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Hopeful Signs, Alarming Realities on the Road to Climate Justice

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"Climate change for us is a matter of life or death."[1] These stark words were spoken by Rev. Tafue Lusama, General Secretary of the Tuvalu Christian Church, in September 2014 at an interfaith summit in New York. How prophetic they were in March 2015 when Super Cyclone Pam wreaked havoc on the Pacific island state, killing dozens and destroying thousands of homes in neighbouring Vanuatu. Rising sea levels and warmer water temperatures have increased the frequency and intensity of tropical storms like this one and Typhoon Haiyan, which struck the Philippines in 2013.

Yet, although climate change is already devastating the lives of millions of vulnerable people, Rev. Olav Tveit, General Secretary of the World Council of Churches, reminds us: "Despite all the negative conditions, we have the right to hope, not as a passive waiting but as an active process towards justice and peace."[2] This *Briefing Paper* examines some hopeful signs of progress in the struggle for climate justice, despite major obstacles.

Our hopes are not based on a naive optimism for the 21st UN climate change meeting in Paris, November 30-December 11, 2015. All indications are that the world's governments once again will fail to agree on adequate measures to keep the rise in global temperatures under 2^0 Celsius. That is the official target that many scientists see as the borderline between destructive and catastrophic climate change. As previous KAIROS *Briefing Papers* have explained, many things can be done to slow climate change without waiting for the Paris conference to make decisions that, in most cases, will take effect only in 2020.

Cyclone Pam survivors survey damage in Vanuatu.

Hopeful signs include initiatives being undertaken by some Canadian provinces such as putting a price on carbon emissions and declaring moratoria on hydraulic fracturing (fracking) to extract shale gas. As well, a number of civil society groups, such as Climate Fast, are persuading politicians to confront crucial issues of energy policy.

Another sign of hope is the strengthening movement for divestment from fossil fuels which is exposing the risks facing companies that produce coal, oil and gas. The need to keep most known fossil fuel reserves in the ground is gaining recognition in official quarters.

Scientists are publishing research on how we can gain time for the critical task of reducing carbon diox-

ide (CO_2) emissions by curbing emissions of other greenhouse gases (GHGs) and short-lived pollutants. And the cost of producing renewable energy, especially solar power, is falling dramatically.

At the same time, there are disturbing trends and frightening scientific discoveries. The concentration of CO_2 in the atmosphere has surpassed 400 parts per million (ppm), which is well above the 350 ppm threshold deemed to be the "safe" level for ensuring that runaway climate change does not imperil life on Earth.[3]

Recent investigations have found that methane, a greenhouse gas 86 times more potent than CO_2 over a 20 year period, is leaking from oil and gas production sites much faster than previously thought. Moreover, melting permafrost and undersea hydrates in the far North are starting to release thousands of tonnes both of CO_2 and methane at alarming rates. Large new craters in Siberia are being linked to underground methane explosions that bode ill for keeping these huge quantities of frozen methane hydrates contained.

A. Climate Justice Can't Wait for the Paris Conference

Media and political commentators regularly describe the 2015 Paris Conference of the Parties (COP21) to the UN Framework Convention on Climate Change (UNFCCC) as a make-or-break moment for government actions on climate change.

However, 350.org founder Bill McKibben writes: "What happens in Paris will be at best one small part of the climate story. … What comes before and after will count more."[4] Christiana Figueres, Executive Secretary of the UNFCCC, concedes: "We already know that the sum total of efforts [in Paris] will not be able to put us on the path for two degrees."[5]

Some commentators maintain that the November 2014 agreement between the United States and China could spark a more hopeful outcome at Paris. In that deal, President Obama pledged that the U.S. would emit 26% to 28% less carbon dioxide in 2025 that it did in 2005, doubling its pace of emission reductions from its previous target.

In turn, China pledged that its emission would peak by 2030 when China will get 20% of its energy from renewable sources. But these pledges are voluntary and not binding under any international agreement. There is a legitimate fear that a future president or Congress would ignore Obama's promises.

Earlier the European Union announced a new target of keeping its emissions to 40% below their 1990 levels by 2030. An analysis by Climate Action Tracker concludes that should the EU, the U.S., and China – which together account for more than half of all global emissions – keep their promises, global temperatures would still rise by between 2.9^0C and 3.1^0C above pre-industrial levels by the end of this century instead of 3.9^0C *without* these new commitments.

