Climate Risk:
Scope and Probability

Klimarisikoutvalget
17 January 2018

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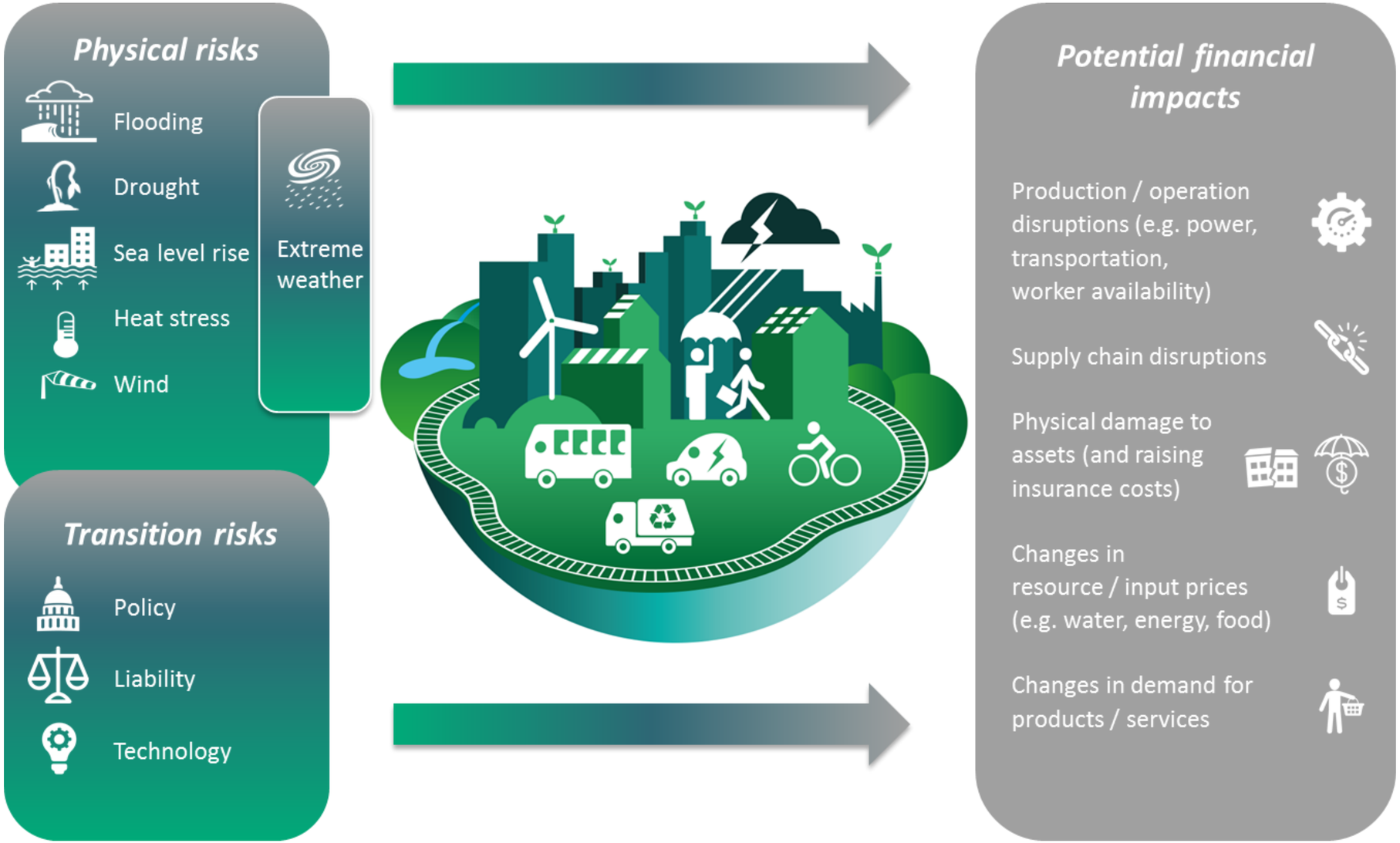
What is climate risk?

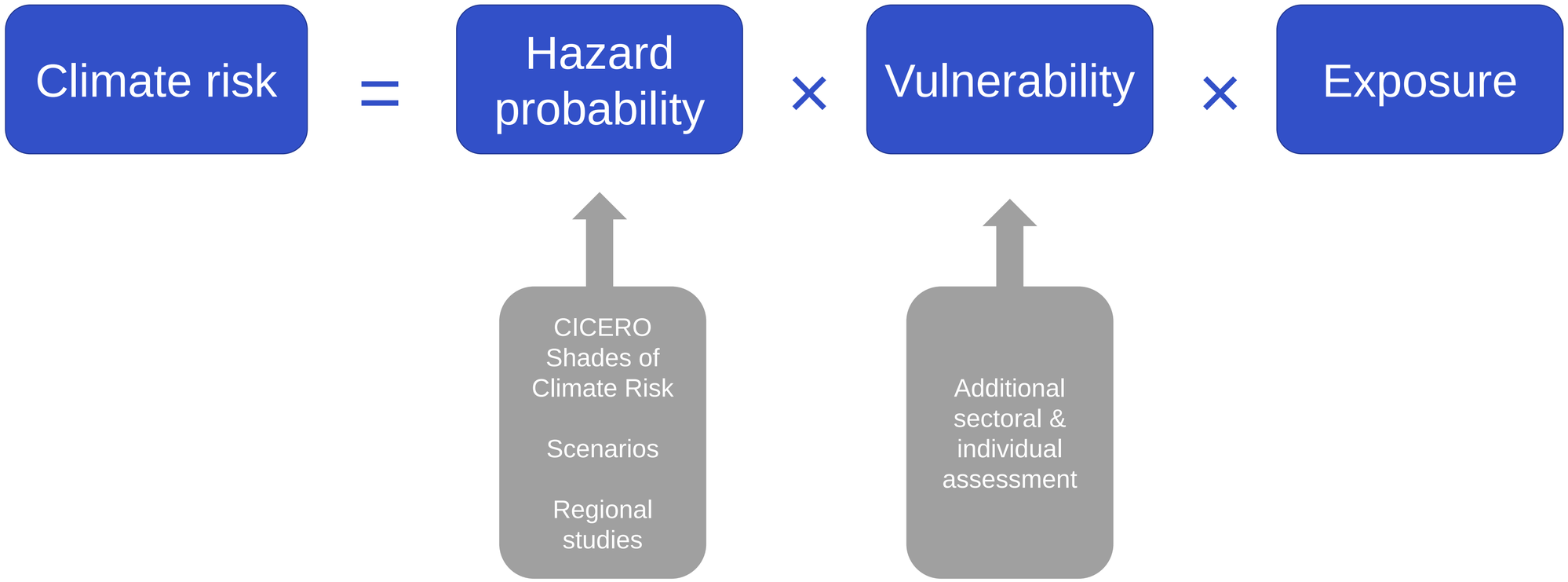
Scope of climate risk



CICERO

Source: Shades of Risk, CICERO, 2017

Climate change risk equation



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Source: Shades of Risk, CICERO, 2017, based on IPCC risk equation

