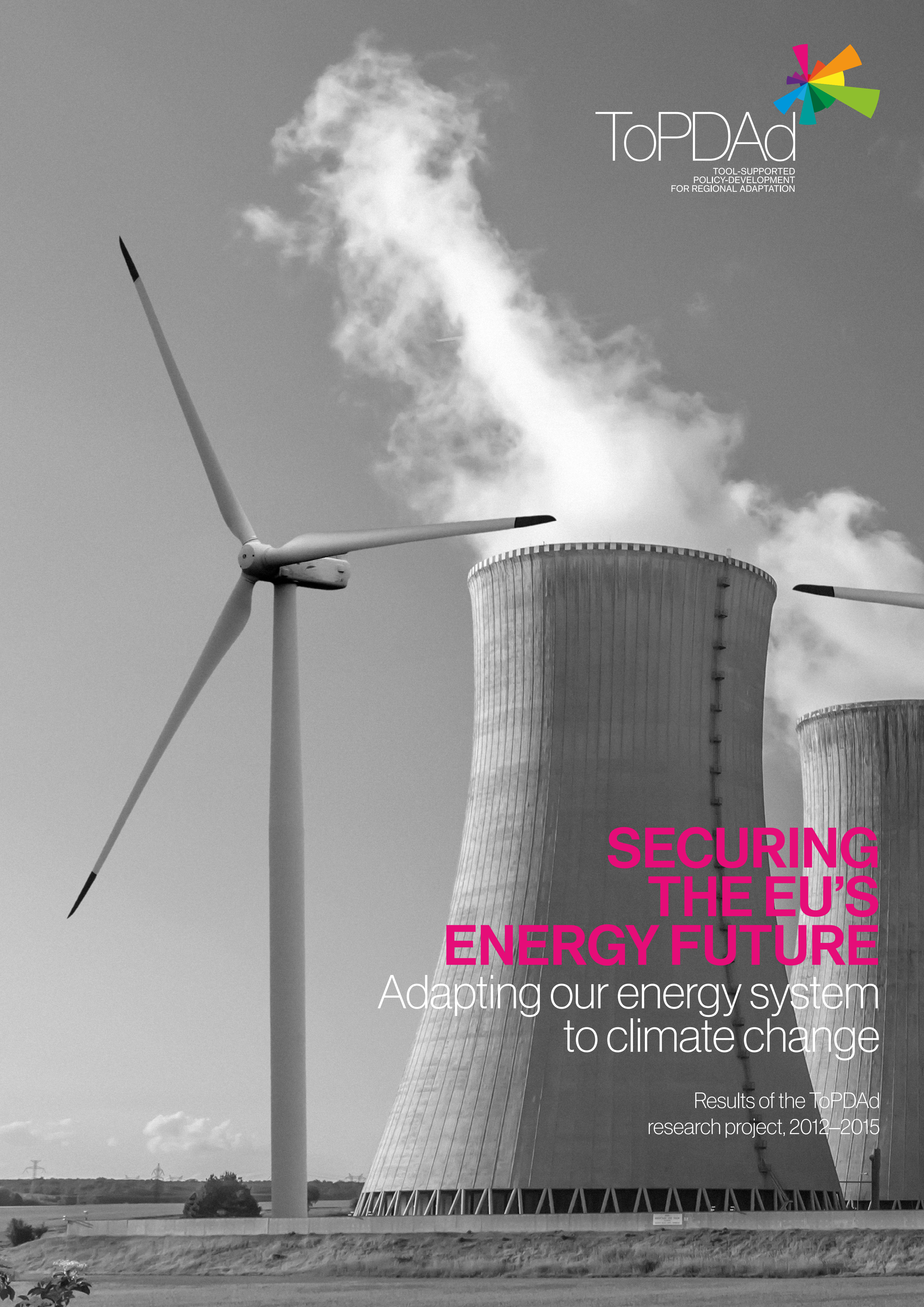

ToPDAd

TOOL-SUPPORTED
POLICY-DEVELOPMENT
FOR REGIONAL ADAPTATION

SECURING THE EU'S ENERGY FUTURE

Adapting our energy system to climate change

Results of the ToPDAd research project, 2012–2015

Executive summary

SECURING THE EU'S ENERGY FUTURE

Adapting our energy system to climate change

Climate change poses multiple challenges to the energy system of the European Union. Energy generation must become less carbon-intensive, as climate mitigation policies progressively rely on low-carbon, renewable energy. In addition, there is increased focus on reducing the vulnerability of that energy system to climate impacts.

ToPDAd has brought together economic, energy, climate and social models to provide a glimpse into how the energy system might evolve over the coming decades and into the points of greatest vulnerability. Several case studies look at the impacts of both gradual climate change and extreme weather events. The results show that whereas the EU energy system can largely accommodate gradual climate change, it is particularly vulnerable extreme weather events.

Adaptation of the energy system will happen largely automatically. Currently, investments already take long-term uncertainty (including uncertainty in the climate) into account. However, improved scientific knowledge of the scale and timing of climate change through ToPDAd will reduce this uncertainty and hence reduce investment risk.

ToPDAd also studied the broader macro-economic impact of climate damage – with and without adaptation scenarios. Using the case of nuclear power in France as an example, the results show that losses could vary between tens and several hundred billions of euros per decade as of 2100, if the current infrastructure and policies remain in place. Adaptation strategies like building a smart grid and changing the coolant regulations for nuclear plants could reduce economic losses by a third or more. This is a clear message that investments in adaptation of the energy system and the policies that support them, do pay off.

ToPDAd has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 308620.

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Key findings

Variations in renewable energy production and energy demand in Northern Europe under gradual climate change

A changing climate will not significantly affect the production of wind and solar energy in this region, while the overall electricity demand will decrease due to warmer temperatures and reduced heating load in winters.

