INTERNATIONAL CRYOSPHERE CLIMATE INITIATIVE (ICCI)
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INFORMATION PAPER

The Cryosphere and Need for Enhanced Pre-2020 Ambition: Submission to UNFCCC ADP Workstream 2 by the International Cryosphere Climate Initiative (ICCI)

Summary: In accordance with the information requested in paragraphs 5(a) and 5(b) of Decision 1/CP.19, regarding Workstream 2 of the Ad Hoc Working Group on the Durban Platform on Enhanced Action (ADP), the following information paper provides consideration of the needed elements to enhance pre-2020 ambition levels, particularly from the point of view of climate change in cryosphere regions. This includes enhanced action on deep and immediate cuts in CO2, especially from those sources that also produce short-lived climate pollutants. A sectoral approach that takes into account all pollutants, and both near-term as well as long-term impacts, should comprise a key consideration in pre-2020 ambitions, as well as Paris agreement actions.

Background

The earth's cryosphere – regions of snow and ice – over the next few decades may tip the balance between successfully addressing climate change, or tipping into a cascade of changes that will spell catastrophe for many ecosystems and human communities. These regions already have warmed more than two times faster than the rest of the planet. If this rate continues, we will see the impacts all over the globe from a temperature increase ranging from 4 to 10 degrees in cryosphere regions: sea level rise, permafrost melt that could release greenhouse gases equal to that from all human sources, loss of snow and ice that otherwise cool the planet by reflecting the sun's rays. These are not hyperbole, but physical processes well documented in the scientific literature: we run the risk of crossing certain thresholds that cryosphere scientists categorize as essentially irreversible.

This physical "cryosphere imperative" provides one of the key aspects of pre-2020, as well as 2020-30 ambition. Constraining warming in these regions may prove as important as any overall global goal for temperature rise. Current climate goals aiming at a certain ultimate global temperature, whether 2 or 1.5 degrees, do not fully appreciate this rapidly warming cryosphere and its global implications, and what it means in terms of required urgency to address carbon emissions. Slowing this warming will require far more aggressive action than anything being considered in even the most ambitious climate negotiations – more urgent action on CO2 and other long-lived greenhouse gases, preferably complemented with the less-known air pollutants black carbon and ozone as well as methane.

In many ways, these thresholds have their greatest importance outside of the cryosphere, especially in small island developing states and other low-lying areas, due to the consequences of sea-level rise in particular. As AR5 made clear, some sea-level rise already appears inevitable, but the earlier we take action, the more this risk can be

limited. In this sense, pre-2020 action aimed at slowing cryospheric warming is a matter for global, not just regional concern.

The *On Thin Ice* report, produced by ICCI with the support of the World Bank (2013)[1], details some of the most recent cryosphere changes ands thresholds that may impact sea-level rise, greenhouse gas releases from permafrost and near-shore Arctic seabeds, and acidification of the polar oceans that provide much of current fisheries productions. At the same time, it provides modeling of potential air quality benefits that might slow this cryosphere warming and its impacts, with specific sectorally-based actions in the 2015-2030 timeframe. The report's climate and health modeling shows that successful action is indeed possible, and can even enhance global economies.

ICCI is moving to support new modeling that would examine the best mixture of CO2 and air quality actions. For example, fossil fuel extraction (especially coal, oil and gas) produces large amounts of leaked methane, as well as black carbon from activities such as flaring and diesel transport. These emissions can impact the climate in the near-term, especially in regions close to the Arctic and Himalayas. When these fuels are then burned, they then produce CO2 – sharpening in other words arguments for early transition to low-carbon fuels. Efficiency measures similarly would cut both CO2 and "short-lived climate pollutants" (SLCPs). The additional climate modeling is aimed at quantifying such benefits, and ICCI will provide updates to Workstream 2 as these proceed.