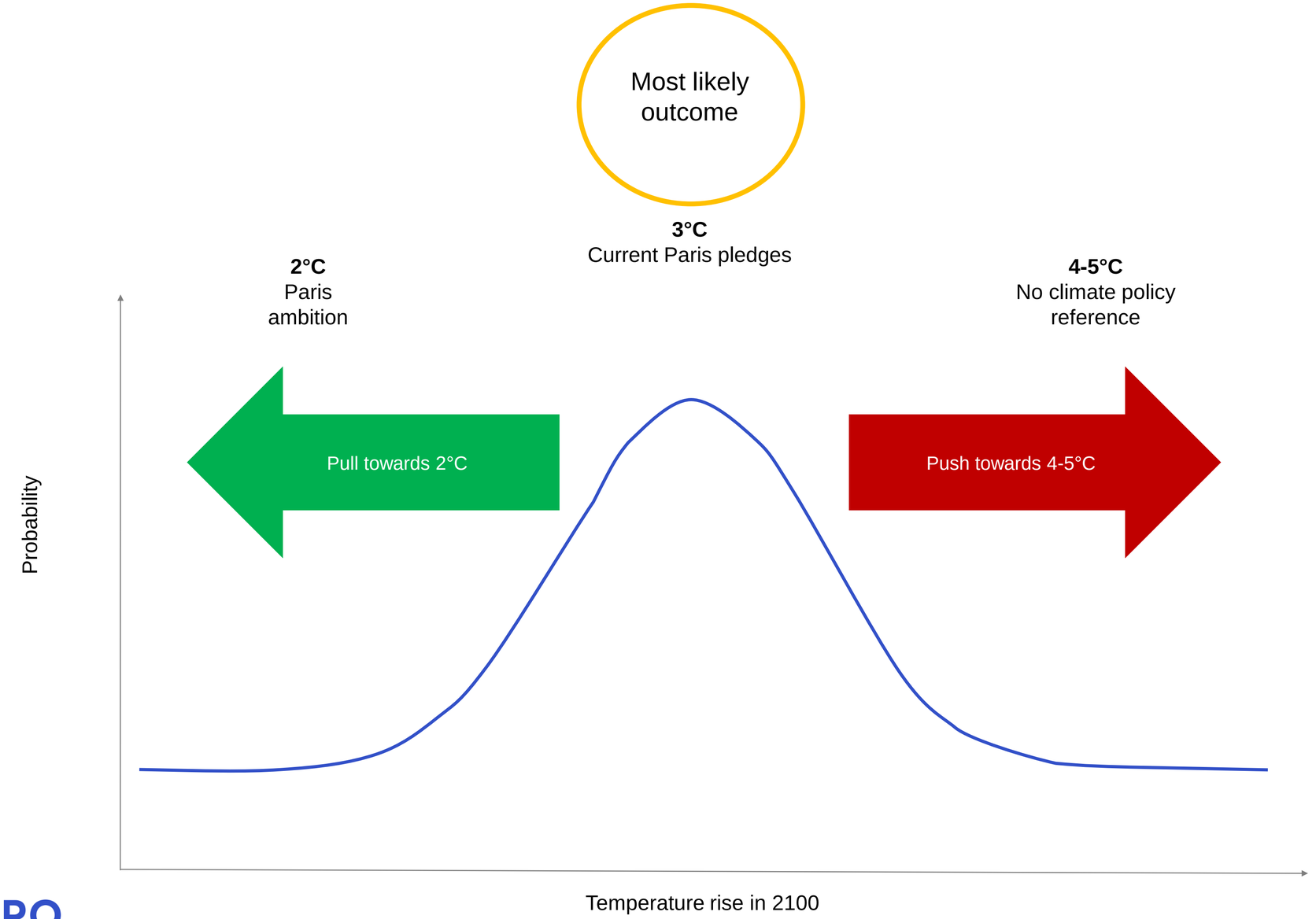
Expressing relative climate risk

Environmental Finance Green Bond Awards 2017 Winner
Best external review provider

Green Bond Awards 2017
Climate Bonds Initiative

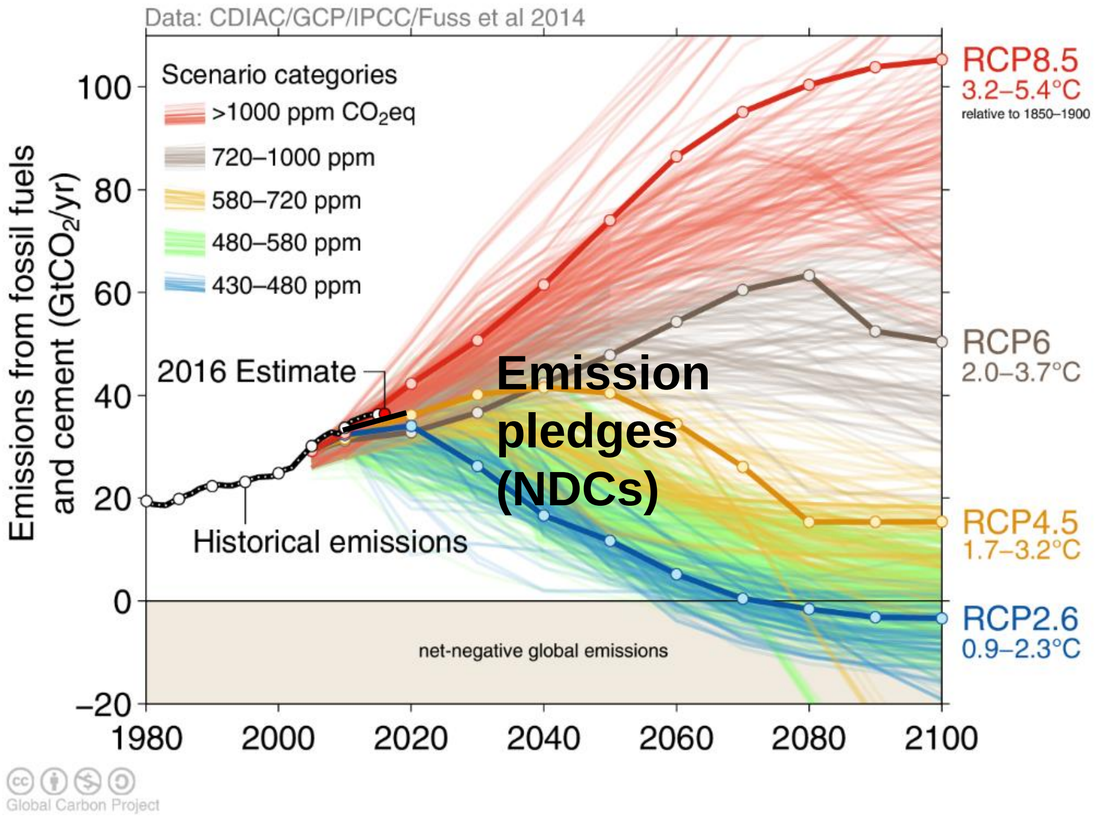
SHADES OF GREEN	EXAMPLES
Dark green is allocated to projects and solutions that correspond to the long-term vision of a low carbon and climate resilient future.	 Wind energy projects with a governance structure that integrates environmental concerns
Medium green is allocated to projects and solutions that represent steps towards the long-term vision, but are not quite there yet.	 Plug-in hybrid busses
Light green is allocated to projects and solutions that are environmentally friendly but do not by themselves represent or contribute to the long-term vision.	 Efficiency in fossil fuel infrastructure that decreases cumulative emissions
Brown for projects that are in opposition to the long-term vision of a low carbon and climate resilient future.	 New infrastructure for coal

Which scenarios are most likely?



