© Brian A Jackson / Shutterstock

WWF

WORKING PAPER

EN

2014

FIVE PERCENT RENEWABLE ENERGY INVESTMENTS IN A TWO DEGREES WORLD

An illustrative case of allocating five percent of Norway's sovereign wealth fund into infrastructure for renewable electricity worldwide.

Written by Lars Erik Mangset and Stefano Esposito

We would like to thank:
Jan Schelling (Statkraft)
Tabaré Arroyo Curras (WWF International)
Arild Skedsmo (WWF Norway)
Stephan Singer (WWF International)
Ester Rønsen (Student at the University of Oslo)
who provided precious inputs and feedbacks.

Contact person: Lars Erik Mangset, +47 932 09 494, lemangset@wwf.no
WWF-Norway: +47 22 03 65 00

Graphic design: Stefano Esposito, Lene Jensen

Front cover photo:
© Brian A Jackson / Shutterstock

Published in September 2014
by WWF-World Wide Fund For
Nature (Formerly World Wildlife Fund), Oslo, Norway

WWF is one of the world's largest and most experienced
independent conservation organizations, with over
5 million supporters and a global Network active in
more than 100 countries.

WWF's mission is to stop the degradation of the planet's natural
environment and to build a future in which humans live in harmony
with nature, by conserving the world's biological diversity, ensuring
that the use of renewable natural resources is sustainable,
and promoting the reduction of pollution and wasteful consumption.

CONTENTS

INTRODUCTION

There is a widely acknowledged need for a global energy transition from a system reliant on coal and oil for electricity generation, to one which uses renewable energy sources like wind, sun and water. A key enabler for such transition is to increase direct investments in infrastructure for renewable energy. While such investments have experienced relative high growth rates in the past decades (BNEF 2014), the world needs further and sustained growth to supply enough renewable energy to ensure that atmospheric greenhouse gas (GHG) concentrations does not exceed 450 ppm by 2050, the target which gives a 50 percent likelihood of limiting global warming to 2 degrees Celsius (IEA 2013).

Increasing renewable energy generation and distribution worldwide is not only an imperative in the quest to avoid the most dangerous impacts of climate change. It also represents an investment opportunity for investors, including institutional investors such as sovereign wealth funds, insurance and pension funds. This sector holds about 76 trillion USD in assets, but invests on average less than 1 percent in infrastructure projects (Kaminker et al. 2013), most likely with only minor shares invested in infrastructure for renewable energy. These vast capital holdings could play a key role in increasing renewable energy worldwide, thus enabling the energy transition. CERES, a coalition of institutional investors with a total of USD 9 trillion in assets, has called for institutional investors to commit 5 percent of their holdings to clean energy investments (CERES 2014). WWF supports this strategic recommendation and with this interest in mind, this working paper makes a case study of the Norwegian Government Pension Fund Global (GPFG), the world's largest sovereign wealth fund. The GPFG is currently investing only in listed stocks, bonds and unlisted real estate; it is not allowed to invest directly into renewable energy projects. A 5% investment mandate would be similar to its current mandate to invest up to 5 percent of its value into real estate.

This working paper seeks to illustrate the impact of an implemented policy which allows the GPFG to invest 5 percent of its market value directly into infrastructure for renewable energy. Impact in terms of renewable electricity generation and associated emission reduction will be investigated through a three step approach:

1. Provided a step-wise growth in investments from 2016-2020 – what is the volume of financing if the GPFG by the end of 2020 invests 5 percent of its market value into renewable energy projects?
2. How much electricity would be generated by renewable sources that can be associated with the investments volumes from the GPFGs alone?
3. Provided this new renewable electricity fully replaces electricity from a mix of coal, oil and gas – what is the quantity of averted emissions of greenhouse gases?

Wind turbines funnel wind from the Columbia River Gorge, Washington-Oregon border, USA.

METHODOLOGY

#1 Forecast of the future market value of the GPFG

In order to estimate the amount of investment from the GPFG towards new renewable energy projects worldwide, it is first necessary to determine the future market value of the fund and, secondly, to calculate how much money must be invested to achieve a 5 percent target. . We have obtained a forecast of the market value of the Fund from 2016-2020 from the Norwegian Ministry of Finance (MOF 2014) as a basis for further calculations.

