Valuating the benefits of improved cooking solutions

Impact data in high resolution

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Valuing the co-benefits of improved cooking solutions supports deployment of best available cooking technologies at scale

Evidence shows that improved cooking solutions (ICS) can have a positive impact on a wide range of environmental and social outcomes. More than 2.85 billion people in developing countries rely on solid fuels – for example wood, charcoal, dung or coal – as their primary means of cooking.[1] Conventional cooking methods using solid fuels, mainly open fires and rudimentary cookstoves, are inefficient, unhealthy, and unsafe. Their negative impacts range from the extensive time and costs required for fuel production and collection to the health and environmental impacts of emissions from inefficient combustion of these fuels. Many of these negative impacts can be alleviated through the adoption of improved cooking solutions.

This study aims to shed light on the shared value that investors create through supporting ICS, in order to attract more capital to ICS. It builds on earlier work[2] commissioned by the Gold Standard Foundation (GSF) by valuing a broad set of co-benefits and using new primary data from the GSF portfolio. As such, it supports ongoing work by many organisations to rapidly deploy best available cooking technologies at scale by:

- **Providing a more complete picture of monetary benefits** of a representative set of ICS projects (both cookstove and domestic biogas projects) that have been accredited by GSF.
- **Introducing a forward looking impact evaluation tool for ICS projects,** that can be used by project developers to understand which deployment locations and ICS-technologies might deliver the highest impact on the SDGs. The tool will be released soon.

This briefing note describes the monetised 'shared value' (co-benefits) from ICS projects within the Gold Standard Foundation (GSF) portfolio, and maps these to the Sustainable Development Goals (SDGs). The analysis covers both fuel-efficient cookstove technologies and biogas installations for domestic use, deployed in developing countries. It only studies the economic value that is created by the GSF portfolio and does not consider the initial capital investment costs needed. It uses a methodology that combines third party research with a thorough analysis of GSF Project Design Documents and Monitoring Reports to come to an estimation of ICS impact through four impact channels. This methodology is then applied to the Gold Standard Foundation ICS portfolio to date.

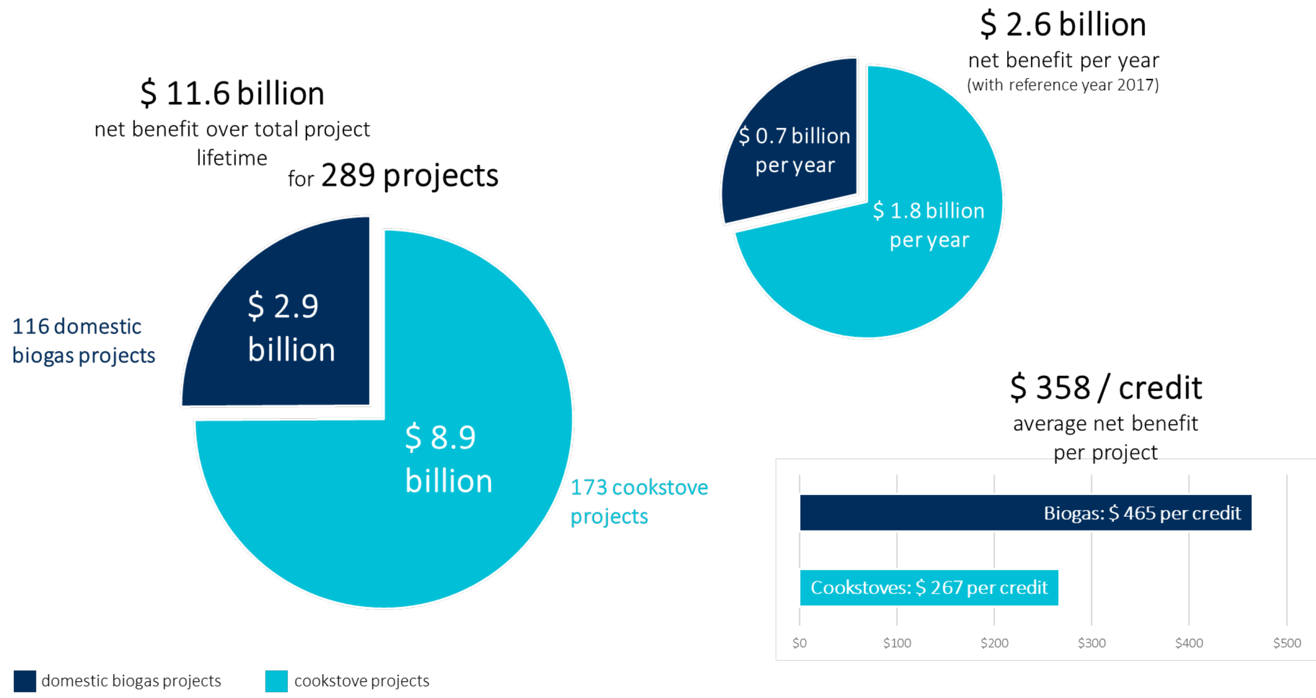
The net benefit of the GSF ICS portfolio adds up to $2.6 billion per annum (reference year 2017) and, to date, $11.6 billion over total project lifetime (Figure 1). The GSF ICS portfolio includes 289 projects that have issued credits.[3] About 60% of those are improved cookstove projects, which represent 75% of the total net benefit per year created by ICS projects. The other 40% are biogas projects, which represent 25% of the total net benefits created by ICS projects to date. The average net benefit per project is much larger for biogas projects than for cookstove projects. This is mostly due to the larger average health benefits ($199 per credit for biogas projects vs. $63 per credit for cookstove projects) and to a lesser extent to the larger average livelihood benefits (see Figure 4 for a deep dive of dollar value per impact channel). However, the average net benefit per project is higher for cookstoves than for biogas projects, which suggests that cookstove projects have issued many more credits per project (over total project lifetime).