Source: CICERO Climate Scenario Guide (forthcoming February 2018)

Temperature impacts expected to be more severe in Nordics



6-8° warmer in Nordics

Photo from Aftenposten taken by Olav Olsen

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Sources: (Fuss et al. 2014) (CDIAC) (IIASA AR5 Scenario Database) (Global Carbon Budget 2016))

When to use scenario stress-testing … and when it doesn't matter

	Now	Next 10-20 years	Mid-century
Physical Risk 	Scenarios don't make much difference due to locked-in GHG emissions Consider probabilities of physical events (e.g. CICERO's Shades of Risk.	Scenarios don't make much difference due to locked-in GHG emissions Consider probabilities of physical events (e.g. CICERO's Shades of Risk)	Scenarios can help bound range of risks Consider scenario range of 2-4°C
Transition Risk 	Scenarios can help bound range of risks Consider scenario range of 2-4°C	Scenarios can help bound range of risks Consider scenario range of 2-4°C	Scenarios can help bound range of risks Consider scenario range of 2-4°C

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Source: CICERO Climate Scenario Guide (forthcoming February 2018)

Transition risk

IEA WEO* Scenarios' "Must Haves"

Current Policies

New Policies

Sustainable Development

Must Haves	Current Policies		New Policies		Sust. Development
CO_2 price**	Low CO2 price in only a few developed economies	increase 20 %**	Moderate CO2 price in some major economies	increase 192%**	High CO2 price in most major economies
Energy efficiency***	Energy intensity**** improves at average annual rate of 1.9 %	increase 21%	Energy intensity**** improves at average annual rate of 2.3 %	increase 39%	Energy intensity**** improves at average annual rate of 3.2 %
Renewable electricity generation	Renewables rise to 31% of global generation in 2040	increase 29 %	Renewables rise to 40 % of global generation in 2040	increase 58%	Renewables rise to 63 % of global generation in 2040
Electric vehicles (EV)			EV make up 14 % of global passenger cars	increase 214%	EV make up 44 % of global passenger cars
Carbon capture & storage (CCS)					210 GW of coal power production, o/w 150 in China) is CCS equipped

Note: The order of «Must Have's» was chosen for demonstrative purposes. The order does not imply magnitude. All values in boxes are for 2040 (end of IEA WEO scenario periods)
Values in arrows mark the increase needed for one Must Have to move from one scenario to the next

* The IEA World Economic Outlook scenarios were chosen since they focus on transition risks, are from an independent source, and are most commonly used

** CO_2 prices are for the EU Emissions Trading System (ETS) in 2040. EU ETS was chosen since institutions for CO_2 pricing already exist and because it is the only large market included in all three scenarios.

*** Energy efficiency refers to the ratio of benefits to expenses. We apply the end-use energy efficiency perspective on the demand-side with an increase in energy end-use efficiency achieved by technical, organizational, institutional, structural or behavioral changes.

**** Energy intensity is understood as the amount of energy used per unit of GDP. Improvements in energy intensity are to a large extent driven by improvements in energy efficiency.

Source: CICERO Climate Scenario Guide (forthcoming February 2018)

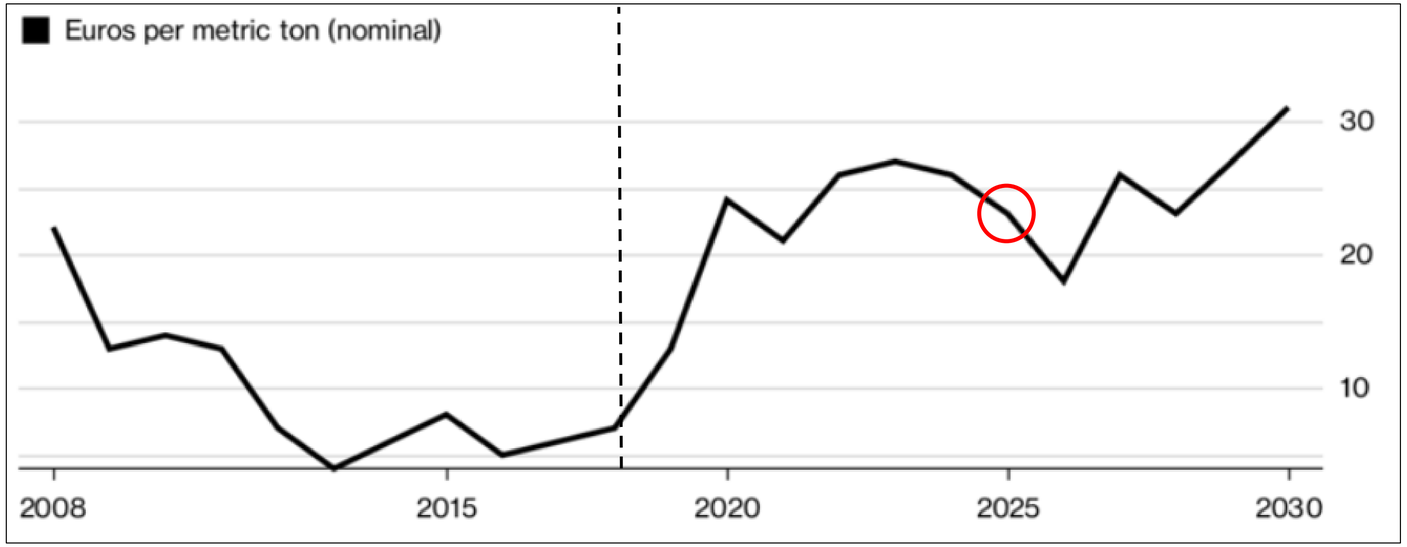
CO_2 pricing – Not on track for 2°C target

Current Policies
Low price in a few big economies

New Policies
Moderate price in several big economies

Sust. Development
High price in most big economies

EU Emissions Trading System* – Price forecast compiled after reform decision



Source: Bloomberg New Energy Finance estimates, retrieved 12.12.2017

CO_2 price assumptions in selected regions

USD (2015) / t CO2	Sector	2025	2040
European Union	Power, industry, Aviation	22	40
Korea	Power, industry	22	40
Canada	Power, industry, Aviation	15	31
European Union	Power, industry, aviation	25	48
Canada	All sectors	25	45
Korea	Power, industry	25	48
China	Power, industry, aviation	17	35
South Africa	Power, industry	10	24
Advanced Economies	Power, industry, Aviation	63	140
China, Russia, Brazil, South Africa	Power, industry, aviation	43	125

Source: International Energy Agency, World Energy Outlook 2017

* EU ETS was chosen as an example since institutions for CO_2 pricing already exist and because it is the only large market included in all three scenarios.
** Forecast 2025, 2030: BNEF, December 2017. https://www.bloomberg.com/news/articles/2017-11-13/here-s-what-europe-s-carbon-market-overhaul-means-for-businesses.
*** Second forecast 2030: https://www.platts.com/latest-news/coal/london/eu-co2-price-to-hit-eur33-35mt-by-2030-under-26767414