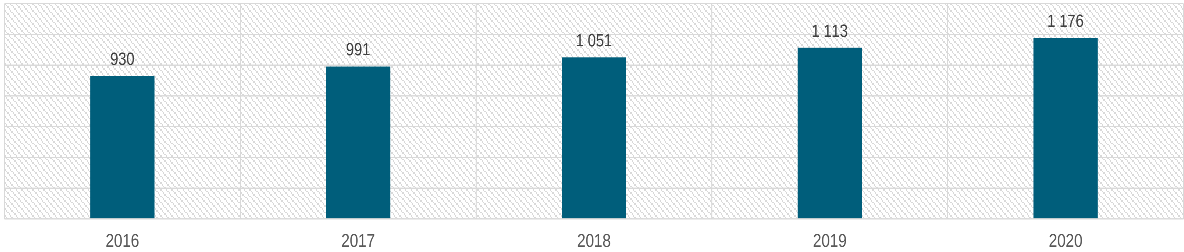

Figure 1 - Forecasted of the GPFGs total market value expressed in USD billion using the exchange rate at 1st January 2014, and expressed in USD2011 to be in line with other data used in the model (Source MOF 2014).

We assume that the GPFG starts to invest in 2016 in a new asset class focused on renewable energy infrastructure. The fund will invest 1 percent in 2016, 2 percent in 2017, and so on, reaching finally 5 percent in 2020. For this modelling period, it is assumed that investments dedicated to infrastructure projects are "locked", that is, once invested in one year, that financing is tied to a specific project throughout the modelling period. This is shown in Figure 2 where the light green bars represent the annual new investments in renewable energy projects, while the dark green bars show the cumulative investments.

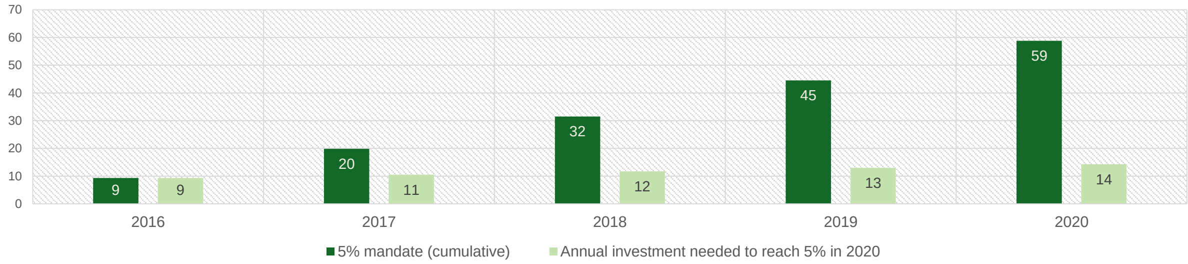

Figure 2 Cumulative and annual allocations of money from the GPFGs directly into renewable energy. Value expressed in USD2011 billion using the exchange rate at 1st January 2014 (Source MOF 2014).

#2 Allocating investments to different technologies for renewable electricity generation

This study takes into account the main renewable energy technologies as classified by the International Energy Agency, namely: hydropower, bioenergy, geothermal, wind, solar PV, concentrated solar power (CSP) and marine. The annual investment from the GPFG (Figure 2) is then allocated to these different technologies in accordance with their relative share of the world's electricity mix. The mix is defined in the IEA's World Energy Outlook (IEA 2013), where different climate scenarios are presented. Based on data available, we rely on the IEA's central scenario, called "New Policy Scenario" (NPS), in which currently discussed policies are adopted, for the period 2016-2019. For the year 2020, we rely on the 450 scenario (450S). Table 1 shows how the amount of capital invested every year is distributed among the different technologies, according to the electricity mix.

