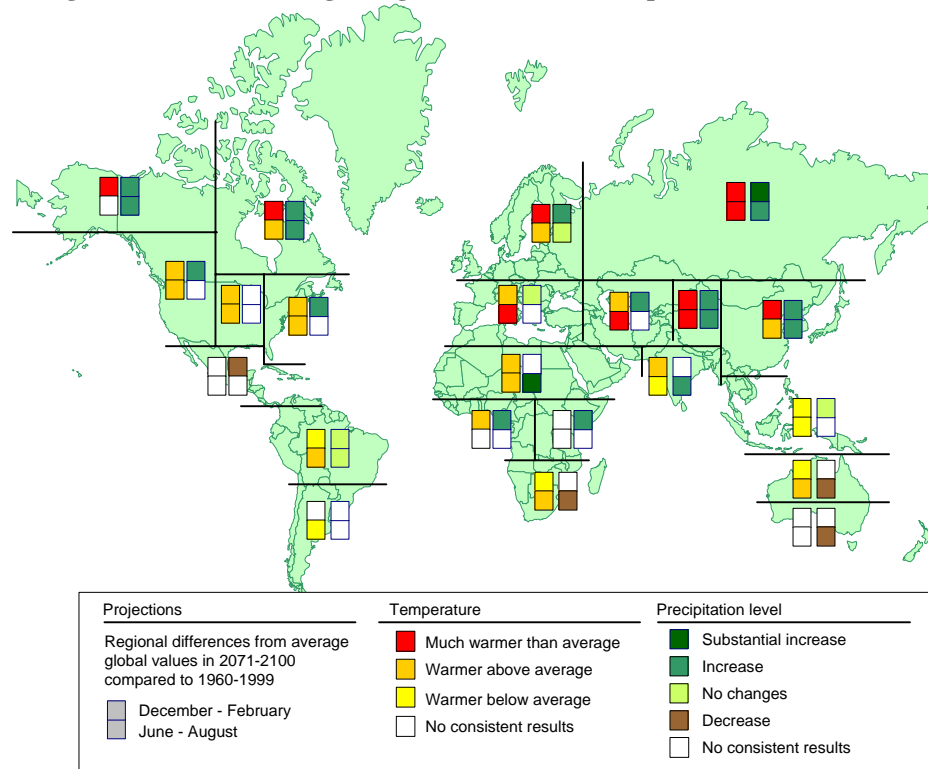
Division between climate dependent assets and climate dependent demand allows to show the diverse nature of risks involved with climate change. Since a number of industries may experience both kinds of vulnerabilities to climate change, it is important to take into account the various kinds of climate dependency while elaborating the adaptation strategy of a company.

The vulnerability of businesses to climate change also depends on the region they operate. Region specific climate changes are extensively studied by means of sophisticated climatic models (IPCC, 2001; Stern Review, 2006). However, the problem of uncertainty still exists due to lengthy forecast periods, probability of unanticipated climate changes (for instance, reversed ocean currents) and global mitigation efforts. To indicate the potentially problematic regions, we summarize the results of IPCC global long term forecasts of temperature and atmospheric precipitation in 2071-2100 compared to 1961-1990 (IPCC, 2001). In Figure 1, we put together the forecasts corresponding to B2 IPCC scenario<sup>3</sup>.

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<sup>3</sup> The scenario implies the medium global warming (+2.2°C on average) as a result of moderate growth rates of population, economic development and technical advances. A particular stress in this scenario is put on local and regional attempts for climate change mitigation and attention to environmental safety. We consider this scenario as an attempt to give a realistic picture of possible climate change in regional breakdown.

**Figure 1. Global warming in regional dimension (adapted from IPCC, 2001)**



The greater climate changes are expected in the region, the more vulnerable the climate-dependent businesses of the region can be. Joint picture of regional differences in temperature and precipitation shows that 3 types of locations are potentially more vulnerable: higher latitude or mountainous areas; water stressed territories and low lying coastal zones. This allows to add another dimension to analysis of adaptation strategies on company level. For instance, if business is located in potentially vulnerable regions, adaptation strategies for it may vary from adaptive actions to re-localization of business when possible. Table 4 lists this potentially most vulnerable locations and most affected business assets.