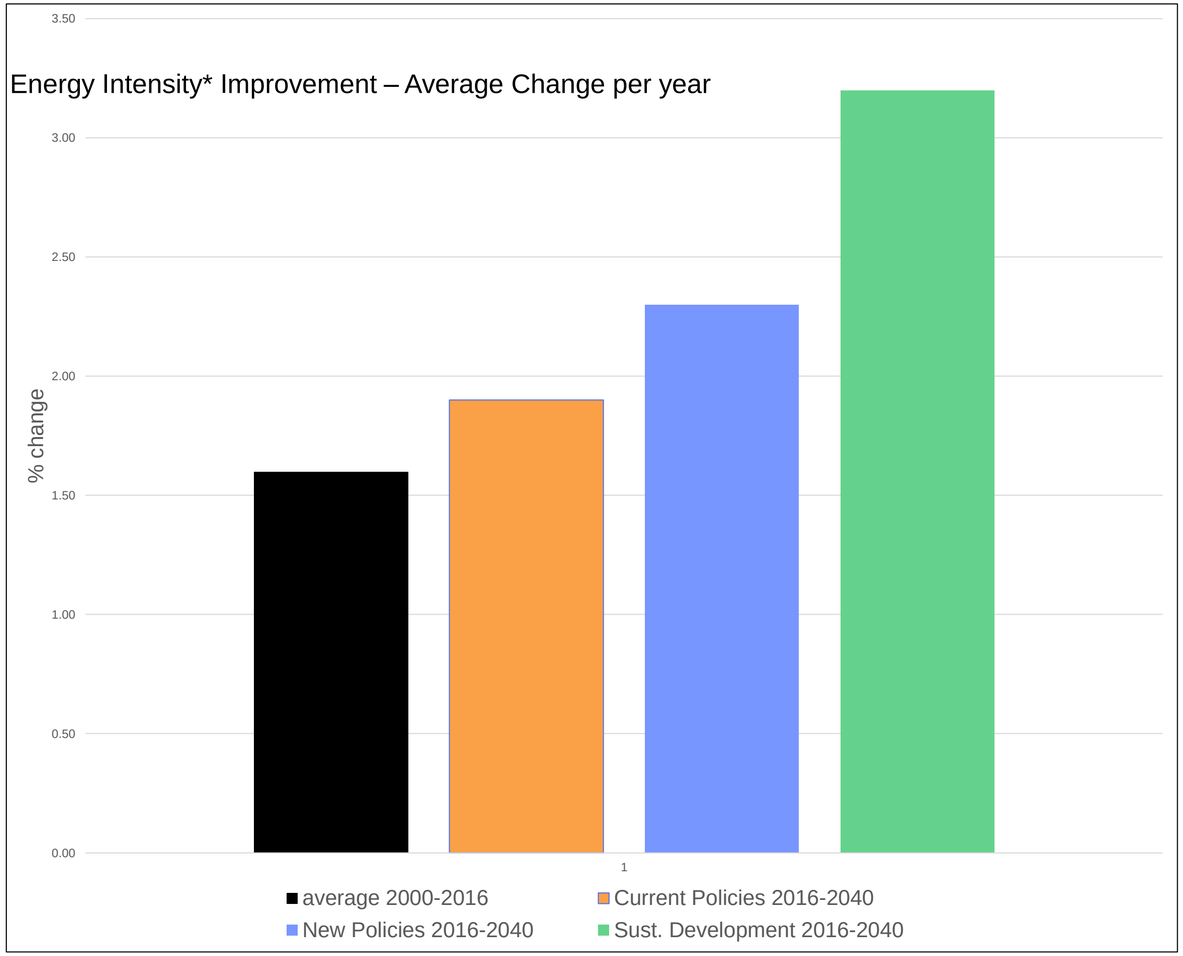
Source: CICERO Climate Scenario Guide (forthcoming February 2018)

Energy Efficiency – On the way, but more efforts needed for 2°C target

Current Policies
Historic rate of 1.9% energy intensity* improvement per year

New Policies
2.3% energy intensity* improvement per year

Sust. Development
3.2% energy intensity* improvement per year



Based on: World Energy Outlook 2017

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*Energy intensity is understood as the amount of energy used per unit of GDP. Improvements in energy intensity are to a large extent driven by improvements in energy efficiency
** Based on IEA Energy Technology Perspectives – Tracking Clean Energy Progress 2017. Judgement based on Energy demand developments in Industry and Transport and combined 13 sub-categories.

Source: CICERO Climate Scenario Guide (forthcoming February 2018)

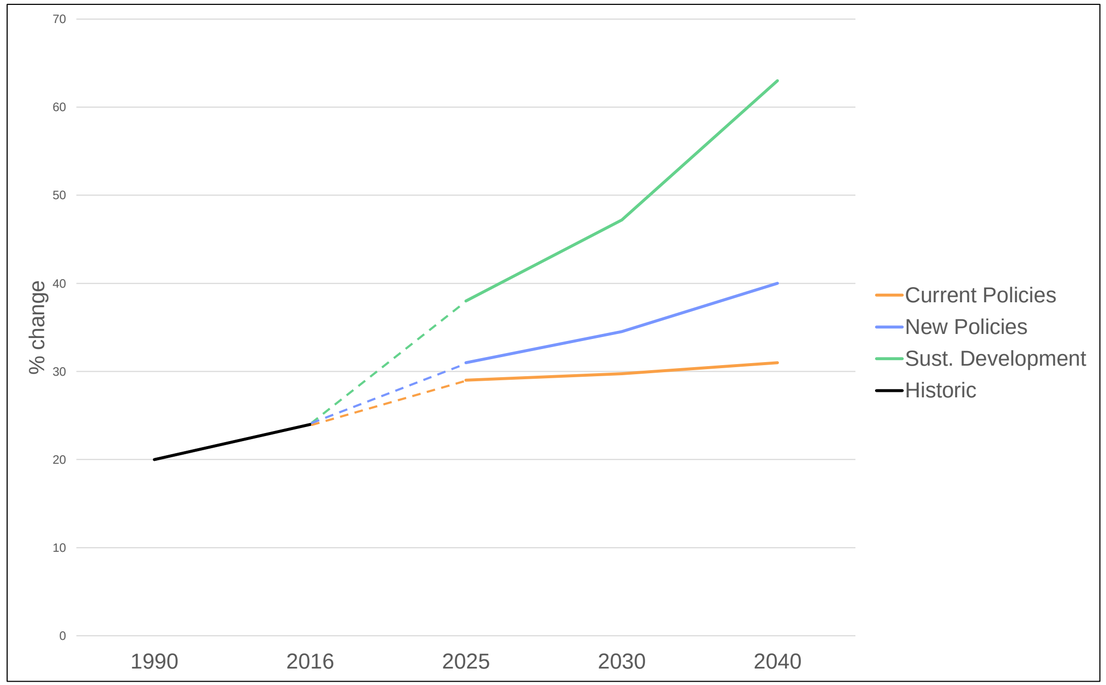
Renewable Electricity Generation:
On the way, but more efforts needed for 2°C target