Table 1 The distribution of annual investment to different renewable energy generation technologies following the electricity mix provided by IEA (2013)

	2016		2017		2018		2019		2020	
Annual investment by GPFG ($ bn) →	9,3		10,5		11,7		13,0		14,3	
Technologies in the energy mix	Share	$ bn	Share	$ bn	Share	$ bn	Share	$ bn	Share	$ bn
Hydro	68 %	6,3	67 %	7,0	65 %	7,7	64 %	8,4	62 %	8,9
Bioenergy	10 %	1,0	10 %	1,1	10 %	1,2	11 %	1,4	11 %	1,5
Wind	16 %	1,4	16 %	1,7	17 %	2,0	18 %	2,3	19 %	2,7
Geothermal	2 %	0,2	2 %	0,2	2 %	0,2	2 %	0,2	2 %	0,3
Solar PV	4 %	0,4	4 %	0,5	5 %	0,5	5 %	0,6	6 %	0,8
CSP (concentrated solar power.)	0 %	0,0	0 %	0,0	1 %	0,1	1 %	0,1	1 %	0,1
Marine	0 %	0,0	0 %	0,0	0 %	0,0	0 %	0,0	0 %	0,0

Arrays of solar PV panels on the Eigg off Scotland's west coast, UK.

#3 Estimation of electricity generation associated with the GPFG investments

To estimate the electricity generation, we use data on levelized cost of electricity (LCOE) published by the IPCC (2014). LCOE is a metrics that allows comparison between the average cost of electricity generation from different energy technologies, with their differences in CAPEX/OPEX and lifetime. We use the LCOE to estimate the volume of electricity generated (kWh) as a result of the annual investments specified in Table 1 for each renewable energy segment.

In order to correctly interpret the analysis outlined in this working paper, it should be noted that LCOE aims at measuring the lifetime expenses comprising investment costs, operation and maintenance (O&M), fuel costs, carbon and decommissioning costs. LCOE does not include downstream costs of delivering electricity to the end customers which would have increased average cost if included in LCOE, nor subsidies and other policy incentives. Moreover, the LCOE data used in this study represent a global average of all geographical regions and specific climatic conditions, and it is thus unlikely to perfectly match randomly selected projects worldwide.

The IPCC (2014) provide low, median and high LCOE cost estimates, and this study relies on the median value. Furthermore, IPCC (2014) provides more detailed cost data on some sub-technologies, such as wind onshore and wind offshore, or solar rooftop and utility. To align this dataset with the IEA's industry classification, we aggregated sub-technologies and take the average value for the median value[1]. The LCOE data used in this study is outlined in Table 2, as well as other LCOE data reviewed in this study to illustrate the level of discrepancy between sources,.

Table 2 Comparison of LCOE data from different sources, and variation compared to IPCC 2014. (FLH = full load hours)

Source →	**IPCC 2014**		**IPCC 2011**		**IRENA 2013**		**IEA 2012a**	
Discount rate →	5% (high FLH)	10% (high FLH)	10 %	Var.	10 %	Var.	7 %	Var.
Hydro	0,022	**0,036**	0,097	271 %	0,048	134 %	0,129	361 %
Bioenergy	0,118	**0,142**	0,137	96 %	0,105	74 %	0,138	97 %
Wind	0,091	**0,130**	0,159	123 %	0,130	100 %	0,158	122 %
Geothermal	0,061	**0,091**	0,110	121 %	0,070	77 %	0,118	129 %
Solar PV	0,112	**0,163**	0,499	306 %	0,230	141 %	0,253	155 %
CSP	0,153	**0,204**	0,284	139 %	0,235	115 %	0,230	113 %
Marine	0,112	**0,153**	0,306	200 %	n.a.	n.a.	n.a.	n.a.

This study links (i) the amount of money invested annually with (ii) the cost of generating one unit of electricity, as expressed by LCOE. Specifically, we match the amount of capital that can be invested from a 5% allocation of the GPFG into renewable energy projects with the average cost of generating 1 kWh of electricity, as expressed by LCOE (IPCC 2014). Future revenues are discounted with a 10% interest rate, over the average life-time for every individual renewable energy technology based on data and methodology from IPCC (2014, Annex III, pages 4-5) using equation (1) and (2):

[1] Solar PV rooftop is excluded from this analysis, since it is deemed not a relevant investment area for direct infrastructure investments by the GPFG.