→ Overall, the impacts of climate change on normal operation of power and heat sectors are likely to be slightly positive in this region. Other factors such as changes in GDP, fuel price or investment costs will probably affect the costs for the power system more than climate change.

→ The cost of adapting to variations in renewable energy production could be small, if investments could be allocated in the best possible way. However, if other policies – such as maximizing the share of renewable sources – take precedence, costs may go up.

The vulnerability of the EU energy system and economy to extreme weather

→ Climate change will affect the energy system through, for example, changes in temperature and rainfall patterns, sea level rise, storm surges and combinations of drought and heatwaves.

→ This will lead to changes in heating and cooling demand, but it will also affect supply infrastructure.

→ The changes are likely to be modest through 2050 under all but the most dramatic scenarios of climate change. The projected changes remain within the range of weather variability that is already incorporated into the design and management of energy systems.

→ Changes move beyond the current range of weather variation between 2050 and 2100, requiring adaptation strategies and investments to be in place by 2050.

The loss of sufficient coolant water for nuclear stations in France

Combined drought and heatwaves can curtail power production from nuclear energy, causing significant economic loss.

→ Under a medium climate change scenario costs can amount to tens of billions euro, while under a high climate change scenario, costs could raise to several hundred billion euro.

→ Losses are markedly higher in 2100, approximately doubling above the baseline and 2050 values.

→ Adaptation strategies reduce the losses significantly after 2050 by between 5 billion EUR (reducing energy exports) and 15 billion EUR (temporary reductions in non-essential energy use by means of a smart grid) per year.

→ Thus, a cost-benefit calculation calls for adaptation investments on the same scale.

The EU energy system is facing multiple challenges

The European Union has committed to decarbonising its energy system to reduce the risks from climate change. At the same time, the energy system must increase its resilience to potential damage from climate change. Both gradual change and extreme weather events will influence the reliability of the system and the variability in the available resources (including wind, water and sun). The policy challenge is to provide energy security, while maintaining economic vitality and meeting climate targets.