Current Policies
RE reaches 31% of global electricity generation in 2040

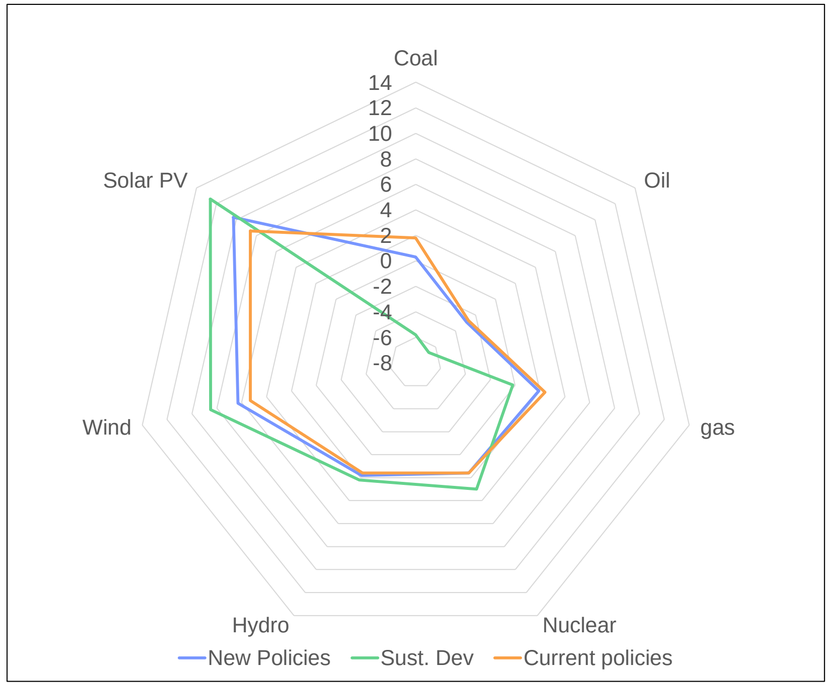
New Policies
RE reaches 40% of global electricity generation in 2040

Sust. Development
RE reaches 63% of global electricity generation in 2040

RE Generation* / Total Power Generation



Average Annual Growth Rate by Technology



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*Renewable Electricity (RE) technologies: Hydro, bio, wind, geothermal, solar PV, CSP, marine

** Based on IEA Energy Technology Perspectives – Tracking Clean Energy Progress 2017.

Source: CICERO Climate Scenario Guide (forthcoming February 2018)

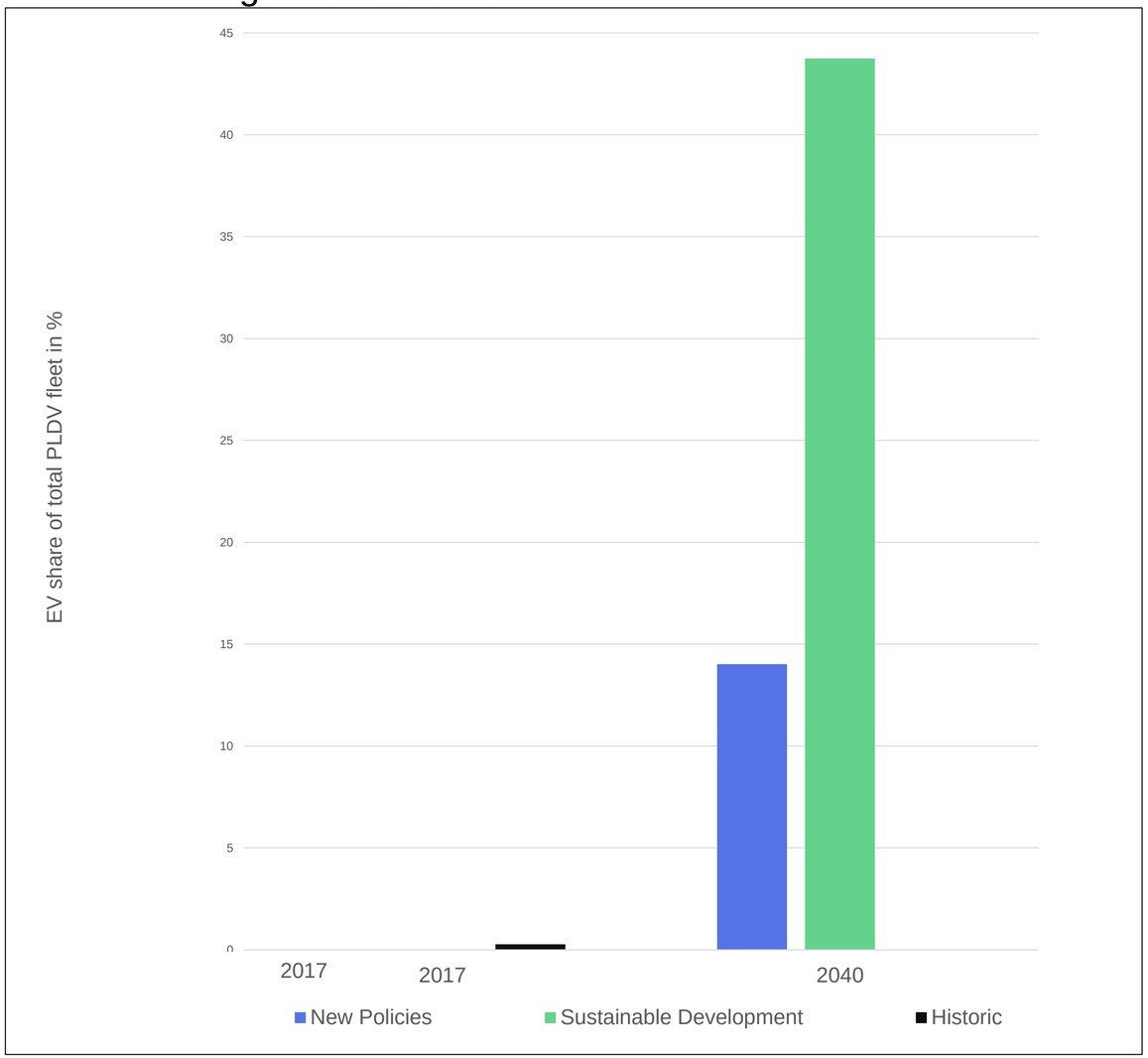
Electric vehicles – On track for 2°C target

Current Policies
n.a.

New Policies
EVs stand for 14% of global PLDV fleet

Sust. Development
EVs stand for 44% of global PLDV fleet

EV shares of global PLDV* fleet **



*Passenger light duty vehicles
**2040 global EV stock: IEA WEO 2017 Sust. Development scenario 875 million; IEA ETP 2017 629 million; BNEF Electric vehicle outlook 2017 ca. 500 million.
*** Based on IEA Energy Technology Perspectives – Tracking Clean Energy Progress 2017
Note: 2017 EV share of PLDV fleet: BNEF 2017 forecast 3 million Evs, global PLDV stock 1.2 bn

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Source: CICERO Climate Scenario Guide (forthcoming February 2018)