**Table 3. Business locations potentially most vulnerable to climate change**

Location types	Expected changes	Examples	Most affected assets and industries
Higher latitude or mountainous areas	Much warmer winters, ice melting, water logging	Northern regions of Russia and Canada, Alaska, Central Asia	Mining, hydro power generation, all infrastructure assets, tourist resorts
Water stressed territories	Hotter summers, increased water stress, droughts	South-East Asia, Australia, Southern Europe, South Africa, Central America	Agriculture, forestry, water supply, hydro power generation
Low lying coastal zones	Warmer temperatures, sea level rise, floods	South Asia, North-West Europe, Pacific islands, Florida	Agriculture, water supply, fisheries, tourist resorts

Source: Stern, 2006; IPCC, 2001

It is known that climate change potentially brings new business opportunities (Stern, 2006). They originate either from activities in climate change mitigation, or emerging new markets, or in some cases from assets productivity growth due to climate change. To date, the existing research on new climate related opportunities for business is focused on mitigation, including participation in carbon trade, clean development mechanism and joint investment (Hoffman, 2006). However the discussion of business opportunities, arising from global warming itself, is less common.

Using ISIC codes, we summarized the potential business opportunities in a hotter world (Appendix 2). Since we left aside the extensively studied mitigation activities, the remained opportunities can be divided by the origin into assets improvement and demand increase. The improvement of assets is attributable to some business units closely connected with natural resources exploitation. For instance, potentially some new areas may be available or accessible for agricultural, forestry, fishing, mining and other resource extraction activities. The demand increase as potential business opportunity is probable for some manufacturing industries (manufacturers of beverages, wearing apparel, cooling systems) and services (construction, medical services and new forms of insurance). The possibility of new business opportunities indicates that the adaptation strategy for company should address the question if there are any climate-induced opportunities and how to take advantage of them.

#### **4. How to Become Climate-Proof Company?**

A climate-proof company is a business unit resistant to climate-induced risks. Becoming climate-proof requires to implement the climatic risk factor and climate-induced business opportunities into the company's decision making, from elaboration of development strategies to day-to-day routines. In other words, climate-proof company develops adequate response, or adaptation strategy, to the challenges of climate change.

To date, the business response to climate change is diverse, ranging from long-term active adaptation strategies to passive absorption of costs entailed by climate change. Since the challenges imposed by climate change are relatively new for companies, yet few of them can be considered climate-proof. The existing company strategies in response to climate change are focused mostly on medium-term activities corresponding to international mitigation schemes (Hoffman, 2006; CDP Report, 2006), such as emissions reduction and investment to clean development projects. In addition, some companies are elaborating adaptation strategies which include protection of climate dependent assets, possible relocations of business, and taking advantage of new business opportunities resulting from global warming. Due to the uncertainty

of scale of expected climate changes and, in particular, the limitations of after-Kyoto period, the planning horizon in many cases is no longer than 5 years (till 2012). However, the need for becoming climate-proof is expected to increase and to cover almost all companies in the world in future, as even in optimistic scenarios the climate change is inevitable (Stern Review, 2006).

A number of companies have already faced the impact of climate change and necessity to adapt to it. There is a growing amount of adaptation attempts, connected with both the general impact and selective impact of climate change. To date, the majority of such examples correspond to the most vulnerable companies, which possess climate-dependent assets, operate on the market with climate-dependent demand and located in the so-called “hotspots” of expected climate changes, including coastal zones, water stressed regions, high latitude and mountainous areas. These businesses are the first to encounter impacts of climate change. The adaptation experience of these companies is useful for the rest of the business units with similar assets, demand and locations. These examples also demonstrate the passive and active ways of adaptation on a company level.

We summarize the existing examples of company adaptation to various impacts of climate change on the basis of Carbon Disclosure Project Questionnaire (CDP Report, 2006) and other publicly available data on European, US, Japanese and Russian companies and industries (Appendix 3). The examples are grouped by industry in accordance with ISIC codes.

The cross-industry adaptation examples clearly demonstrate the diversity of ways to become climate-proof company. Logically, an adaptation strategy of a company depends on the source of climate-induced vulnerability – assets, demand, and location. It also depends on the kind of climate change impact, whether it is general (covering all industries in the location) or selective (covering certain industries or companies).

The adaptation actions of companies range from climate controlling inside the production facilities and labor adjustments to more specific actions as improvement of particular assets and accommodating to demand shifts. Table 4 links the impacts of climate change with applicable adaptation actions which are now employed in business practice.