Scientific knowledge of the magnitude of climate change, its economic impacts, and the technologies and investments required to make the energy system resilient, is advancing rapidly. It is especially important to understand the relationships between the energy and other economic sectors, like transport, tourism etc. Where policies do not reflect these relationships – either due to lack of data or appropriate conceptual models, there is danger that solutions will simply shift problems from one economic or infrastructure sector to another, rather than addressing various sectors as an interacting system.

ToPDAd has created a toolset that provides a glimpse into the evolution of the energy systems of the EU in response to both climate and energy policies. It analyses the main vulnerabilities of the EU energy system, the implications for the EU economies, and the adaptation policies that will reduce this vulnerability.

The interdisciplinary research behind this research project captures the relationships between different economic sectors. VTT Ltd and the University of Cambridge Centre for Climate Change Mitigation Research (4CMR) led the research, while also linking to the work of ToPDAd's transport, climate science, decision analysis and macroeconomic teams.

The researchers studied two cases: how climate change and adaptation will affect renewable energy sources in Northern Europe (the Nordic and Baltic countries, Poland and Germany); and how vulnerable the EU energy system and economy are to extreme weather. In both cases, three progressive climate change scenarios were applied – so-called Representative Concentration Pathways: RCP 2.6, RCP 4.5 and RCP 8.5. In RCP 2.6 climate change remains limited and global warning would stop mid-century due to timely and radical emission reductions. In RCP 4.5 global emission reduction efforts build up slower and less radical than in RCP 2.6, resulting in more climate change while global temperature rise stops – almost – only by the end of the 21st century. In RCP 8.5 global emission reductions remain very modest, resulting in ongoing climate change and substantial global temperature rise by 2100.