(1) $Annual\ output\ (KWh) = \frac{Investment_t}{LCOE} * CRF$ (t= year of investment, i.e. 2016-2020)

where

(2) $CRF = \frac{i}{1-(1+i)^{\wedge}-n}$ *is the capital recovery factor and the net present value of all life-time expenditure (i = weighted average cost of capital (WACC) and n = expected lifetime of the renewable energy project)* (Suerkemper et al. 2011).

Based on the above, we calculate the annual electricity generation based on the investments shown in Table 1. Afterwards, we multiply the annual electricity generation with the expected lifetime of each technology (Figure 3), in order to derive the total electricity generation associated with a 5% investment mandate for the GPFG. It should be noted that we do not include future forecast on how LCOE values may change in the future.

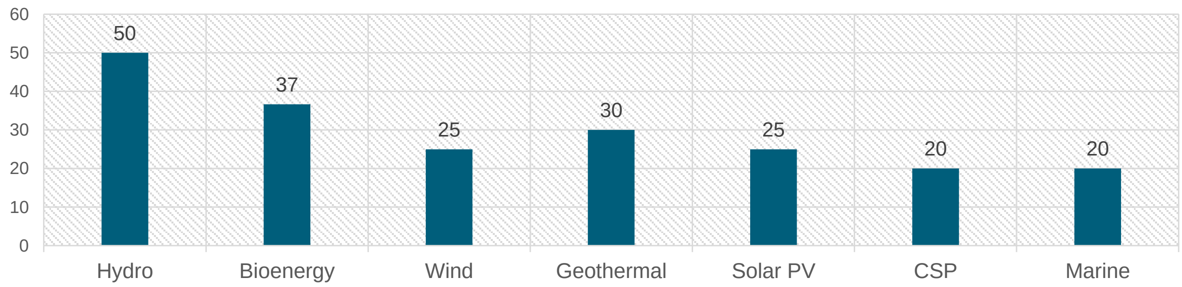

Figure 3 Average lifetime of renewable energy technologies (years) (IPCC 2014).

#4 The effect of replacing a mix of electricity from fossil energy sources with renewable energy

In order to achieve the goal of limiting atmospheric GHG concentrations to 450 parts per million (ppm) by 2050, renewable electricity generation must replace electricity generated from fossil energy sources. To illustrate the CO_2 emission reduction effect of a 5% GPFG renewable investments it is assumed that new renewable energy from the GPFG investments replaces a mix of coal, oil and gas (Table 3).

Table 3 shows the applied emission factors for each technology, based on average life-cycle emission from electricity generation (CO_2 equivalent/kWh). We use the median values for our calculation. Using the emission factors, we calculate emissions averted if the amount of electricity generated by a mix of fossil fuels would instead be generated by a mix of renewable energy sources, based on the outlined electricity mix by the IEA in the period 2016-2020. The lifetime electricity production based on investment from the GPFG is then matched against the IEA's electricity mix in 2016-2020 to calculate averted GHG emissions.

Table 3 – Emissions of selected electricity supply technologies (gCO_2-eq/(kWh) (IPCC 2014)

Power segment	Grams CO2eq/kWh	Power segment	Grams CO2eq/kWh
Coal	820	Wind (onshore and offshore)	12
Oil (from IPCC 2011)	840	Geothermal	38
Gas - Combined Cycle	490	Solar PV (utility)	48
Nuclear	12	CSP (concentrated solar power.)	27
Hydropower	24	Ocean (Marine)	17
Biomass (cofiring and dedicated)	485		

A photo voltaic solar power station near Caravaca, Andalucia, Spain, with wild flowers.

MODELLING RESULT

A 5 percent investment by the GPFG

If the GPFG invests 5 percent of its market value directly in infrastructure for renewable energy by 2020 – what is the effect on renewable electricity generation output worldwide?