Assessing the outcome of last December's 20th UN climate conference in Lima, Peru, Pablo Solón, former Bolivian Ambassador to the UN and chief climate negotiator, said the conference in Paris won't produce adequate results. According to Solón, if world governments wait for the Paris conference to make decisions that won't take effect until 2020, it will be impossible to keep the rise in global temperatures below two degrees Celsius. According to the UN Environmental Program and the Stockholm Environment Institute, global greenhouse gas emissions would have to start declining prior to 2020 to meet the 2^0C target.[6]

Solón summarizes the major weaknesses of the "Lima call for climate action" which will serve as the basis for negotiations in Paris:

- Greenhouse gas emission reduction commitments will be voluntary. There is no requirement that these commitments will be sufficient to keep temperature increases below 2^0C. Each country was to submit its "intended nationally determined contribution" to mitigation by the end of March, if it was "ready to do so."

- There is no proposal from any country to leave fossil fuel reserves in the ground. According to the latest report from the Intergovernmental Panel on Climate Change, from 75% to 86% of known fossil fuel reserves are unburnable if we are to meet the 2^0C target.[7]

- There is no strong proposal for a compliance mechanism to hold countries to their stated commitments.

- Commitments to provide financing for mitigation and adaptation in developing countries rely on "mobilizing" funds from private sources through mechanism like carbon markets instead of promises for public funding.

In short, Solón characterizes the Lima agreement as a "roadmap to global burning ... [that] puts the future of humanity and life as we know it on our planet Earth in serious jeopardy."[8]

Unlike the U.S., China and the EU, Canada missed the March 31 deadline for submitting its new mitigation target. Reportedly, the federal government is still in consultation with the provinces and may not make a submission "for several months," possibly not until after the October 19 federal election.[9]

What is clear is that Canada will not meet its current target of reducing emissions to 17% below 2005 levels by 2020. On the contrary, Environment Canada projections show that Canada's GHG emissions in 2020 will be 20% *above* that target.

A new analysis done for Sustainable Canada Dialogues explores the consequences for Canada of two scenarios. If global GHG emissions stabilize by 2050, which is possible only if all countries take immediate ambitious action, Canada could avoid extreme warming.

On the other hand, if global GHG emissions continue to grow until the end of this century "coastal British Columbia and Atlantic provinces could warm by about 4ºC; northern Saskatchewan, Manitoba, Ontario and Québec could warm more than 6ºC; and Canada's Arctic temperature could increase by 14ºC."[10] This latter projection is extremely alarming for the Inuit whose traditional way of life, based on hunting and fishing, is already threatened by the warming Arctic climate.

B. Provinces Stepping Forward

One hopeful sign is that several Canadian provinces are actively pursuing climate mitigation plans without waiting for the federal government to take action. These initiatives range from British Columbia's carbon tax to moratoria on shale gas extraction through hydraulic fracturing (fracking) in Quebec, New Brunswick, Nova Scotia, and Newfoundland and Labrador. Ontario's Minister of the Environment has invited citizens to debate options for taking action.[11]

While there appears to be agreement among Canada's largest province's – B.C., Alberta, Ontario and Quebec – that putting a price on carbon emissions is key for encouraging energy conservation, they also agree with the need for investment in low-carbon technologies and the use of renewable energy. However, there is no consensus among provincial governments on how best to achieve this goal.

Three ways of pricing carbon are in effect or under consideration. One option is to put a tax or fee on fossil fuels to increase their costs and thus discourage their use. A second option is a cap-and-trade system whereby governments set limits, or caps, on the amount of permissible greenhouse gas emissions, limits that would decline over time. Companies that emit less than their allotted cap can sell credits on carbon markets to others who exceed their allotted caps. The price for any excess emissions is set by supply and demand.

A third option is Alberta's Specified Gas Emitters Regulation. It requires large industrial actors to reduce the intensity of their emissions, that is, the amount of GHGs emitted per unit of output. Industrial emitters that do not reduce emission intensity have the option of paying a $15 per tonne levy on that portion of their emissions that exceeds intensity reduction targets.