Plotting a course for future investments in the energy system in Northern Europe

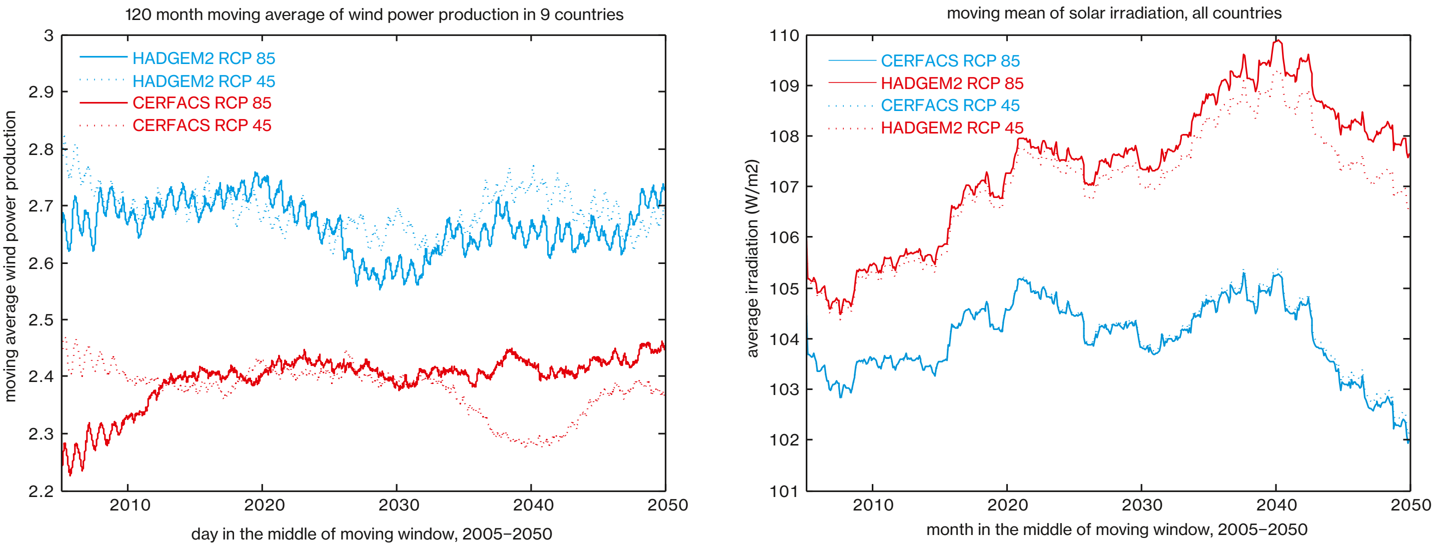


Figure 1: ToPDAd projections of the amount of wind power and solar irradiation under different RCPs and for different years out to approximately 2050.

In this case study ToPDAd examines the evolution of the energy system between today and 2050 under gradual climate change (i.e. without extreme weather events such as floods or heatwaves). Both supply and demand changes are assessed using the VTT-Times and Balmorel energy system and energy market models, which together follow the market for energy and the technologies that will appear in that market to meet demand.

The results reveal that a changing climate will not significantly affect the production of wind and solar energy in Northern Europe, with a potential slight increase in solar insolation.

Changing rainfall patterns will give greater potential for hydropower. However, the projected decrease in snow and melting water, as well as smaller spring floods, will require a more flexible use of hydro reservoirs. Bio-energy was not a part of this study.

Climate change will decrease the gap between supply and demand of energy in Northern Europe. Due to warmer winters and increased rainfall, the region will see a slight decrease in heating demand during winter and an increased availability of hydropower. Therefore, the need for investments in the energy sector in Northern Europe will decrease.

Table 1:
ToPDAd projections of the changes in supply and demand characteristics of the Nordic energy system under different RCPs in 2050, with and without adaptation strategies. Percentage changes are relative to the baseline of no climate change.

	RPC 2.6 Low climate change	RPC 4.5 Medium climate change	RPC 8.5 High climate change
		Demand	
Electricity demand	-1%	-1%	-2%
Heat demand	-8%	-10%	-13%
		Supply	
PV Solar	–	–	+3%
Run-of-River hydro	–	+4%	+8%
Reservoir hydro	–	+6%	+8%
		Total energy system costs	
Adaption	-1.3%	-1.7%	-2.5%
No adaption	-1.0%	-1.4%	-2.4%
		Variable costs	
Adaption	-1.1%	-1.4%	-2.4%
No adaption	-2.8%	-3.7%	-5.5%

Vulnerability of the EU energy system and economy from extreme weather due to climate change

Individual nations have developed climate adaptation strategies in their medium- and long-term planning for energy security. A review of these reports indicates they all consider approximately the same mix of broad climate impacts that present challenges to the energy system under a changing climate, some of which are technological and others socio-economic.

In Central and Eastern Europe, the following climate change impacts on energy systems are projected:

→ Temperature increase in summer, leading to increased power demand as air conditioning becomes more prevalent, as well as decreased ability of network lines to carry power (the warmer it becomes, the less wires can shed off heat).

→ Temperature increase in winter, leading to decreased heating demand. At present, this reduces the demand for natural gas, but this might reverse with progressing electrification of the energy system.

→ Increased rainfall during winter months, with the potential flooding of substations. Decreased rainfall during summer months, with droughts damaging underground cables – reducing their ability to shed heat – and subsidence causing damage to the foundations of substations.

→ Combinations of drought and heatwaves that reduce the cooling water capacity at power stations, often at precisely the time when power demand is highest due to the need for cooling in buildings.

→ Sea level rise, with implications for coastal power generation capacity.

→ Storm surges, again with implications for coastal power generation as well as generation capacity located within or near flood plains.

These changes are likely to be modest through 2050 under all but the most dramatic climate scenarios. The projected changes in climate remain within the range of weather variability already incorporated into the design and management of energy systems. After 2050, changes move outside this range. However, there is uncertainty as to whether effects will become significant closer to 2050 or 2100. Therefore, this will require adaptation strategies to be in place prior to 2050.