Figure 4 summarizes the main results from this modelling exercise. The blue bars represent the annual electricity generation output (TWh) in a lifetime perspective (hence Figure 3) estimated on the basis of the GPFGs investment volume from 2016-2020. The orange bar represents, for comparative purposes, Norway's hydropower generation output in 2012 (SSB 2014). The GPFGs investment in electricity generation theoretically results in an average renewable production of 109 TWh per year from 2016-2069, equivalent to 87 percent of Norway's total hydropower generation in 2012. The maximum electricity generation can be observed to be 124 TWh in the period 2020-2040.

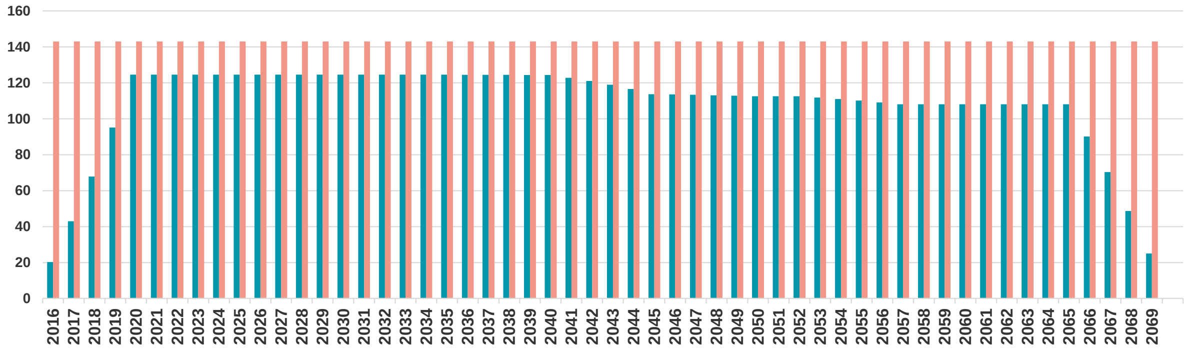

Figure 4 Annual, electricity generation output (TWh) resulting from GPFG investing 5% in in renewable energy production (with 2016-2020 being the investment period). Turquoise bars represent the annual electricity output derived from GPFG investment, while orange bars show Norway's total hydropower generation in 2012 for matters of comparison.

Aggregating the electricity generation over the estimated lifetime of the different renewable technologies gives 5871 TWh, which by comparison is almost equivalent to China's total electricity consumption in 2013 (5322 TWh), and more than 40 times Norway's annual hydropower production in 2012.

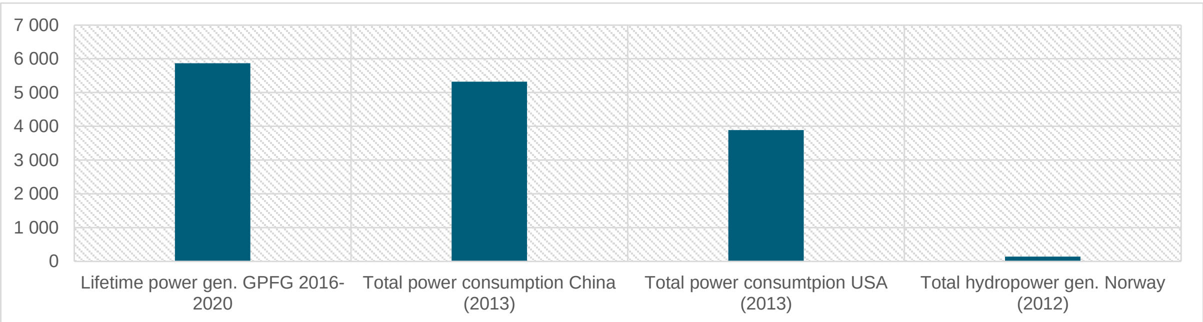

Figure 5 Total electricity production from GPFG financed capacity expansion (SSB 2014, CIA 2014, UNFCCC 2014).

Finally, if we assume that the added renewable energy electricity generation output would replace fossil energy generation based on the electricity mix provided by the IEA (2013) from 2016-2020, we calculate that the averted emissions of GHG would be equal to 3933 Mt (million tonnes) CO_2 equivalents. The following Figure 6 puts this in perspective by comparing this number with annual GHG emissions from different countries and sectors such as aviation.