The following provides an overview from certain sectors drawing on the *On Thin Ice* work. However, it should be noted that it draws only on modeling involving black carbon and methane measures, preliminary to a more integrated CO2-SLCP approach currently under way, per the above. **The below modeling and sectoral information is therefore in no way meant to minimize the importance of deep and immediate cuts in sectors targeting CO2 in the pre-2020 time frame. Without such cuts – in both the pre-2020, and 2020-2030 time frames – the below sectoral actions will still carry significant and important health and crop benefits – but any cryosphere climate benefits will be eventually eclipsed by rising CO2 levels.**

Cookstoves:
By far, cookstoves measures have emerged as the greatest single source of benefits for health and the cryosphere in the On Thin Ice modeling, indicating an opportunity for early and urgent action that addresses CO2 (including by decreasing cutting of forests as a carbon sink) and short-lived climate pollutants, as well as carrying significant benefits to development and adaptation. From a cryosphere preservation standpoint, addressing this source provided the largest benefit in the *On Thin Ice* modeling, from the Himalayas to the Arctic to (rather surprisingly) Antarctica. Most of this benefit arose from direct forcing of black carbon in the atmosphere, which over snow and ice provides a clear degree of radiative forcing. Even though most of the black carbon falls out of the atmosphere much closer to the main source regions, the amount of emissions from cookstoves is so great that even though only a relatively small percentage reaches these

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[1] *On Thin Ice: How cutting pollution can slow warming and save lives* (2013). World Bank for Reconstruction and Development and International Cryosphere Climate Initiative, available at iccinet.org/thinicepubfinal

cryosphere regions, the modeling indicates it is still enough to make a measureable impact on radiative forcing in all cryosphere regions, including distant ones.

Nearly three billion people living in developing countries — close to half the world's population — rely on biomass (wood, charcoal, dung, and crop residues) and coal burning to cook their food and heat their homes, and face daily exposure to smoke. Recent studies[2] have found that the tiniest particles within such particulate pollution (smaller than PM2.5), inflict the gravest respiratory damage. Once lodged in the lungs, these superfine particles—which include black carbon/soot—cannot be coughed out, creating the conditions for disease. The latest Global Burden of Disease estimates that some 7 million people die prematurely each year from the effects of poorly ventilated cooking smoke today.

Woodfuel demand for energy can have serious negative effects on forests and woodlands where large and sometimes lucrative woodfuel markets create incentives for forest and woodland clearance, or where rural communities depend on fragile ecosystems that are already under environmental stress. In addition, the daily burden of firewood collection contributes to gender inequality, by preventing women and girls from spending time in school or engaged in productive economic activities, while exposing them to risk of sexual violence.

Encouragingly, the modeling showed nearly equal health benefits from two different approaches to replacing traditional cookstoves: *replacing biomass cookstoves with a 50/50 combination of liquid petroleum gas (LPG) and biogas,* which achieved the greatest potential reduction; but nearly as much good results from *replacement by fan-assisted/forced-air biomass cookstoves*, at least for outdoor air exposure to stoves pollution (the modeling did not capture household/indoor impacts, which might increase this difference). This flexibility in approach addresses one key barrier to effective cookstoves programs, that of fuel availability options. Although considered a "gold standard" technology, biogas or LPG fuel replacement (or replacement by sustainable production of ethanol, under increasing use in Africa) may not meet the needs of the rural poor. In particular, wood, dung and grass may prove cheaper or more widely available.

All four cookstove models are proven to reduce particle pollution and black carbon – LPG, biogas, ethanol, and forced-draft stoves – but present different challenges for implementation. Fugitive methane emissions can occur from the two gas-driven stoves; and a badly-maintained or improperly–used forced draft stove will emit copious amounts of smoke and black carbon. All stoves must be used on a regular basis and maintained properly to effectively curb pollution emissions. Training, proper maintenance and long-term monitoring and evaluation must be essential elements of cookstoves replacement programs. In addition, past experience shows that the sustainability of cookstoves programs is dependent on the socio-cultural context, market conditions, and affordability[3]. Cookstoves designed without the user in mind have often failed; as have

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[2] International Agency for Research on Cancer (IARC), 2012. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans, Vol. 105: DIESEL AND GASOLINE ENGINE EXHAUSTS AND SOME NITROARENES, Lyon, France: 5-12 June 2012.

[3] The World Bank (2011). Household Cookstoves, Environment, Health, and Climate Change: a new look at an old problem

programs that lack after sales services and, donor driven handouts of expensive cookstove models.