Significant changes to vulnerability begin under both RCP 4.5 and 8.5 nearer to 2050 than 2100, so investments in a climate-resilient energy system must be in place before 2050 to allow time for the investments to be staggered. If investments come later, significant climate impacts could occur before the investments in resilience are complete. Investments in adaptation should be coupled to water basin management strategies to ensure cooling water availability for power production during droughts and heatwaves.

Assessing wider economic effects: the case of the loss of sufficient coolant water for nuclear stations in France

In the second energy case study, ToPDAd analyses how damage to the energy system will 'ripple' through the wider economic system. A vibrant economy depends on a reliable and affordable energy system. In some cases, indirect economic effects can be as large as the direct impacts on the energy system. An Adaptive Regional Input-Output (economic) model, developed originally for the UK ARCADIA project (ARCADIA-ARIO) and enhanced through the ToPDAd project, was applied to two case studies: extreme weather in London and one energy-related scenario – loss of sufficient coolant water for nuclear stations in France. In this section, we will focus on the latter case.

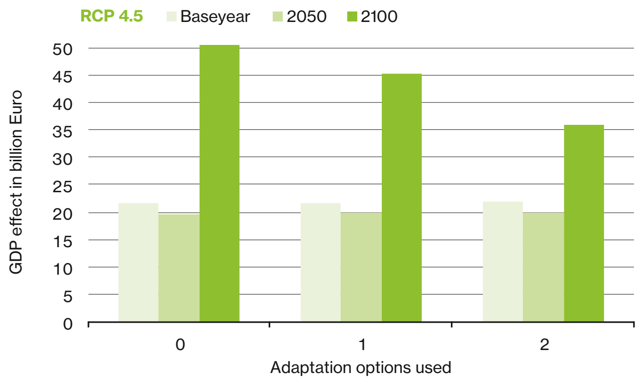
The project uses two combined heatwaves and droughts in France, in 2003 and 2006, as a baseline, and assesses their direct and indirect damages through the ARCADIA-ARIO model. To predict future climate projections from the University of East Anglia about temperature and rainfall in 2050 and 2100. And this for three climate scenarios – RCP 2.6, 4.5 and 8.5 scenarios. From this climate information, we estimated the increased frequency with which combined droughts and heatwaves at least as deep as those in 2003 and 2006 might occur, and then estimated the direct and indirect damage caused in the decades of 2050 and 2010.

Combined protracted heatwaves and drought lead to an increase in water temperature and a reduction in water flow in the rivers. Especially the first is a threat to nuclear power production, more so than low water flow. In 2003 and 2006, these conditions resulted in 10–15% power loss throughout the heatwaves, with higher losses during the peaks. Under this scenario losses range between 200 and 300 million EUR per year, with adaptation measures reducing these losses by 60 billion euros per year or more.

Under the RCP 8.5 scenario, economic losses amplify due to the greater height of summer temperatures, resulting in higher water temperatures and a greater reduction in water flow. Therefore, there is an even more compelling cost-benefit case for adaptation under RCP 8.5. Some of the necessary changes to the nuclear power system are already being made, representing a form of automatic adaptation.

Finally, ToPDAd looked at a variety of adaptation strategies that could reduce this economic loss, including:

1. During a period of reduction, residual power is allocated to maintain industrial production and meet final consumer demand in France, while power exports are reduced.
2. Residual power is allocated to maintain industrial production, final demand and exports, while a smart grid and smart buildings allow for reduction of non-essential energy use during the 'brownouts'.