With this option, the average cost for companies has been $1.80 per tonne of total emissions. Moreover, these costs are tax deductable. "For a typical *in situ* oil sands facility, the $1.80 per tonne cost translates into approximately $0.08 per barrel if tax and royalty implications are considered."[12] Clearly, this small cost in not sufficient to induce significant changes in corporate behaviour.

An examination of recent experience with the two principal options for pricing carbon suggests that a tax or fee on carbon is a better option than a cap-and-trade system.

British Columbia's carbon tax has successfully reduced emissions

British Columbia's carbon tax started at $10 per tonne of carbon dioxide in 2008 and rose to $30 a tonne by 2012. Since its implementation, per capita GHG emis-

sions in B.C. have fallen by 9% and fossil fuel use has declined by 16%. This compares to a 3% increase in the rest of Canada.[13] The simple design makes the tax easy to administer. By offering rebates to low-income households, B.C. avoids penalizing those who are least able to afford higher energy prices. Fifty-eight percent of the public supports the tax.

One drawback is that the tax has been capped at $30 per tonne since 2012 instead of continuing to rise in annual increments. According to a 2009 study by M. K. Jaccard and Associates, in order to maintain temperature increases below two degrees Celsius, a price of $50 per tonne of carbon dioxide equivalent in 2010 would have to rise over 10 years to $200 per tonne.[14] Similarly, a report by the Intergovernmental Panel on Climate Change estimates that a global carbon price of US$200 per tonne by mid-century is needed to have a high likelihood of avoiding dangerous climate change.[15]

At first glance, $200 per tonne may appear high and difficult to sell politically. However, Marc Lee, an economist with the Canadian Centre for Policy Alternatives, reflecting on the drop in the cost of gasoline following the 2014-15 slump in crude oil prices, calculates: "If we were to boost gasoline prices [in Vancouver] back to June 2014 levels, we would be looking at a carbon tax of more than $200 per tonne."[16]

While B.C.'s tax applies broadly to many kinds of fossil fuels, it does not apply to the shale gas and liquefied natural gas (LNG) sectors. A study prepared for B.C.'s Environment Minister warns that the pursuit of an LNG industry could double the province's GHG emissions, imperilling its legislated targets for GHG reduction.[17]

Problems with cap-and-trade systems

The experience of the European Union's Emissions Trading System (ETS), the world's largest cap-and-trade system, illustrates many of the problems associated with carbon trading. In the first phase of the ETS, carbon prices fell to very low levels as too many permits were allocated, sometimes as a result of lobbying by special interest groups in the name of competitiveness. As a result, electric utilities in the U.K., Spain, Germany, Italy and Poland made between US$32 billion and US$99 billion in windfall profits over a period of only five years.[18]

According to conservative estimates, between one-third and two-thirds of credits obtained through the purchase of offsets from abroad did not represent real emission reductions.[19] Many offset projects in developing countries have been tainted by fraud and human rights abuses. Peasant farmers, for example, were pushed off their lands after they were taken over for carbon sequestration projects.

Emission reductions resulting from the ETS have been modest at only 2% to 4% of total capped emissions.[20] California's cap-and-trade system, which Quebec joined in 2014 and Ontario may also join, has also resulted in low prices (of US$12.21 per tonne in February 2015) and modest GHG reductions to date.[21]

Federal party leaders vary in their support of provincial initiatives

Federal party leaders have spoken in favour of some provincial initiatives to put a price on carbon. Prime Minister Stephen Harper has voiced support for the Alberta model that charges a low price on emissions that exceed an intensity cap per unit of output which account for only 4% of Alberta's total emissions.[22]

The New Democratic Party has endorsed a national cap-and-trade system. NDP leader Thomas Mulcair supports Quebec's cap-and-trade system and calls provincial carbon taxes "interesting additions" to a cap.[23] Deputy NDP leader Meagan Leslie has said the party could seek "equivalency agreements in which a province could be exempted from federal regulations when it demonstrates it has similar measures that achieve a comparable outcome."[24] Justin Trudeau, the Liberal Party leader, has proposed a "medicare approach" whereby the federal government would set overall targets while giving provinces "the flexibility to design their own policies to achieve those targets, including their own carbon pricing policies."[25]

Allowing each province to pursue its own path to carbon pricing without a co-ordinated national plan would have hidden costs. A 2009 report from the National Roundtable on the Environment and the Economy examined the implications of each region trying to reach a national reduction target on its own. It found that "carbon prices would have to rise in the order of 25% above [what they would be under] a unified approach."[26] Moreover capital and energy expenditures would also be significantly higher.