Nevertheless, the costs of continued traditional cookstove use in terms of family health and welfare – let alone the climate impacts – speak for intensified efforts to overcome these barriers and increased "learning by doing", as in the approach used by donors to the HIV/AIDs, malaria and TB health crisis of the late 1990's. The barriers to distribution and proper use of cookstoves include some striking similarities to the public health challenges of these three infectious diseases: need to solve issues of distribution (which for anti-retroviral drugs included keeping the supply cold throughout the supply chain in rural areas without refrigeration); education in proper use; and ongoing monitoring, evaluation and follow-up. Addressing local barriers to improved cookstoves adoption is however key, as would be affordability, and well-designed monitoring and evaluation programs to ensure proper use over time.

Biomass and Coal Heating Stoves:
Modeling of the emission reduction measures for biomass and coal heating stoves improved on previous studies by placing use of these stoves when it most often occurs: during the colder months. This resulted in clearly higher climate impacts in the Arctic and Eastern Himalayas; somewhat higher health impacts in northern Europe where biomass stove use is growing, and in parts of Eastern Europe and China for coal stoves. Rising oil prices, combined with climate change policies aimed at promoting renewable energy over fossil fuels, have contributed to greater use of solid biofuels, especially wood, for household heating. Many recent studies in Europe have associated the growing use of wood heating as a source of winter air pollution – in some cities such as Berlin, becoming the most significant source of particle pollution even when averaged year-round. Wood burning stoves and fireplaces, as well as boilers, have long played a central role in home heating in Nordic countries. A 2012 study by the International Energy Agency concluded that even in the absence of a global climate change agreement, bio-fuels in the residential sector will increase.[4] Hence there is an urgent need to design and implement an effective approach to limiting black carbon emissions from home heating sources as their use continues to rise.

Coal stoves, in addition to the modeled measure of fuel replacement by coal briquettes, have also seen successful reductions in China through replacement with LPG or biogas stoves, usually however when such stoves are used more for cooking than heating. Briquettes offer a cost-effective interim solution that can be used in existing stoves.

Open Burning:
The 50 percent decrease in open burning modeled for the Report showed little climate impact; however it showed surprisingly strong health benefits, ranking it as the second most effective mitigation measure in health terms (though it still ranks below cookstoves by nearly a factor of 10). This reflects the large amount of particle pollution released as burning occurs, with most health impacts occurring quite close to the source.

Using the "northern Eurasia" option for open burning however (90 percent decrease, reflecting the difference in burning frequency between this region and similar ecosystems in the European Union) did yield appreciable climate impacts, not just in the

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[4] "Nordic Energy Technology Perspectives", IEA and Norden, 2012.

Arctic but also in the Himalayas, which borders some extensive seasonal burning in Kazakhstan and Mongolia. This indicates that when open fires are controlled to their greatest extent, not only health but climate benefits could prove quite significant. Outside high altitude and boreal regions, almost all open burning occurs as a result of anthropogenic, human activities; whether these are set agricultural or forestry fires, or waste or camp fires that grow out of control.[5] [6]

Introduction of no-burn alternative agricultural methods has resulted in higher yields and profits for many farmers in Western Europe. Public information campaigns to prevent accidental fires can also prove quickly effective. Both measures are relatively inexpensive. Greater exploration of the true reduction potentials for open burning in other regions of the world, beginning with characterization of what is being burned and the motivations behind it could be a necessary first step.

Diesel:
Greatest benefits from diesel measures – whether aimed at on-road transport or off-road mobile machinery such as construction and farming equipment – arose in developing countries where relatively dirty diesel engines without particulate filters are expected to continue in wide use through 2030. The Himalayan region showed especially strong impacts from diesel measures, but East Africa and to some degree the Andes also showed benefits both on the health and climate side. Diesel reduction measures also showed strong benefits using two of the three sets of forcing assumptions in the Arctic, but results were quite weak using the GISS-AIE assumptions.

It bears noting that this measure assumes that in most OECD countries, all mobile diesel sources would meet EURO-VI standards by 2030, so these reductions are not included in the benefits calculations. Some policy decisions that might delay this change – in particular, any delay in replacing the current transport and off-road fleets with cleaner vehicles – would change that result. Particle filters can reduce black carbon and $PM_{2.5}$ emissions essentially to zero,[7] and and retrofitting vehicles with such filters may provide a useful means to advance this trend.

Oil and Gas Flaring
Recent work[8] by a European Union project found this source showed greater levels of black carbon deposition at six measuring stations than any other source globally. This source may prove quite significant in future in the Arctic context given plans for expansion of oil and gas exploitation, and rising exploitation of shale gas that involves flaring in North America and elsewhere. Such activities may increase emissions of methane from that sector (see below discussion on methane emissions from oil and gas-related activities).