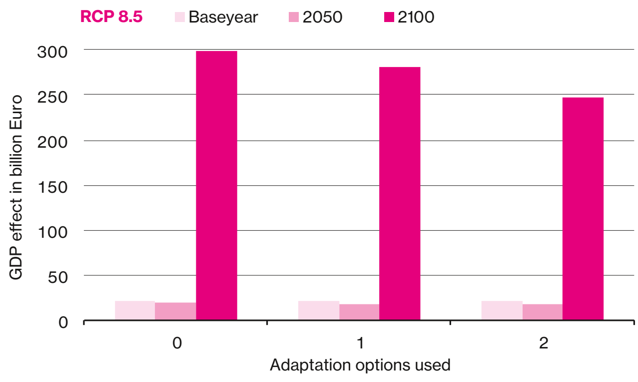


Figure 2.
Total GDP loss (in billion Euro) in France in 2010 (baseyear), 2050 and 2100 and levels of adaptation aimed at avoidance of power loss during combined heatwave & drought, for RCP 4.5 and RCP 8.5

About the ToPDAd toolset and project

ToPDAd
TOOL-SUPPORTED POLICY-DEVELOPMENT FOR REGIONAL ADAPTATION

ToPDAd stands for "tool-supported policy development for regional adaptation" to climate change. This EU-funded research project developed a toolset to help decision makers at various levels – from individuals and private businesses to national and European policy makers, mapping future challenges related to climate change adaptation and making a cost-benefit analysis of different adaptation strategies.

The ToPDAd toolset integrates climate scenarios and socio-economic data from 15 existing models, allowing for an integral assessment of adaptation strategies. It builds on a broad range of data – from the impacts on choices of transport routes and tourist destinations to impacts on macroeconomic indicators, such as GDP, sector composites, market prices and greenhouse gas emissions.

Decision makers at local level or SMEs often sit on different information than national decision makers or multinational companies. Therefore, national or European adaptation strategies may imply limitations, barriers and constraints to local initiatives for increasing climate resilience, and vice versa. By bringing together information from different sectors and disciplines and combining the output from both micro- and macro-models, ToPDAd is among the first to show strong interdependencies between various sectors and decision levels.

To demonstrate its potential, the ToPDAd toolset was applied in seven case studies about three economic sectors – energy, tourism and transport. While starting from local events and situations, the results of these studies are also relevant for and applicable in wider regions in Europe. The cases look forward to 2050 and some to 2100, while applying different climate scenarios, based on combinations of the climate pathways (RCPs) and socio-economic pathways (SSPs).

The case studies cover the following themes: (1) summer beach tourism, (2) winter skiing tourism, (3) the effects of extreme events on traffic in cities, (4) new potential arising for shipping as a result of Arctic ice melting, (5 & 6) effects of climate change on energy production (renewable energy and nuclear energy), and (7) the macro-economic impact of extreme rainfall in cities.

In addition, ToPDAd studied the potential consequences of climate change on public health and assessed adaptation strategies from a macro-economic perspective. Available studies on the impacts of climate change on public health focus primarily on mortality under heat waves. Adaptation strategies therefore focus mainly on monitoring vulnerable people during heat waves and enhancing services to tackle heat stress. This is for example relevant for beach tourism, which is one of the case studies of ToPDAd. Integrating the available knowledge on health impacts in a macroeconomic model however reveals some broader consequences of climate change on public health. While some affected people might need surgery, others will need to rest more and become less productive. This may also affect labour productivity. In other words, adaptation strategies need to go beyond monitoring vulnerable people, but also need to take into account the labour market. Again, these results show the importance of an integral cost-benefit assessment of adaptation strategies, as is done with the ToPDAd toolset.

For more information on the research project and its outputs, visit www.topdad.eu or explore how results may be relevant for your sector or region with the interactive tool at http://topdad.services.geodesk.nl/.

The research project ran from October 2012 to September 2015 and received EUR 4 556 233 in funding by the European Union's research programme FP7 under agreement number 308620. It involved ten research institutes from nine European countries, coordinated by VTT Technical Research Centre of Finland Ltd.

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