C. Divestment Movement Gaining Strength

In an earlier *Briefing Paper*, KAIROS explored the moral and financial case for divesting from fossil fuels. Since then several Canadian churches and religious orders have followed the precedent set by Trinity St. Paul's United Church in Toronto in removing fossil fuels from their portfolios. Eastminster United Church voted to divest in June 2014, and last October Scarboro Missions decided to sell its investments in fossil fuel and related infrastructure companies over the next five years.

In December, the Board of the Catherine Donnelly Foundation, created by the Sisters of Service, decided to divest from companies with the largest coal, oil and gas reserves as listed in the Carbon Tracker Initiative's "Unburnable Carbon" report. The Foundation will seek out companies investing in renewable energy, other low-carbon fuel sources and energy efficiency. Globally180 institutions, including universities and the Rockefeller Brothers Fund, with investments worth US$50 billion, have chosen to divest.

In addition to these largely symbolic actions, motivated by ethical concerns not to profit from the destruction of the planet, the financial case for divestment is also growing stronger. With low oil prices, many petroleum corporations are experiencing financial distress. A survey of Canadian "oil and gas producers by BMO Nesbitt Burns found capital expenditures are forecast to outstrip cash flow by about 10 per cent in 2015."[27] Globally "the world's 127 largest oil and gas firms generated $568 billion in cash from their operations during 2013-2014, while their expenses totalled $677 billion."[28] If low oil prices continue, more companies will experience debt problems – "the Achilles heel" of the industry, says Dr. Kerri Lynn Karl.[29]

The Bank of England is taking very seriously the prospect that investments in fossil fuels may become stranded assets. After its Governor, Mark Carney, began talking about how the vast majority of fossil fuel reserves are unburnable, the Bank began to investigate the financial risks posed by the carbon bubble. A report for the British government is expected before the end of 2015.

Paul Fisher, deputy head of the Bank of England's prudential regulation authority, has warned insurance companies that they face large claims due to disasters resulting from climate change and also risk significant losses from investments in fossil fuels. Fisher told an insurance conference: "As the world increasingly limits its carbon emissions, and moves to alternative energy sources, investments in fossil fuels ... may take a direct hit."[30]

Keeping fossil fuel reserves underground

There are a range of estimates on the proportion of fossil fuel reserves to be kept in the ground to deter global temperatures from rising above two degrees Celsius. This range is due largely to diverse assumptions about the extent of existing reserves. However, they all point in the same direction.

The International Energy Agency estimates that two-thirds of known fossil fuel reserves must stay underground to meet the international goal of keeping warming under 2^0C.[31] The Intergovernmental Panel on Climate Change says there is more than four to seven times as much carbon contained in existing fossil fuel reserves than what can be burned, implying that 75% to 86% of reserves must be kept in the ground.[32]

A recent study published in the journal *Nature* adds another dimension to these warnings by examining which fossil fuels are most costly to develop and located farthest from markets. The authors conclude that one-third of global oil reserves, half of all gas reserves (including 88% of unconventional gas from fracking) and over 80% of coal reserves should remain unused in order to meet the 2^0C target.

The study finds that bitumen from the Alberta tar sands and oil from the Arctic are among the most costly and least economical. It concludes that 75% of Canada's known oil reserves, 24% of gas reserves and almost all coal reserves are unburnable.[33] The implication is that the remaining amounts must be carefully allocated for use within Canada as part of a transition to renewable sources, while tar sands expansion and fossil fuel exports are curtailed.

Costs of renewable energy falling

The search for alternatives to fossil fuels has prompted analysts to take a fresh look at opportunities for investing in renewable energy. While the assump-

tion is that a cold Northern country like Canada cannot as easily move off fossil fuels as warmer countries, this does not explain what is happening in Denmark. That Northern country is on track to produce 33% of its total energy needs from renewable sources by 2020, and to achieve complete independence from oil, gas and coal by 2050.[34]

Wind power, chiefly from offshore turbines, will provide nearly half of Denmark's electricity by 2020 with another fifth coming from biomass. The government is promoting this remarkable transition in part by allowing households or community wind-turbine cooperatives to sell excess power back into the grid.