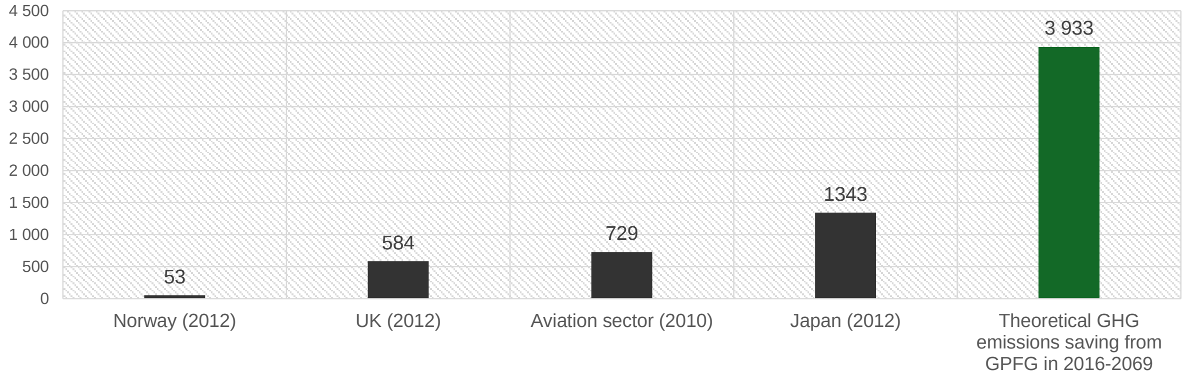

Figure 6 Averted GHG emissions from GPFG, compared with other sources (in million tonnes) (UNFCCC 2014, SSB 2014, Ecofys 2013).

DISCUSSION

The calculations presented in this working paper is a theoretical exercise to illustrate the effect of new renewable electricity generation resulting from 5% investment by the GPFG. Moreover, we aim at showing the potential for renewable energy to avert GHG emissions if substituting electricity generated from a mix of coal, oil and gas. In the following, we briefly discuss some key elements in this study.

Considerations on deriving electricity generation from investment levels

A key component in our analysis is the *conversion* of money into electricity generation, by using LCOE. Following the methodological approach expressed in the IPCC (2014), we incorporate a weighted average cost of capital (WACC) of 10 percent, and moreover we also discount future revenues with a 10 percent discount rate. The IPCC also provides LCOE data with a WACC of 5 percent, where it would hence be appropriate to discount revenues with a 5 percent discount rate. Based on the use of a 5 percent WACC and discount rate, we obtain lifetime electricity generation output of 5062 TWh (compared to 5871 TWh with 10 percent), with associated potential averted GHG emissions of 3403 Mt CO_2 (3933 Mt CO_2 with 10 percent).

Finally, our modelling distributes investments to individual renewable energy technologies according to their relative share in the electricity generation mix as outlined by the IEA (2013). The large dominance of hydropower - that provides the lowest cost of electricity generation per unit - results in relative higher electricity generation output compared to a situation where the GPFG chooses to invest relatively more in e.g. wind and solar electricity.

Averting GHG emissions

By assuming that renewable electricity generation financed by the GPFG replaces fossil-based electricity, we have calculated potential averted GHG emissions. There is little evidence supporting the replacement assumption. It rather appears that while renewable energy production output grows, so does electricity generation for fossil sources. However, within the framework of limiting atmospheric GHG concentration levels to 450 ppm by 2050, these trends cannot continue. In particular, the IEA shows that achieving the 450 ppm scenario will require an incremental transition from an energy system based on fossil fuels to a system more reliant on renewable sources. In the 450 ppm scenario by IEA (2013) specified for the period 2020-2035, we observe that renewable electricity generation grows by +4,9 percent every year while electricity generation from fossil sources (coal, oil, gas) decreases by -2,3 percent. In 2030, annual electricity generated from renewables becomes higher than the electricity generated by fossil fuels in this scenario, and by 2035, the relative reduction of coal in the global electricity mix (-19 percentage points) is replaced by an approximately equivalent increase in the share of renewable electricity generation (+20 percentage points).