**Table 4. Directions of adaptation to climate change on company level**

	Climate change impact	Adaptation actions of companies
General impact (all industries)	Direct impact (assets and inputs)	
	<ul style="list-style-type: none"> <li>▪ Changes in labor conditions</li> <li>▪ Damage from natural disasters in affected regions</li> </ul>	<ul style="list-style-type: none"> <li>▪ Labor conditions adjustments (new working regime, climate control in production facilities)</li> <li>▪ Account for probable meteorological changes and climatic extremes in infrastructure and facilities planning</li> <li>▪ Insurance against natural disasters</li> </ul>
	Indirect impact (demand-side effects)	
	<ul style="list-style-type: none"> <li>▪ Economic shocks caused by natural disasters</li> </ul>	<ul style="list-style-type: none"> <li>▪ Additional insurance or re-insurance against economic risks</li> </ul>
Selective impact (selected industries)	Direct impact (assets and inputs)	
	<ul style="list-style-type: none"> <li>▪ Assets and inputs of climate dependent industries</li> </ul>	<ul style="list-style-type: none"> <li>▪ Protection and improvement of vulnerable assets (dyke construction, cold and drought resistant crops, enlarged water reservoirs, etc)</li> <li>▪ Reallocation and diversification of assets (change in transportation routes, developing new winter resorts at higher altitudes, etc)</li> <li>▪ Diversification of supplies from climate dependent sources</li> <li>▪ Climate-induced adjustment in production standards</li> </ul>
	Indirect impact (demand-side effects)	
	<ul style="list-style-type: none"> <li>▪ Shifts in demand for selected goods and services</li> </ul>	<ul style="list-style-type: none"> <li>▪ Adjustment in company product mix according to climate induced shifts in demand</li> <li>▪ Improvement of energy efficiency and total productivity</li> </ul>

*Source: Carbon Disclosure Project, 2006; company data*

Table 4 shows that selective impact of climate change is most difficult to adapt to. In fact, the industries with climate-dependent assets or climate-dependent demand face double challenge. First, they have either to protect and improve their assets or to adjust to demand shifts. Second, they are also vulnerable to the risks of general impact of climate change, like all other industries. That is why the task of becoming climate-proof for companies exposed to selective climate change usually requires greater efforts and entails higher costs. Probably this is one of the reasons why a number of companies vulnerable to selective impact of climate change, yet prefer passive adaptation strategies, such as closing or reducing the production volumes and adsorbing the other costs of climate change. In view of long term business development, more active adaptation approach is required. One of the ways to stimulate the active response to climate change on company level is to encourage the innovations of companies enabling them to become climate proof.

## Conclusions

To date, the impact of climate change and opportunities for adaptation to it vary across companies. Climate change can influence companies directly, through their assets and inputs, or indirectly, through the shifts in demand. It also can be general, i.e. influence all the companies within a specific location, or specific, i.e. affect certain industries. The vulnerability of a business

unit to all these kinds of climate change impact depends on assets it employs, goods or services it produces and geographic location it operates.

The most vulnerable to climate change are businesses with climate-dependent assets or climate-dependent demand, which are located in higher latitude or mountainous areas, water stressed territories, and low lying coastal zones. These companies are at higher risks of climate change and potentially are the first to experience the necessity of adaptation to climate change. The existing examples of companies' adaptation to climate change correspond mostly to such companies. The number of companies experiencing the need for adaptation strategies is expected to grow in the near future.

To become climate-proof, the companies need to implement the climatic risk factor and climate-induced business opportunities into the company's decision making, from elaboration of development strategies to day-to-day routines. The existing experience of adaptation to climate change demonstrates a variety of actions ranging from climate controlling inside the production facilities and labor adjustments to more specific actions as improvement of particular assets and accommodating to demand shifts. Since the challenges imposed by climate change are relatively new for companies, yet few of them can be considered climate-proof. To stimulate this process, it is advised to encourage the innovations of companies enabling them to develop adequate adaptation strategy to the challenges of climate change.