A study by a group of 70 Canadian scholars shows how Canada can achieve 100% reliance on low-carbon electricity by 2035 with an 80% reduction in GHG emissions by 2050. Key policy initiatives to achieve these goals include putting a national price on carbon and eliminating subsidies to fossil fuel industries. Other strategies include building an East-West electricity grid, energy efficiency and conservation programs, the electrification of transportation and carbon-neutral building standards.[35]

A 2014 study by two McGill University scholars assesses the physical availability of energy from wind, solar, hydro, tidal, wave, geothermal and biomass in Canada without taking into account economic considerations. The conclusion: "With current technology, Canada could more than provide for its energy needs using renewables, two-thirds of which would come from onshore and offshore wind, with much of the remainder coming from hydro."[36]

According to the International Renewable Energy Agency, the costs of generating electricity from renewable sources including hydro, geothermal and onshore wind are competitive with fossil fuels in many parts of the world.[37] The most dramatic cost declines – 75% since 2009 – have been for solar photovoltaic installations. However, these costs vary widely from region to region. In the United States, solar power is on track to be as cheap or cheaper than average electricity costs in 47 states by 2016, provided that a 30% tax credit for system costs is maintained.[38]

The Canadian Wind Energy Association acknowledges that wind power currently costs more than electricity from generating plants that were built and paid for decades ago. However, it states: "Wind is extremely competitive with new installations of coal, hydro and nuclear power when the cost of health and environmental impacts are considered." [39]

Similarly the Canadian Solar Industries Association, while acknowledging that solar photovoltaic electricity is not yet cost competitive, states that it can be competitive by 2020 provided that certain conditions are met including the establishment of a supportive policy and regulatory environment.[40] Solar space and water heating systems are already cost competitive when investments are amortized over several years.

In order to make more renewable energy projects viable, government and public support is essential. The 2007 federal ecoENERGY for Renewable Power program provided incentives for generating electricity from renewable sources. However, this successful program ended in January 2011 when no new funding was provided for it in the 2010 federal budget.[41] Investing one million dollars in oil and gas creates two jobs while the same investment in wind, solar, hydro and biomass energy creates 15 jobs.[42]

D. The Growing Hazards of GHGs other than Carbon Dioxide

While curtailing carbon dioxide emissions is crucial, climatologist James Hansen has stated that three pollutants – ozone, black carbon, and methane – may, over the short term, have a greater impact on the climate than CO_2.[43] Unlike CO_2 that can linger in the atmosphere for a century or longer, these pollutants remain in the air for shorter time periods and need to be dealt with now when action on climate change is most needed. Here we examine how each of these three pollutants affects the climate.

Ozone

Ozone interacts with the other drivers of climate change in complex ways. When ozone is formed naturally in the upper atmosphere (stratosphere), it absorbs ultraviolet radiation from the sun as well as infrared radiation reflected from the lower atmosphere. The ozone layer has the beneficial effect of protecting plants, animals and humans from too much ultraviolet radiation. The loss of ozone in the upper atmosphere due to human's use of ozone-depleting chemicals such

as chlorofluorocarbons (CFCs) has a cooling effect at those high altitudes. This cooling effect of ozone depletion is responsible for colder winter temperatures in the Antarctic. [44]

Meanwhile the warming of the lower atmosphere (troposphere), also due to human activity and particularly methane emissions, can accelerate photochemical reactions resulting in too much ozone closer to the Earth's surface where it is harmful for human health.

Ironically the successful actions undertaken under the Montreal Protocol to reduce the use of CFCs, and thus repair the hole in the ozone layer in the upper atmosphere, has had unintended consequences. The major replacement for CFCs, and other ozone-depleting chemicals, has been HFCs (or hydrofluorocarbons) used as refrigerants and in other products.

HFCs unfortunately are also powerful greenhouse gases. According to the UN Environmental Program, HFC emissions could potentially be equivalent to 18% to 45% of the CO_2 emissions allowable by 2050 to keep temperature increases under 2^0C.[45] Fortunately, the UNEP reports that there are a number of alternatives available that would substitute for HFCs, such as ammonia or dimethyl ether.