[1] Putti, V.R., Tsan,M., Mehta, S., Kammila, S. (2015), *The State of the Global Clean and Improved Cooking Sector*

[2] Gold Standard Foundation (2014), *The real value of robust climate action: Impact investment far greater than previously understood*

[3] Subset of GSF ICS portfolio up to 01 June 2018. Of the total ICS portfolio, only projects with status "issued" (i.e. which have issued CO2 credits) were included in the valuation.

Figure 1 Gold Standard ICS projects have contributed billions of dollars in environmental and social benefits

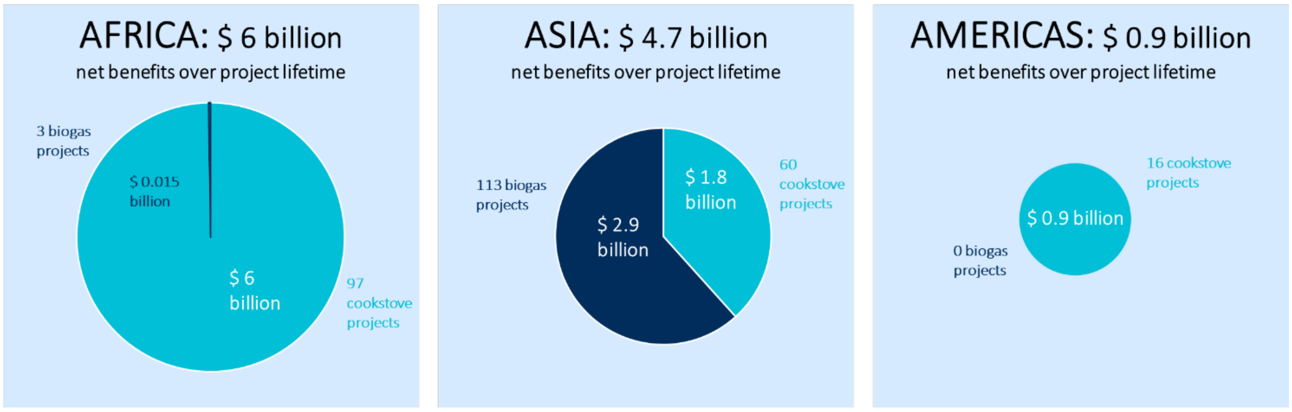


Note: Project lifetime is calculated from beginning of each individual project until 1 June 2018 (end of assessment period). $ values are given in 2017 USD.

Source: Vivid Economics

The highest net benefits to date ($6 billion over the project lifetime) have been realised in Africa (almost only cookstove projects) (Figure 2). Biogas projects are predominantly implemented in Asia, with a large number located in China (91 out of 116 total biogas projects).

Figure 2 Geographic distribution of Gold Standard ICS projects, in terms of net benefits over project lifetime, and number of projects



Note: $ values are given in 2017 USD

Source: Vivid Economics

Improved cooking solutions are an effective intervention for advancing the SDGs

Improved cooking solutions are crucial for achieving SDG7, but progress is slow. Despite advances on other SDG7 targets, there is little progress on improving access to improved cooking fuels and technologies.[4] There is a lack of incentives for consumers and producers to adopt improved cooking technologies, and current investment in the sector is a tiny fraction of the investment needed by 2030.[5,6] By their essence, ICS projects contribute to SDG7 (affordable and clean energy for all).

Apart from accelerating progress to SDG7, ICS projects are an effective intervention to contribute to other SDGs by delivering impacts across four main 'impact channels': climate, ecosystem, livelihood, and health. The analysis examines the impact of ICS projects on SDGs 13 (climate action), 15 (life on land), 1 (no poverty), 8 (decent work and economic growth) and 3 (good health and well-being). To demonstrate the contribution of projects to these SDGs, the analysis links the drivers of the impact channels that can be monetised based on relatively robust existing evidence to the most immediately relevant SDG target, and then to the overarching SDG goal (Figure 3). However, the deep interconnectedness of the SDGs and fundamental shift in household day-to-day activities that ICS projects bring about implies that the impacts goes beyond these primary SDGs, with manifold benefits extending out to SDGs 2 (zero hunger), 5 (gender equality) and 4 (quality education).