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**Appendix 1. Examples of industry specific selective vulnerabilities to climate change (based on Carbon Disclosure Project data and company data)**

ISIC	Industry	Selective influence of climate change	
		Direct (assets and inputs)	Indirect (demand-side effects)
A01	Agriculture and hunting	<ul style="list-style-type: none"> <li>▪ Meteorological changes affect the productivity of crops and cattle</li> <li>▪ Soil erosion and sea level rise reduce available rural areas</li> <li>▪ Increased aridity at some territories impedes agriculture and hunting</li> <li>▪ Migration of species changes usual hunting areas and probably cause new vector borne diseases to living resources</li> </ul>	<ul style="list-style-type: none"> <li>▪ Textile and apparel industry demand less products for “winter” textiles</li> </ul>
A02	Forestry, logging and related services	<ul style="list-style-type: none"> <li>▪ Global warming changes productivity of forests and seasonal logging</li> <li>▪ In higher latitudes, ice and snow melting restricts winter logging</li> <li>▪ Increased aridity in some regions causes forest fires</li> <li>▪ Climate change leads to substitution of northern forest species with southern ones</li> </ul>	<ul style="list-style-type: none"> <li>▪ Low-value added products for heating are less demanded</li> </ul>
B05	Fishing, operation of fish hatcheries and fish farms	<ul style="list-style-type: none"> <li>▪ Sea warming affects fish productivity and fishing seasons</li> <li>▪ Unstable meteorological conditions increase risks of fishing</li> <li>▪ Migration of species changes the usual fishing areas</li> <li>▪ Changes in ecosystems probably cause changes in quality of fish</li> </ul>	
C11	Extraction of crude petroleum and natural gas	<ul style="list-style-type: none"> <li>▪ In higher latitudes, the permafrost melting leads to wetlands influencing equipment and pipelines</li> <li>▪ Sea level rise influences oil and gas extraction on sea shelf</li> </ul>	<ul style="list-style-type: none"> <li>▪ Warming weakens the seasonal pattern in oil and gas consumption</li> </ul>
C13	Mining of metal ores	<ul style="list-style-type: none"> <li>▪ In higher latitudes, wetlands impede mining processes</li> </ul>	
D15	Manufacture of food products and beverages	<ul style="list-style-type: none"> <li>▪ Agriculture and fishing supplies may be limited</li> </ul>	
D18	Manufacture of wearing apparel, dyeing of fur	<ul style="list-style-type: none"> <li>▪ For some territories, agricultural supplies may be limited</li> </ul>	<ul style="list-style-type: none"> <li>▪ Global warming reduces demand for fur and other winter apparel</li> </ul>
D20, D21	Manufacture of wood and cork products; paper and paper products	<ul style="list-style-type: none"> <li>▪ For some territories, forestry supplies would be restricted</li> <li>▪ Forestry and energy supplies may be limited</li> </ul>	
D24	Manufacture of chemicals and chemical products		<ul style="list-style-type: none"> <li>▪ Demand for pharmaceuticals is increasing due to climate change impact on health</li> </ul>
D27	Manufacture of basic metals	<ul style="list-style-type: none"> <li>▪ At some areas, energy supplies may be limited</li> </ul>	