In her speech at the Lima climate conference, Leona Aglukkaq, Canada's Environment Minister, identified HFCs as one of "the world's most potent and fastest growing GHGs."[46] Accordingly Canada, together with the U.S. and Mexico, has proposed a phase out of HFCs under the Montreal Protocol.

Black carbon

A 2013 study published in the Journal of Geophysical Research Atmospheres suggests that the impact of black carbon aerosols (such as soot from burning wood and diesel exhausts), "may have twice as much impact on global warming than previously thought."[47] The study's authors estimate that the effect of black carbon emissions may be two-thirds as great as that of carbon dioxide.

A more recent Norwegian study suggests this estimate may be overstated, but still finds a net warming effect from black carbon in the atmosphere.[48] In Europe, North America and Latin America, diesel engines account for about 75% of black carbon emissions. In Africa and Asia, burning firewood accounts for 60% to 80% of these emissions.

Black carbon, like ground level ozone, is dangerous for human health, contributing to respiratory and cardiovascular diseases, lung cancer and exacerbating allergies.[49] An estimated 4.2 million persons, mostly women, die every year from inhaling smoke from cooking fires.[50]

Fortunately there are technologies available for reducing black carbon from diesel transportation and from open cooking fires. Intermodal shipping where merchandise is moved over distances by train is three times more efficient than transportation by long-haul trucks burning diesel.

A group in India has developed a cooking stove that reduces fuel use in half and black carbon emissions by 90% through the use of solar powered fans.[51] Professor Piers Forster, from the University of Leeds School of Earth and Environment, says: "If we did everything we could to reduce [diesel and cooking black carbon] emissions, we could buy ourselves up to half a degree less warming – or a couple of decades of respite."[52]

Methane

One estimate by the Intergovernmental Panel on Climate Change (IPCC) suggests that methane accounted for about 20% of human-caused GHG emissions in 2010. This estimate is based on methane's global warming potential in terms of carbon-dioxide equivalent over a period of 100 years.[53]

However, it is important to note that methane is a much more potent GHG over shorter periods of time. While the global warming potential of methane is 34 times greater than CO_2 over a 100 year period, the IPCC reports that it is 86 times stronger over 20 years and 108 times more forceful over 10 years.[54]

The IPCC has concluded that at current rates of human-induced emissions over a 10-year period, methane emissions are slightly more significant than all CO_2 emissions that result from human activity. Over 20 years, global methane emissions are as damaging as 80% of those from CO_2.

Cornell University scientist Robert Howarth has studied the impact of "fugitive emissions" of methane from the production of natural gas through hydraulic

fracturing (fracking) of shale gas. He found that when natural gas is extracted from shale formations through fracking, about 50% more methane leaks into the atmosphere than from conventional wells.

Howarth cites other studies that predict: "Unless emissions of methane and black carbon are reduced immediately, the Earth's average surface temperature will warm by 1.5^{0}C by about 2030 and by 2^{0}C by 2045 or 2050 ... ." He concludes: "Reducing methane and black carbon emissions, even if carbon dioxide is not controlled, would significantly slow the rate of global warming and postpone reaching the 1.5^{0}C and 2^{0}C marks by 15-20 years." [55]

President Obama has announced plans to impose new regulations on methane emissions from oil and gas wells and pipelines. The U.S. aims to cut methane emissions by up to 45% from 2012 levels by 2025. The initiative follows a 2014 study in the journal *Science* that "found that methane was leaking from oil and natural gas drilling sites and pipelines at rates 50 percent higher than previously thought."[56]

To date Canada has not announced a comparable policy, despite past claims that Canada would harmonize its policies on climate change with those in the United States.

Reducing emissions from agriculture and food waste

In 2010, emissions from agriculture accounted for 14% of the total global warming potential of all GHG emissions, measured over a 100-year period. When measured according to their global warming potential over a 20-year period, agricultural emissions jump to 22% of the total.[57] One reason for the difference is that agricultural methane emissions from the decomposition of livestock manure and the digestive processes of ruminant animals (such as cattle) represent a large portion of total agricultural emissions.

Globally, agricultural manure decomposition contributed about 4% of methane emissions in 2010.[58] These emissions can be reduced through the use of anaerobic digestion technology, a process by which microorganisms break down biodegradable material in the absence of oxygen.