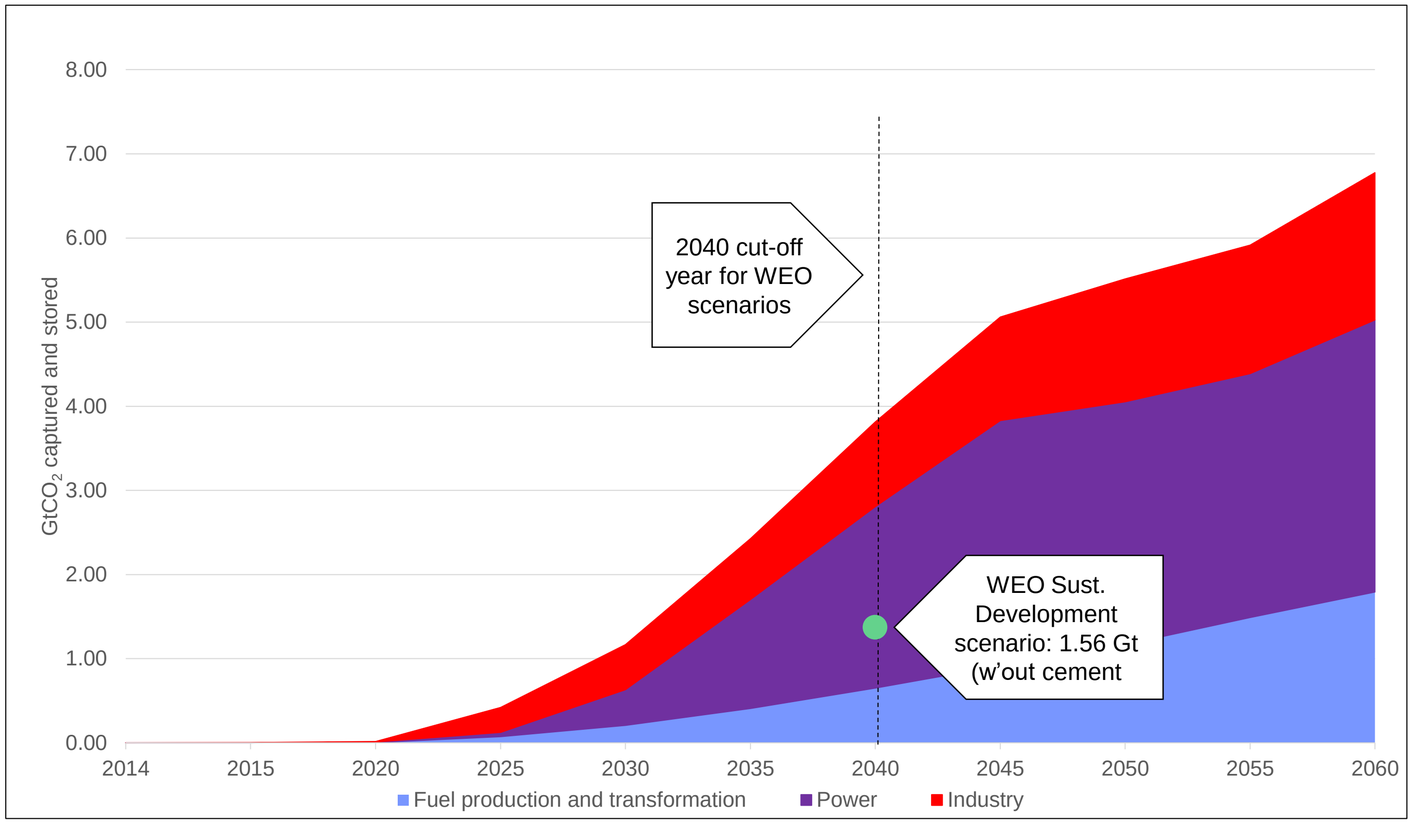
CCS – Not on track for 2°C target

Current Policies
n.a.

New Policies
n.a.

Sust. Development
12% of global fossil fuel electricity generation is CCS equipped

CCS Deployment in a 2°C scenario*



*Graph based on International Energy Agency, Energy Technology Perspectives 2017. The depicted CCS deployment is according to the 2 degree scenario (2DS), which is similar to the 450 scenario in the World Energy Outlook.

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Source: CICERO Climate Scenario Guide (forthcoming February 2018)

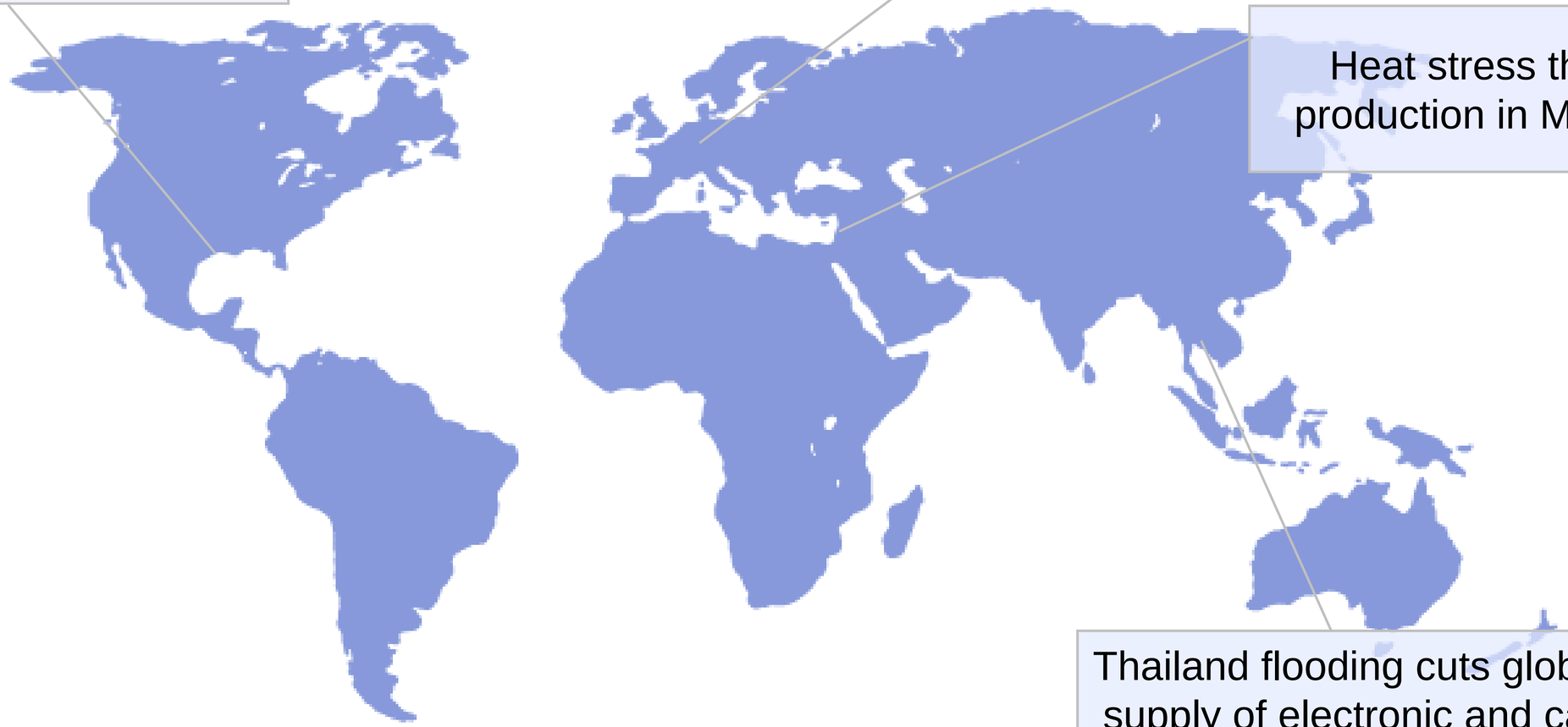
Physical risk

Observed Impacts = Today's News

Coastal flooding threatens energy infrastructure in the US Gulf Coast region

Flooding risk for European cities (and adaptation opportunities)