Following the modelled change in the world's electricity mix outlined by the IEA 450 ppm scenario, we have illustrated the effects of replacing renewable energy with coal, oil and gas.

REFERENCES

Bloomberg New Energy Finance – BNEF (2014) *Global trends in clean energy investments*. Available at;

Central Intelligence Agency (2014) *The World Factbook*. Retrieved September 2014.

CERES (2014) *Investing in the Clean Trillion: Closing The Clean energy Investment gap*. January 2014.

Ecofys (2013). *World GHG emissions flow chart 2010*. Available at http://www.ecofys.com/files/files/asn-ecofys-2013-world-ghg-emissions-flow-chart-2010.pdf

Kaminker et al. (2013) Institutional Investors and Green Infrastructure Investments: Selected Case Studies. OECD Working Papers on Finance, Insurance and Private Pensions, No.35, OECD Publishing.

Intergovernmental Panel on Climate Change (2011) *IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation*. Cambridge University Press,
Cambridge; New York. Available at: http://www.ipcc.ch/report/ar5/wg3/

Intergovernmental Panel on Climate Change (2014) *Working Group III contribution to the IPCC 5th Assessment Report "Climate Change 2014: Mitigation of Climate Change»*. IPCC, Geneva.

International Energy Agency (2010). Projected Costs of Generating Electricity - 2010 Edition. IEA, Paris, France.

International Energy Agency (2012a*). Technology Roadmap, Hydropower*. OECD/IEA.

International Energy Agency (2012b*)*. Technology Roadmap, Bioenergy for Heat and Power. OECD/IEA.

International Energy Agency (2013*). World Energy Outlook 2013*. OECD/IEA.

International Energy Agency (2014*). Special report World Energy Investment Outlook*. OECD/IEA.

IRENA (2013) *Renewable Power Generation Costs in 2012: An Overview*. International Renewable Energy Agency, Abu Dhabi.

IRENA (2012a) Renewable Energy Technologies: cost analysis series - Hydropower. June 2012, Volume 1: Power Sector, Issue 3/5. IRENA, Abu Dhabi.

IRENA (2012b) Renewable Energy Technologies: cost analysis series – Concentrated solar power. June 2012, Volume 1: Power Sector, Issue 2/5. IRENA, Abu Dhabi.

Norwegian Ministry of Finance (2014) *Projection fund size, from the revised National Budget 2014*. Latest update 28.08.2014. Available at: http://www.nbim.no/en/the-fund/market-value/forecast-for-the-size-of-thefund-/

Suerkemper F., S. Thomas, D. Osso, and P. Baudry (2011) *Cost-effectiveness of energy efficiency programmes-evaluating the impacts of a regional programme in France*, Energy Efficiency 5, 121–135.

Statistics Norway (2014) *Electricity, annual figures, 2012*. Published: 28 March 2014
http://www.ssb.no/en/energi-og-industri/statistikker/elektrisitetaar

UNFCCC (2014) *GHG emission profiles for Annex I Parties and major groups*. Retrieved September 2014 at http://unfccc.int/ghg_data/ghg_data_unfccc/ghg_profiles/items/4625.php

FIVE PERCENT RENEWABLE ENERGY INVESTMENTS IN A TWO DEGREES WORLD

5871 TWH:

total lifetime electricity generated by investing 5% of the GPFG*.

3933 MT:

lifetime avoided greenhouse gas emissions, equal to 5 times the annual emissions of the aviation sector.

$59 BILLION:

5% of the GPFG* invested in renewable power in 2020.

109 TWH:

average electricity generated every year in 2016-2069.

*The Norwegian Government Pension Fund Global (GPFG) is world's largest sovereign wealth fund, holding more than one percent of the world's stocks.

WWF

Why we are here

To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

www.wwf.no

WWF-Norway, Organisation No 952330071 and registered in Norway with reg.nos.
 WWF-Norway, P.O.Box 6784 St Olavs plass, N-0130 Oslo, tel: +47 22 03 65 00, email: wwf@wwf.no, www.wwf.no

WWF® FIVE PERCENT RENEWABLE ENERGY INVESTMENTS IN A TWO DEGREES WORLD

WWF.NO