The resulting methane is captured as biogas and used to generate energy for on-farm heating, cooling and electricity generation. Another option is to re-integrate animal husbandry with crop production, feeding ruminants on natural pastures instead of in factory farms. This practice would reduce methane emissions from cows, sheep and goats.

Reducing the long distance transportation of food and putting local markets at the centre of the food system would make a significant contribution to lowering fossil fuel use for transportation and refrigeration as well as reducing the amount of wasted food. Food wastage is estimated to account for as much as 7% of global GHG emissions.[59]

Finding ways to better store, transport and preserve food would not only help feed the one billion people who go hungry each day but also make a significant contribution to slowing climate change.

E. Arctic Methane Emissions

There is growing evidence that warming in the Arctic is accelerating climate change by releasing huge amounts of methane. In 2011, KAIROS published Arctic Melting Sounds the Alarm for Life on Earth, a *Briefing Paper* that summarized several studies on rapid climate change in the Arctic. It cited warnings from climate scientists that feedback effects from thawing permafrost and methane hydrates could take us to a point of no return after which the world would face unstoppable climate devastation. Recent events, and several new studies, have reinforced this concern.

A study in the journal *Geophysical Research Letters* revealed that since 2012 ice from the Austfonna ice cap above Norway's Svalbard archipelago has thinned by more than 50 metres, or one-sixth of its original thickness.[60] The extent of Arctic sea ice at the end of the Northern summer of 2014 was the sixth lowest recorded since satellite images became available.[61] This winter the extent of Arctic sea ice reached the lowest maximum ever recorded on February 25, some 15 days earlier than the average date for maximum ice cover over the years 1981 to 2010.[62]

Harold Wanless, a professor in the department of Geological Sciences at the University of Miami, says that the Intergovernmental Panel on Climate Change's estimate that global sea levels will rise by about 40 centimetres by the end of this century greatly underestimates the threat. He notes that the IPCC does not

take into account the latest evidence of melting sea ice or onshore glaciers in Greenland.

Dr. Wanless says that the amount of greenhouse gases already in the atmosphere is sufficient to cause oceans to rise by 1.2 to 2 metres, three to five times more than what the IPCC predicts.[63] Although the time frame is uncertain, Wanless warns that we are close to causing the entire Greenland ice sheet to melt. This would result in a catastrophic seven metre rise in sea levels.

Ominously the Western Antarctic ice sheet has also begun to collapse in a process that scientists deem to be "unstoppable."[64] The loss of the Western Antarctic ice sheet would cause sea levels to rise by at least three metres. Around one billion people live on sea coasts that are vulnerable to even a one metre rise in ocean levels.[65]

Feedback mechanisms accelerate climate change

Feedback mechanisms, or small climatic changes that unleash forces resulting in much larger amounts of warming, are already occurring. Disappearing ice exposes darker waters that absorb more sunlight than what is reflected back into space by white ice. This is an example of a feedback effect which causes Arctic temperatures to rise twice as fast as elsewhere on Earth.

Another amplifying feedback is that, as temperatures rise, oceans and land-based carbon sinks (vegetation and soils) are becoming less effective at absorbing excess carbon dioxide. Scientists estimate that the ability of ocean and land sinks to absorb CO_2 declined by about one-third between 1959 and 2012. Carbon-cycle feedbacks were responsible for about 40% of that decline.[66]

Another dangerous feedback occurs when warmer Arctic temperatures melt permafrost that has been frozen for thousands of years. NASA's Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE) measures GHG emissions from thawing permafrost. The NASA scientists note:

"Over hundreds of millennia, Arctic permafrost soils have accumulated vast stores of organic carbon – an estimated 1,400 to 1,850 ... billion metric tons. That's about half of all the estimated organic carbon stored in Earth's soils. In comparison, about 350 [billion metric tons] of carbon have been emitted from all fossil-fuel combustion and human activities since 1850. Most of this carbon is located in thaw-vulnerable topsoils within 10 feet (3 meters) of the surface." [67]

The CARVE scientists are confirming that permafrost is not as permanent as its name implies. Its principal scientist, Charles Miller says: "Permafrost soils are warming even faster than Arctic air temperatures – as much as 1.5 to 2.5 degrees Celsius in just the past 30 years.