Heat stress threatens production in Middle East



Thailand flooding cuts global supply of electronic and car components

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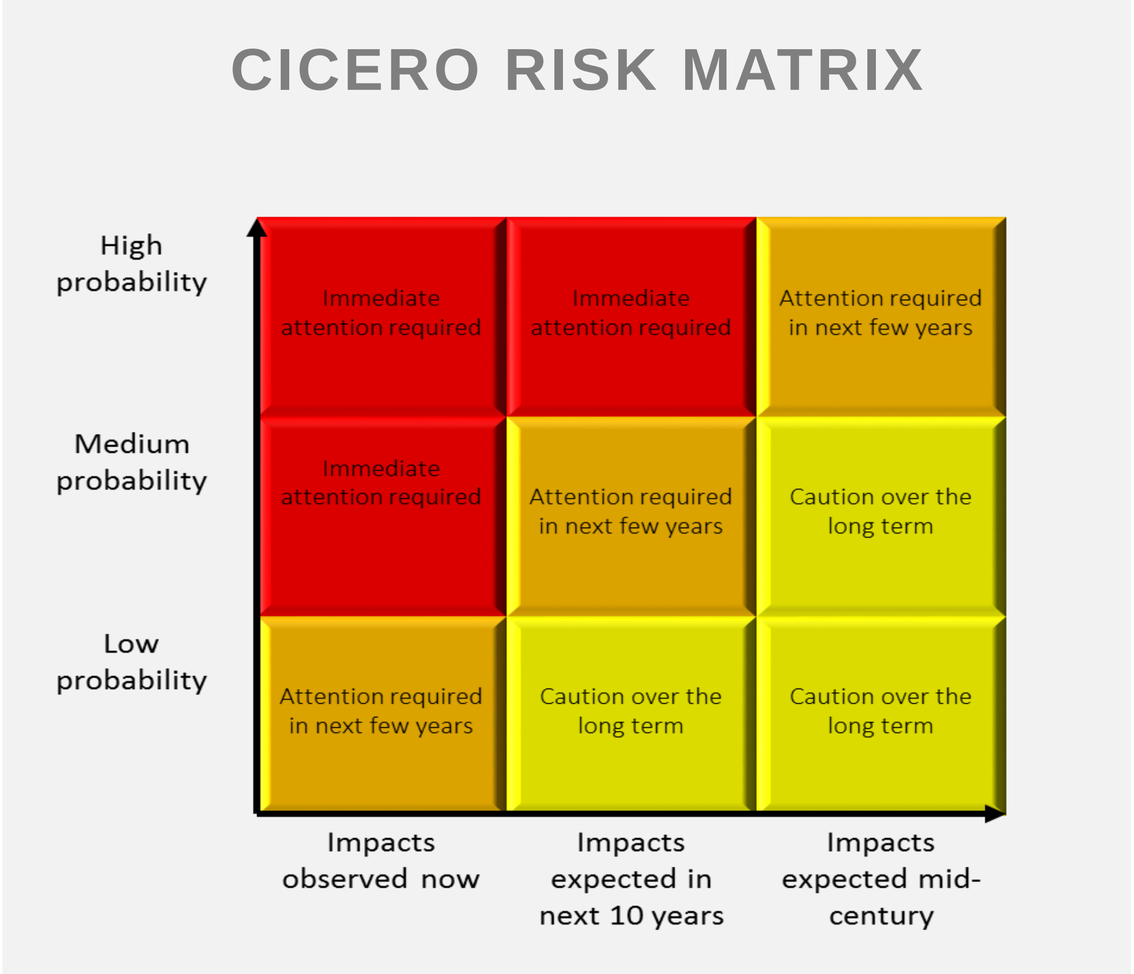
Source: Shades of Risk, CICERO, 2017

CICERO Shades of Risk

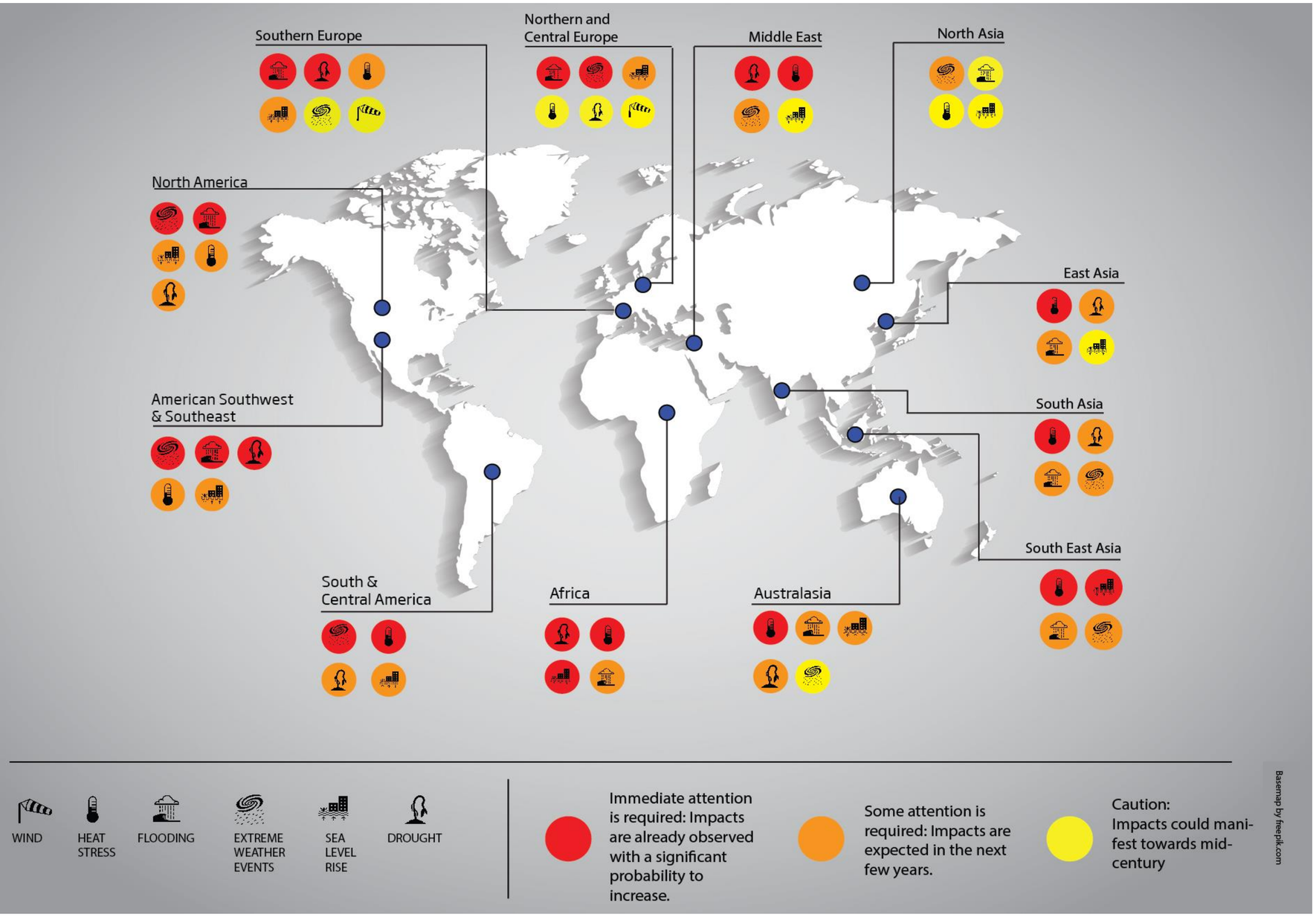
Immediate attention required: impacts are already observed with a significant probability to increase