		<b>Selective influence of climate change</b>	
<b>ISIC</b>	<b>Industry</b>	<b>Direct (assets and inputs)</b>	<b>Indirect (demand-side effects)</b>
E40	Electricity, gas, steam and hot water supply	<ul style="list-style-type: none"> <li>▪ For hydropower production, glacier receding and low rainfall leads to water flow instability and weakening of hydrological potential</li> <li>▪ At higher latitudes, permafrost thawing influences electricity, gas, steam and water supply infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>▪ Global warming causes the decrease in demand for steam</li> <li>▪ Demand for electricity is expected to increase in summer and decrease in winter</li> </ul>
E41	Collection, purification and distribution of water	<ul style="list-style-type: none"> <li>▪ At lowlands, sea level rise increases salinity of water</li> <li>▪ For a number of territories, water stress is expected to increase</li> <li>▪ At higher latitudes, permafrost thawing impacts quality of water and water supply infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>▪ Aridity increases demand for water</li> <li>▪ Lower water quality increases demand for purification of water</li> </ul>
F45	Construction		<ul style="list-style-type: none"> <li>▪ New climate-resistant construction standards are demanded</li> <li>▪ Demand for dyke construction in lowlands and wetland-proof building in permafrost territories increases</li> <li>▪ More frequent unanticipated demand shifts as result of natural disasters</li> </ul>
I61	Water transport	<ul style="list-style-type: none"> <li>▪ In northern territories, ice receding prolongs navigation period</li> <li>▪ Sea level rise and unstable meteorological situation increases risks of navigation</li> <li>▪ In arid territories, lower water level decreases navigation opportunities</li> </ul>	<ul style="list-style-type: none"> <li>▪ Substitution of demand for southern waterways with demand for northern waterways</li> </ul>
I62	Air transport	<ul style="list-style-type: none"> <li>▪ Unstable meteorological conditions complicate the use of air ways and increase operational risks</li> </ul>	<ul style="list-style-type: none"> <li>▪ Safety requirements for fleet are higher</li> </ul>
J66	Insurance and pension funding		<ul style="list-style-type: none"> <li>▪ Demand increases due to growing probability for natural disasters</li> </ul>
N85	Health and social work		<ul style="list-style-type: none"> <li>▪ Higher temperatures shorten the development of pathogens and foster the spread of new vectors such as malaria, Lyme disease, etc</li> <li>▪ Heat waves cause heatstroke and additional mortality from cardiovascular and respiratory diseases</li> <li>▪ Droughts cause malnutrition, less water for hygiene and poor air quality if followed by forest fires</li> <li>▪ Floods, landslips and other natural disasters cause injuries and post-traumatic stress disorders</li> </ul>
O92	Recreational, cultural and sporting activities	<ul style="list-style-type: none"> <li>▪ Glacier and ice melting reduce possibilities for winter resorts</li> <li>▪ Sea level rise threatens existing seaside resorts</li> </ul>	<ul style="list-style-type: none"> <li>▪ Public perception of disasters probability decreases number of tourists</li> </ul>

*Source: Carbon Disclosure Project, 2006; company data*

## Appendix 2. Potential business opportunities in a hotter world

ISIC	Industry	Business opportunities induced by global warming	
		Improvement of assets	Increase in demand
A01	Agriculture and hunting	<ul style="list-style-type: none"> <li>▪ Some new areas may be available for cropping and pasturing</li> <li>▪ Crop productivity grows with increase in CO<sub>2</sub> concentration</li> </ul>	<ul style="list-style-type: none"> <li>▪ Textile and apparel industry demand more products for “summer” textiles, especially in northern and mountainous regions</li> </ul>
A02	Forestry, logging and related services	<ul style="list-style-type: none"> <li>▪ Forest productivity grows with increase in CO<sub>2</sub> concentration</li> <li>▪ New forest territories become accessible in economic terms</li> <li>▪ In higher latitudes, northern navigation facilitates transportation of timber</li> </ul>	<ul style="list-style-type: none"> <li>▪ Fire fighting forest services are more demanded</li> </ul>
B05	Fishing, operation of fish hatcheries and fish farms	<ul style="list-style-type: none"> <li>▪ New fishing areas can be found</li> </ul>	<ul style="list-style-type: none"> <li>▪ Fishing hatcheries and farms are more demanded</li> </ul>
C11	Extraction of crude petroleum and natural gas	<ul style="list-style-type: none"> <li>▪ Northern explored reserves may become economically accessible</li> </ul>	
D15	Manufacture of food products and beverages		<ul style="list-style-type: none"> <li>▪ New markets for foods, beverages and drinking water appear in water-stressed regions</li> </ul>
D18	Manufacture of wearing apparel, dyeing of fur		<ul style="list-style-type: none"> <li>▪ New markets for “summer” apparel and related products in northern regions</li> <li>▪ New markets for apparel and fur in areas with limited agricultural supplies</li> </ul>
D20, D21	Manufacture of wood and cork products; paper and paper products		<ul style="list-style-type: none"> <li>▪ New markets for wood and cork in areas with restricted forestry supplies</li> <li>▪ New markets for paper and paper products in areas with limited supply of wood products and energy</li> </ul>
D24	Manufacture of chemicals and chemical products		<ul style="list-style-type: none"> <li>▪ Increase in demand for pharmaceuticals</li> <li>▪ New markets for energy consuming chemical products in areas with limited energy supply</li> </ul>
D27	Manufacture of basic metals		<ul style="list-style-type: none"> <li>▪ New markets for processed metals in areas with limited energy supplies</li> </ul>
E40	Electricity, gas, steam and hot water supply	<ul style="list-style-type: none"> <li>▪ In some regions, productivity of renewable energy production may increase (due to wind speed increase or rise in water level)</li> </ul>	<ul style="list-style-type: none"> <li>▪ Increase in demand in summer periods (especially at higher latitudes)</li> </ul>
E41	Collection, purification and distribution of water		<ul style="list-style-type: none"> <li>▪ In water stressed and low lying coastal regions, demand for water purification increases</li> </ul>