"As heat from Earth's surface penetrates into permafrost, it threatens to mobilize these organic carbon reservoirs and release them into the atmosphere as carbon dioxide and methane, upsetting the Arctic's carbon balance and seriously worsening global warming."[68]

NASA scientists warn: "Historically, the cold, wet soils of Arctic ecosystems have stored more carbon than they have released. If climate change causes the Arctic to get warmer and drier, scientists expect most of the [GHGs] to be released as carbon dioxide. If it gets warmer and wetter, most will be in the form of methane."[69]

Scientists at the U.S. National Snow and Ice Data Center estimate that permafrost will become a carbon source rather than a carbon sink during the 2020s, adding up to 0.8^{0}C to total global warming by 2100.[70]

Thawing methane hydrates

In addition to the threat posed by melting permafrost, there is growing evidence that dangerous amounts of methane are being released from thawing methane hydrates. These are molecules of methane surrounded by frozen water found on the seabed or deep underground in the Arctic. A 2010 report in the journal *Science* estimated that methane hydrates contain the equivalent of 1,000 to 10,000 billion metric tonnes of carbon, vastly more than all the carbon that human activity has caused to be released into the atmosphere since the industrial revolution.[71]

Recent reports indicate methane is now leaking not only from the ocean floor in the Arctic, but also in unexpected places, including on both the west and east coasts of continental United States.[72] The most dramatic evidence of methane leakage comes from the emergence of huge craters in Siberia. Oil and gas

workers flying over Siberia's Yamal Peninsula were the first to discover craters 200 feet wide.

Siberian crater caused by underground methane explosion.

At first scientists were unsure of the cause since the craters do not resemble those that result from meteor impacts. Russian scientists sent to investigate found "unusually high concentrations of methane of up to 9.6% at the bottom of [a] crater."[73] That is about 50,000 times as much methane as is normally found in the atmosphere leading to the conclusion that the craters are caused by explosions of methane released by underground melting.

A 2013 study published in the journal *Nature* describes a 50 billion tonne reservoir of methane stored in hydrates on the East Siberian Arctic Shelf. The authors state that the methane could be released either slowly over 50 years or suddenly. They explore the consequences of a decade-long release of this methane into the atmosphere over the years 2015-2025. They conclude that a 50-billion tonne "methane pulse will bring forward by 15-35 years the average date at which the global mean temperatures rise exceeds 2^{0}C above pre-industrial levels."[74]

Many scientists believe that the release of vast amounts of methane was what brought about past mass extinctions. In a paper published in the August 2013 edition of *Ecology Letters*, David Wasdel, an expert on multiple feedback dynamics, writes: "We are experiencing change 200 to 300 times faster than any of the previous major extinction events."[75]

Wasdel notes that the oceans have lost 40% of their phytoplankton, the basic element in the marine food chain, due to acidification and temperature variations caused by climate change. He warns that a high temperature event could obliterate 60% to 80% of populations and species of life on Earth.

The frightening consequences of the release of vast amounts of methane due to feedback mechanisms in the Arctic are summarized by University of Arizona scientist Guy McPherson: "We will have very few humans on the planet because of lack of habitat. ... All the evidence points to a lock-in 3.5 to 5 degree Celsius temperature rise above the 1950 'norm' by mid-century, possibly much sooner. This guarantees a positive feed-back already underway, leading to 4.5 to 6 degrees above the 'norm' and that is a level lethal to life. ...

"While the human body is potentially capable of handling a six-to-nine degree Celsius rise in the planetary temperature, the crops and habitat we use for food production are not. ... Humans have to eat and plants can't adapt fast enough to make that possible for seven to nine billion of us."[76]

F. Conclusion

McPherson's dire warning could lead us to despair. Yet an emerging theme from the analysis in this briefing is that by confronting some of the short-term forces accelerating climate change, we can avoid the worst scenarios threatening life on Earth.

Containing these short-term causes of climate change will help buy time for implementing long-term solutions including substituting renewable forms of energy that will allow us to keep most fossil fuel reserves in the ground.

Despite the very real obstacles blocking our path to climate justice, we recall World Council of Churches General Secretary Tveit's insistence on "the right to hope" – not as a passive waiting but as an active reason for redoubling our efforts for climate justice. The determined effort of more and more of earth's citizens can stem the tide of global destruction.

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