Some attention is required: impacts are expected in the next few years

Caution: impacts could manifest towards mid-century



Physical impacts observed in all regions today



Source: Shades of Risk, CICERO, 2017

Scenario planning is not relevant for near-term physical impacts

But limiting GHG emissions now can avoid worse impacts in the future

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Physical impacts for Europe

See website for other regions

Climate risk	Key message	Key impacted sectors	Shade of Risk
Extreme precipitation	High variability expected in precipitation, greater intensity in North. Precipitation could become more extreme in Mediterranean when it does occur after long dry spells (see also drought)	Infrastructure in high density urban areas	Northern & Central Europe Southern Europe
Flooding	Flooding from precipitation patterns and snow melt is observed and expected to increase	Infrastructure in high density urban areas	All
Drought	Reduced water availability in the South	Infrastructure (high density areas and along rivers), Energy (reduced hydropower generation in the South, increased in North), Agriculture (combined with ground water sinking from irrigation)	Northern Europe Southern Europe
Sea level rise	Sea level rise a concern low-lying coastal areas, especially in combination with extreme events such as hurricanes and spring floods	Infrastructure in coastal regions, nuclear energy	Coastal areas
Heat stress	Heat stress observed especially in South and expected to increase with high likelihood	Impacts on health, labour productivity, Agriculture (crop production, wildlife in South)	Northern Europe Southern Europe
Wind	No clear trend	Energy (changes in wind energy production uncertain, reductions most likely in South)	All

Immediate attention required: impacts are already observed with a significant probability to increase

Some attention is required: impacts are expected in the next few years

Caution: impacts could manifest towards mid-century

Source: Shades of Risk, CICERO, 2017

Regional flooding, Norway 2012 - 2013

Event Parameters

- Flooding along Dovrebanen rail and E6 highway (2013) and extreme rainfall in Buskerud county (2012)
- Frequent water overflow cause of majority of costs (not extreme events)
- Both events led to infrastructure damages to the national rail system and supply chain disruptions

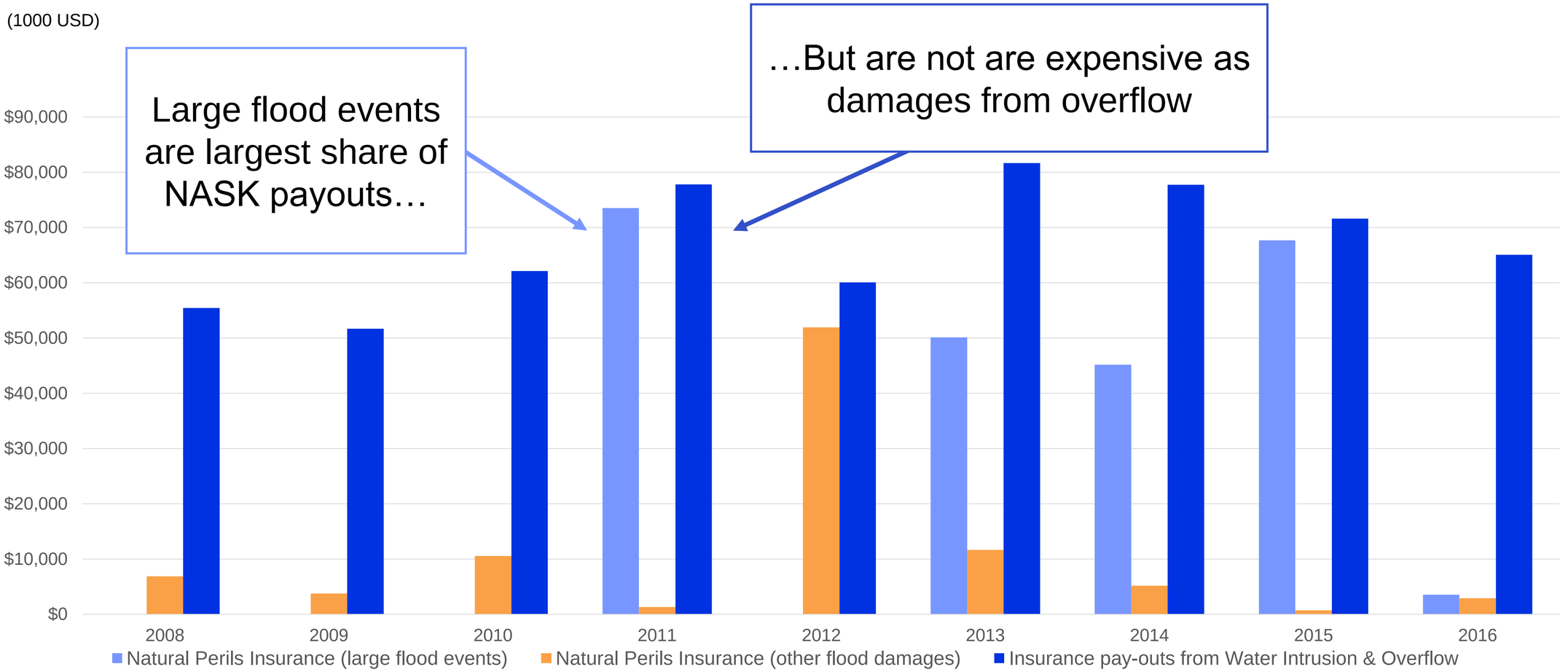
Total Costs (rail only)	Buskerud: 2.6 million USD Dovrebanen: 49 million USD
Indirect share of costs (rail only)	Buskerud: 53% Dovrebanen: 37%
Insurance coverage	No data

Policy context

Flood insurance is bundled into fire insurance which leads to a high insurance coverage. For uninsurable assets, the government has a separate natural hazard compensation scheme.

Sources: (Olsen and Traae 2015) (Siedler 2015)

Store flomhendelser får mest oppmerksomhet, men overvann koster mer



Sources: ("NASK - Naturskadestatistikk " 2017) ("VASK - Vannskadestatistikk " 2017) Note: the VASK data covers approximately 85 % of the market. All figures adjusted to 2015 NOK (SSB KPI for Norway) and converted to USD using the 2015 annual average exchange rate from the Bank of Norway .

Photo credit: U.S. Coast Guard photo by Petty Officer 3rd Class Johanna Strickland / Flickr

Resources

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Bridging the gap between climate scientists and financial decision makers

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NORGES BANK
INVESTMENT MANAGEMENT

Norwegian Ministry
of Foreign Affairs

Andra AP-fonden
Second Swedish National Pension Fund - AP2

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DNB

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OSLO
OSLO BØRS

SEI

INITIATIVE FOR
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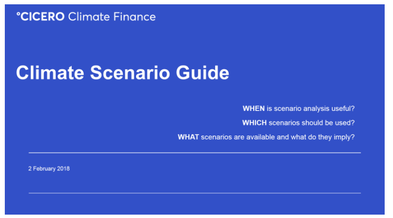
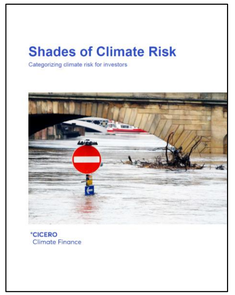
CICERO Climate Risk Resources

Climate Scenario Guide (forthcoming 2 February 2018)



Shades of Climate Risk report (2017)
http://www.cicero.uio.no/en/climateriskreport



Flood Risk for Investors (report forthcoming 2018)

Climate Risk Assesment of Norway's Financial Sector (CICERO project funded by ENOVA, January – June 2018)

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