ISIC	Industry	Business opportunities induced by global warming	
		Improvement of assets	Increase in demand
F45	Construction		<ul style="list-style-type: none"> <li>▪ New market for infrastructure adjustment at permafrost thawing regions</li> <li>▪ New markets for dyke construction in coastal regions, wetland proof building at northern territories; country-houses (due to worsening thermal conditions in the cities) and construction of climate control systems</li> <li>▪ Increase in demand for construction of renewable energy and atomic energy production facilities</li> <li>▪ Unanticipated demand in the regions affected by natural disasters</li> </ul>
I61	Water transport		<ul style="list-style-type: none"> <li>▪ Increased demand for northern sea and river waterways due to the prolonged navigation period and less traditional winter ways available</li> </ul>
J66	Insurance and pension funding		<ul style="list-style-type: none"> <li>▪ Demand for insurance greatly increases due to growing probability for natural disasters</li> <li>▪ New markets for insurance against property losses and business interruptions</li> </ul>
N85	Health and social work		<ul style="list-style-type: none"> <li>▪ Demand for various medical services and emergency increases</li> <li>▪ New markets for emergency and disaster relief services</li> </ul>
O92	Recreational, cultural and sporting activities	<ul style="list-style-type: none"> <li>▪ Global warming potentially results in formation of new resort territories</li> </ul>	

*Source: Carbon Disclosure Project, 2006; company data*

### Appendix 3. Cross-industry examples of company adaptation to climate change

ISIC	Industry	Climate proof action taken	Source
A01	Agriculture	Extreme weather events or changing climate conditions increase risks for availability and sourcing locations of food ingredients and raw materials. Some products of <b>General Mills</b> , such as vegetables, rely on proprietary strains which have been developed over many years to grow under a variety of climatic conditions. This work continues in order to develop these product sources suitable for multiple geographies, to minimize drought or other climate risks.	<i>CDP</i>
A02	Forestry, logging and related services	Logging companies in Russia encountered additional transportation expenses and decrease in logging due to the warm winter in 2006/2007. 65% of timber in Russia is logged in winter period when forest tracks are frozen. In North-West part of the country warming caused 30% decrease in logging. Due to the lack of timber a number of sawmills in Arkhangelsk region were stopped. In total, the monthly losses in the industry were about \$100 mln in December and January	<i>Vedomosti, 16 January 2007</i>
C11	Extraction of crude petroleum and natural gas	<b>Petro-Canada</b> has adapted the internationally recognized Incident Command System into a process, called the Incident Management System (IMS), which provides managers with the tools and ability to be able to manage any type of emergency that might face the organization. The process integrates the hands on (Tier I) responses at facilities with Tier II (Response Management) activities that support those responses. The Tier III response process is called Crisis Management and is directed at protecting the corporation against financial and reputation consequences of emergencies.	<i>CDP</i>
C13	Mining of metal ores	<b>Iluka</b> company is changing its mining operations to reduce water usage via reduced processing of ore deposits with higher clay content, implementing a tailings disposal at the Douglas mine site (Victoria) that maximizes the use of return water, as well as supporting an industry research initiative examining options to reduce use of water in dry mineral processing. In the Murray Basin, Iluka has reached agreement with the local water authority (Grampians Wimmera Mallee Water) for the development of an additional bore which is expected to supply 2 mega liters per day into the GWMW system.	<i>CDP</i>
C14	Other mining	<b>Diavik Diamond Mines Inc.</b> relies on “ice bridges” to move equipment and materials to the northern regions of Canada. However, the 2006 winter was so warm that roads closed early and the ice never got thick enough to allow transport of the heaviest trucks. The company had to absorb the additional costs of shipping materials by helicopter.	<i>Hoffman, 2006</i>
D20, D21	Manufacture of wood products; paper and paper products	<b>Klabin</b> , pulp and paper producing company in Brazil, is gradually closing circuits and investing in technology that will allow water reuse in near future. Klabin is updating its power plants in order to optimize the electrical energy cogeneration as well as condensing capacity as a back up.	<i>CDP</i>
D24	Manufacture of chemicals and chemical products	<b>GlaxoSmithKline</b> , the company that owns Ribena and buys 95% of the UK blackcurrant harvest, is concerned that production of the fruit will suffer in milder winters. The pharmaceutical group has asked scientists to cross-breed varieties that are less reliant on harsh winters and heavy frosts.	<i>CDP, The Independent, 31 May 2006</i>
E40	Electricity, gas, steam and hot water supply	<b>TransAlta</b> , an electricity generator with facilities that stretch from Mexico to Alberta, is now faced with unreliability of water flows for hydro-generation. Some of TransAlta’s hydro reservoirs have experienced one year in a century low-water conditions, several years in a row. In the Canadian Rocky Mountains basic water flows have been affected by receding glaciers and erratic snow packs, reducing the generating capacity of hydroelectric facilities. Water sustainability is now a key factor in corporate planning within the company and, as the physical aspects of climate change continue to become more acute, related risks to TransAlta’s physical assets and future investments will become more severe. <b>RWE</b> power generation company treats adaptation to climate change as major challenge. The revision planning of RWE’s power plants had to be adapted to the higher demand it faced during past summer periods. The increase in installed wind power capacity requires additional back up capacity of conventional generation capacity to secure electricity supply.	<i>CDP</i>