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[5] Giri, C., and S. Shrestha. 2000. Forest fire mapping in Huay Kha Khaeng Wildlife Sanctuary, Thailand. *International Journal of Remote Sensing* 21:2023-2030.
[6] Flannigan, M. D., M. A. Krawchuk, W. J. de Groot, B. M. Wotton, and L. M. Gowman. 2009. Implications of changing climate for global wildland fire. *International Journal of Wildland Fire* 18:483-507.
[7] EPA (2012). Report to Congress on Black Carbon, p.175.
[8] Stohl et al. (2013). Why models struggle to capture Arctic Haze: the underestimated role of gas flaring and domestic combustion emissions. Atmos. Chem. Phys. Discuss. 13, 9567–9613.

Wick Lanterns

The *On Thin Ice* Report was in progress when new work was published characterizing the impacts on health and climate of wick lanterns, which usually run on kerosene; hence wick lamps were not modeled as a measure. Lam et al (2012)[9] estimate that wick lanterns might prove the second largest source of harmful particles and black carbon in the household setting, especially because the smoke arising from the wicks is almost pure black carbon.

In many settings, replacement of kerosene wick lanterns by solar lanterns provides a relatively cheap and effective mitigation measure. The World Bank[10], TERI in India and a number of private efforts have combined effective provision of such lanterns with microenterprises that include lantern charging centers, often run by local village women.

Methane Measures:

Methane capture is often considered as a measure that "pays for itself", assuming revenues from the sale of methane (or productive use of methane, e.g., to generate power) outweighs investment and maintenance costs. However, capture of methane requires not only investments in the technology for capture, but the creation of market and distribution systems. Some regions, such as the oil industries of the North Sea and northern Russia, exist far from population centers; but even in high-population regions of China, India and Nigeria, most of the methane from these industries is lost to the atmosphere and enhances today's warming. A recent approach[11] methane and black carbon emission reduction argued that these negative-cost options should not be included in estimates of SLCP reduction potential as they would naturally take place due to rational economic behavior; the track record of the past four decades argues however against such "automatic" projections for SLCP mitigation.

A number of studies have proposed different ways to make up the gap between potential wins from methane capture and associated costs, including floor price supports for methane products under the Clean Development Mechanism or pay-for-performance schemes.[12] Some of these projects can carry extremely strong development benefits, especially when combined with biogas capture for cooking and heating.

The below table shows the relative percentage of methane reductions available from the seven emission reduction measures modeled in *On Thin Ice*:

Table 1. Percentage of methane reductions available from the defined measures as modeled.

Rice paddies	Livestock manure	Wastewater	Municipal waste	Coal mines	Gas distribution	Oil and Gas

[9] Lam, NL et al (2012). "Household Light Makes Global Heat: High Black Carbon Emissions From Kerosene Wick Lamps," *Environmental Science & Technology* **,** *46*, (24), 13531- 13538.

[10] www.lightingafrica.org

[11] Reference: Steven J. Smith and Andrew Mizrahi," Near-Term Climate Mitigation by Short-Lived Forcers," PNAS, Aug. 12, 2013, DOI 10.1073/pnas.1308470110.

[12] See the World Banks's Report of the Methane Finance Study Group (www.worldbank.org/mfsg) and various publications of the Methane Blue Ribbon Panel (www.globalmethanefund.org).

						production
6.6	4.4	2.7	20	31.1	4.9	30.3

Oil and Gas Extraction and Mining Operations
Four groups of measures involving fossil fuel extraction of coal, oil and gas contribute 65 percent of the crop, health and climate benefits from methane reduction measures. Addressing methane emissions from production activities in industries could constrain Arctic warming by approximately 0.4 degrees Celsius by 2050, and on Antarctica and in the Himalayas by 0.2 Celsius degrees. For crops, reductions in ozone from greater control of methane releases under these measures would contribute about 8 million metric tons of additional staple crop yield annually.

Much of the global efforts to cut CO2 emissions focus on emissions from these fossil fuel industries. However, during a transition to less fossil-fuel intensive economies, the impact of the extraction process itself on near-term rates of warming and the cryosphere also needs to be addressed with great urgency. This is one sector where the transition to a low-carbon economy needs to include both the cryosphere imperative of SLCP reductions due to front-end industry emissions, and the long-term CO2 emissions that result when these fuels are burned for energy.