ISIC	Industry	Climate proof action taken	Source
F45	Construction	<p><b>Hochtief</b> company has new business opportunities in the changing demands made by clients in the services sector closely associated with construction work. These include “sustainable building”, which is growing in importance worldwide. Hochtief continues to be active in the development, planning and construction of production plants for regenerative energies as well as revitalization of dams and port facilities. In future the company shall enforce activities to manage risks in order to protect its operations. The company is expecting the growing insurance costs.</p> <p>Warm winter 2006-2007 <b>in Russia</b> increased efficiency in building and decreased its losses. Concrete is cheaper, less antifreezing agents are needed, less expenses are needed for heating and warm clothes. Usual expenses can be decreased by 3-5%, but in finishing works which need heating - by 10-12%. The weather lets build by 30% faster.</p>	<p><i>CDP</i></p> <p><i>Vedomosti, 11 January 2007</i></p>
G	Wholesale and retail trade	<p><b>Tesco’s</b> operations and suppliers are affected by extreme weather events. These change customer shopping patterns and availability of product. The company is monitoring the weather and its buyers work closely with its suppliers to respond to changes. Weather patterns also affect the equipment in its stores and its engineering teams are prepared to predict and respond to these changes.</p> <p>During the July 2006 heatwave staff at <b>Starbucks</b> coffee shops struggled to keep pace with demand for frappuccinos and other frozen drinks during the busiest morning hours, when customers normally order hot beverages. Sales growth slowed as a result, and shares fell by 11% after the company announced a change in store operations to improve service. Sales recovered after the chain reviewed its employee training and instore production process</p>	<p><i>CDP</i></p> <p><i>CDP, The Guardian, 4 August 2006</i></p>
I61, I62	Water transport, air transport	<p>Speed limits were imposed on some <b>Underground</b> routes in May 2006, when engineers failed to “pre-stress” and test the rails as temperatures increased. Speed limits of 20 mph were imposed. The delays caused significant disruption to tens of thousands of commuters, with knock-on impacts for the rest of the network.</p> <p>Warm winter was an advantage for water transport. The amount of ships in <b>Saint-Petersburg port</b> didn’t decrease comparing with the autumn, though usually their number is 10-15% less.</p>	<p><i>CDP, The Evening Standard, 10 May 2006</i></p> <p><i>Vedomosti, 12 January 2006</i></p>
I64	Telecommunications	<p><b>Verizon</b> is taking several actions to adapt to extreme weather. It is in the process of significantly upgrading its network to a fiber network which is much less susceptible to changes in weather conditions. It is deploying fiber directly to its customers’ homes and businesses. Verizon is also continuing to build additional redundancy into its network. Fiber and advanced electronics give it much more flexibility to re-route network traffic when a portion of our network is impacted. Verizon is currently exploring the possibility of deploying fuel cells nationwide at remote terminals prone to power outages caused by ice storms, high winds, hurricanes or very hot temperatures. To address unusual events that could impact its network, such as extreme weather conditions, Verizon has established an organization focused around contingency planning. The company has skilled emergency response teams with action plans and clear procedures on how to handle unusual events.</p>	<p><i>CDP</i></p>
J66	Insurance and pension funding	<p><b>IAG</b> (Australia) is highly involved in initiatives to improve knowledge of climate risk and its potential impacts on business and economy. IAG is conducting leading research to model future climate scenarios to identify future risk profiles and economic impacts; sponsoring research at Oklahoma University to better understand the nature of the short and long term commercial risks of climate change across main lines of insurance; sponsoring of Risk Frontiers, which is regarded as a world leader in quantitative natural hazards risk assessment and risk management. <b>IAG</b> sponsors work of the Townsville Cyclone Testing Station which researches, tests and advises industry and governments on building practices that minimise loss and suffering as a result of severe wind events. <b>IAG’s</b> Industry Research Centre has developed the Hail Gun to identify roofing material that can withstand hailstorms. The gun propels hail shaped ice at roofing and building materials to identify key vulnerabilities of the materials to the impacts of hail stones; and how these vulnerabilities change with age. <b>IAG’s</b> Industry</p>	<p><i>CDP</i></p>