For mining operations, the control of methane has a long track record. Coal mining especially can produce large releases of explosive methane gas that can prove extremely dangerous to miners and the surrounding communities. Similar risks arise in the oil and gas community. Almost all large-scale mining, oil rig and refinery accidents, including the 2010 Massey coal mine and Deepwater Horizon explosions in the U.S., occur as a result of improperly controlled methane. Venting or flaring methane is one way the industry controls this risk, but the potential impact from related black carbon emissions on health, crop and climate, unless the flaring is done to highly efficient standards, and the inherent risk of explosion argues for an alternative approach. Both investment incentives and regulatory controls on these practices have been used to great effect, for example among Norwegian North Sea oil rigs.

Recent studies show that flaring and venting close to Arctic ice and snow, together with associated ship or land diesel operations could rapidly speed warming there through the combination of black carbon (from flaring and transport) and methane releases.[13] Hence control of risks associated with SLCP releases must be combined with concerns for safety and other environmental factors unique to operating in this fragile region. The World Bank coordinates the Global Gas Flaring Reduction initiative that is working with public and private entities to address issues of venting and flaring in the oil and gas industry[14].

Wastewater and Landfills
Waste management measures, for wastewater treatment and municipal waste or landfills, provided about 23% of the methane-related climate, health and crop benefits in the *On Thin Ice* study. Implementation of these two measures are almost certain to bring additional benefits from the decrease in water-borne infectious diseases that comes with improved sanitation and water quality. Unfortunately, retrofitting of existing

[13] Stohl et al 2013, ibid.
[14] www.ggfr.org

wastewater treatment plants to capture methane can prove expensive. However, the added cost in building these technologies into plant design from the beginning may prove much lower.

Capture of methane from existing landfills does provide a negative cost over time, but the high up-front investment costs can be a significant barrier to implementation. New landfills on the other hand may be built in a manner that avoids methane production entirely. There is some evidence that landfill owners have designed new sites in a manner that includes methane production and capture, however they still run the risk of generating fugitive emissions.[15] Flaring of methane emissions leads to the production of black carbon, substituting one pollutant for another and creating higher levels of particle pollution around landfill sites.

Agriculture

Improvements to agriculture, whether from the modeled measures for rice paddies or livestock (or from controlling open burning) can bring additional benefits in terms of improved food security and crop yields, providing 11 percent of the total global and regional methane reduction measure benefits. A number of programs already seek to address methane emissions from agricultural activities. Methane from livestock manure is one of the fastest-growing sources of emissions, due to increased demand for meat across the globe. Currently methane emissions from this source are estimated at around 20 percent of the global total. The modeling shows a far lower emission reduction potential from livestock methane capture, about 4 percent simply because the most proven technologies apply only to the largest livestock operations.

However, commercially viable "methane cooker" biogas technologies exist at much smaller scales, including at the household level. They can effectively address cookstove emissions at the same time by employing biogas for cooking rather than biomass. This combination makes household scale manure management one of the more promising SLCP mitigation methods.

Emissions from flooded or wet-method rice paddies contribute a far larger proportion of estimated global anthropogenic methane than current potential reductions: fully 20 percent of anthropogenic methane emissions come from rice agriculture. However as with open burning, alternative proven rice agriculture methods exist that can maintain yields while decreasing reliance on water resources and fertilizer by using an integrated approach to properly time both fertilizer application and irrigation. Many rice varieties in wide use today for example do not require the constant 3-4 months of flooding currently employed. Although not included as an emission reduction measure in this study, the potential also exists for improved varieties of rice that can produce a much larger crop per paddy area and thus decrease the area of flooded fields.

In addition, use of compounds such as ammonium sulphate, which enhance activity of microbial groups that do not produce methane, can cut methane emissions under certain conditions. China has proven a leader in studying methane emissions from rice and

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[15] Sierra Club Report on Landfill Gas-to-Energy, January 2010. See www.sierraclub.org/policy/conservation/landfill-gas-report.pdf.

providing alternative rice production methods. Recent studies indicate[16] substantial emission reduction potential should other countries adopt these methods more widely.

[16] Nature News 2009: doi:10.1038/news.2009.833