ISIC	Industry	Climate proof action taken	Source
		<p>Research Centre has developed the “Greensafe Car Profiler” which provides motorists with a one-stop-shop to gain information about the environmental impact, safety features and running costs of vehicles for sale in Australia.</p> <p><b>Tokio Marine &amp; Nichido Fire Insurance Co.,Ltd.</b> have been developing the products which cover weather risks. For instance it first developed the insurance which covered weather risks and also first developed, available the weather derivatives in the world as standard products, and typhoon derivatives. As the increase of customer's concern about the risks of the climate change, it continues to develop and provide a large number of weather derivatives that can meet the diverse needs of customers recently. As one of Tokio Marine &amp; Nichido Fire Insurance's correspondence to thus climate change, it has participated in joint research with The University of Tokyo and two companies as industry-university co-operation which focus on the climatic and environmental issues. This research inspects what global warming will bring to insurance companies and society.</p>	
N85	Health and social work	<p><b>Novartis</b>, the company operating in the field of pharmaceuticals, consumer health and vaccines, is engaged in the programs against neglected diseases. In particular the Novartis Institute for Tropical Diseases (NITD) conducts research on Tuberculosis and Dengue fever. Novartis Foundation for Sustainable Development (NFSD) has an active program to fight malaria. Furthermore, it is expected the newly established Novartis “Vaccines and Diagnostics” division will contribute to counteracting growing detrimental health effects that might be related to climate change.</p>	<i>CDP</i>
J65	Financial intermediation	<p><b>Westpac</b> (Australia) has recently completed construction of a new corporate headquarters in Sydney. In 2006 Westpac relocated from eleven Sydney CBD corporate office locations down to two sites. A facade design, which incorporates “low-e” double-glazing and a wall cavity ventilation system on the high-rise level areas to provide improved thermal performance and internal comfort. An automated internal blind control system on the building's western front to offset heat from the sun. Provision of a stormwater harvesting system which collects the rain water run off and re uses the water in the air-conditioning system cooling towers to replenish the cooling water lost through evaporation.</p>	<i>CDP</i>
O92	Recreational, cultural and sporting activities	<p>The impact of climate change on the already unpredictable winter sports season has influenced managers to market ski resorts as all-year destinations. This follows the example of <b>Whistler</b> in Canada, a centre for skiing in winter and mountain biking and walking in the summer.</p> <p>Warm winter 2006-2007 could cause 20% decrease of <b>Intersport-Russia's</b> (Saint-Petersburg) sales. Winter collections as a rule are more technological and comprehensive and as a result more expensive, but there was no demand for them. The company had to make special offers for winter collections.</p> <p>About 1,5 months without snow in 2007 caused \$1-6 mln losses for <b>ski resorts</b> near Moscow. The amount of tourists decreased by 50% and the season was opened one-two weeks later than in 2006. Resorts begin to use artificial snow, try to offer more entertainment programs, increase prices.</p>	<p><i>CDP, Financial Times, 10 January 2006</i></p> <p><i>Vedomosti, 12 January 2007</i></p> <p><i>Vedomosti, 26 February 2007</i></p>