Figure 3 The ICS impact channels' contribution to the SDGs is demonstrated by linking the impact drivers to the most relevant SDG target

Impact area	ICS impact driver	Most relevant SDG-target	Corresponding SDG
Climate	tCO2equivalent reduced by the project (both Kyoto and non-Kyoto GHGs), and the social cost of carbon associated with that	Target 13.2: Integrate climate change measures into national policies, strategies and planning	Goal 13: Climate Action
Livelihood	Financial savings from avoided fuel purchase	Target 1.4: By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance.	Goal 1: No Poverty
	Time saved in cooking and collecting wood	Target 8.1: Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7 per cent gross domestic product growth per annum in the least developed countries	Goal 8: Decent work and economic growth
Ecosystem	Number of tons of wood saved by the project	Target 15.2: By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally.	Goal 15: Life on land
Health	Reduction of DALYs due to respiratory illnesses	Target 3.9 : By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.	Goal 3: Good health and well-being
Gender	Proportion of time saved in cooking and collecting wood for women, which can be redeployed for income-generating or non-income generating activities (household chores, time spent with family, etc.)	Target 5.4: Recognize and value unpaid care and domestic work through the provision of public services, infrastructure and social protection policies and the promotion of shared responsibility within the household and the family as nationally appropriate.	Goal 5: Gender equality
Education	Proportion of children that have more time to do homework and to attend school, due to reduction of time spent collecting fuel	Target 4.5: By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples and children in vulnerable situations.	Goal 4: Quality Education
Access to energy	Proportion of population with primary reliance on clean fuels and technology	Target 7.1: By 2030, ensure universal access to affordable, reliable and modern energy services	Goal 7: Affordable and clean energy

Source: Vivid Economics

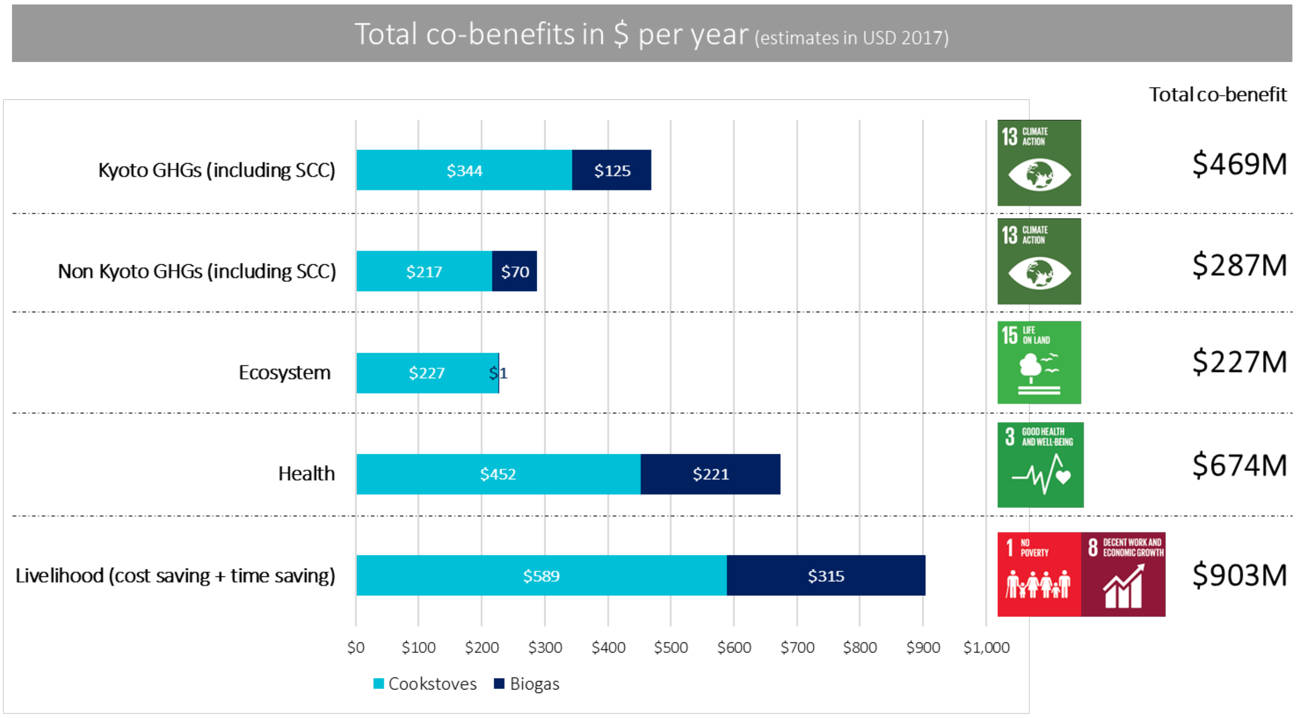
[4] IEA, IRENA, UNSD, WB, WHO (2019), *Tracking SDG 7: The Energy Progress Report 2019*
[5] International Energy Agency (2017), *Energy Access Outlook 2017*
[6] UN (2018), *Accelerating SDG7 achievement: policy briefs in support of the first SDG7 review at the UN high-level political forum 2018*

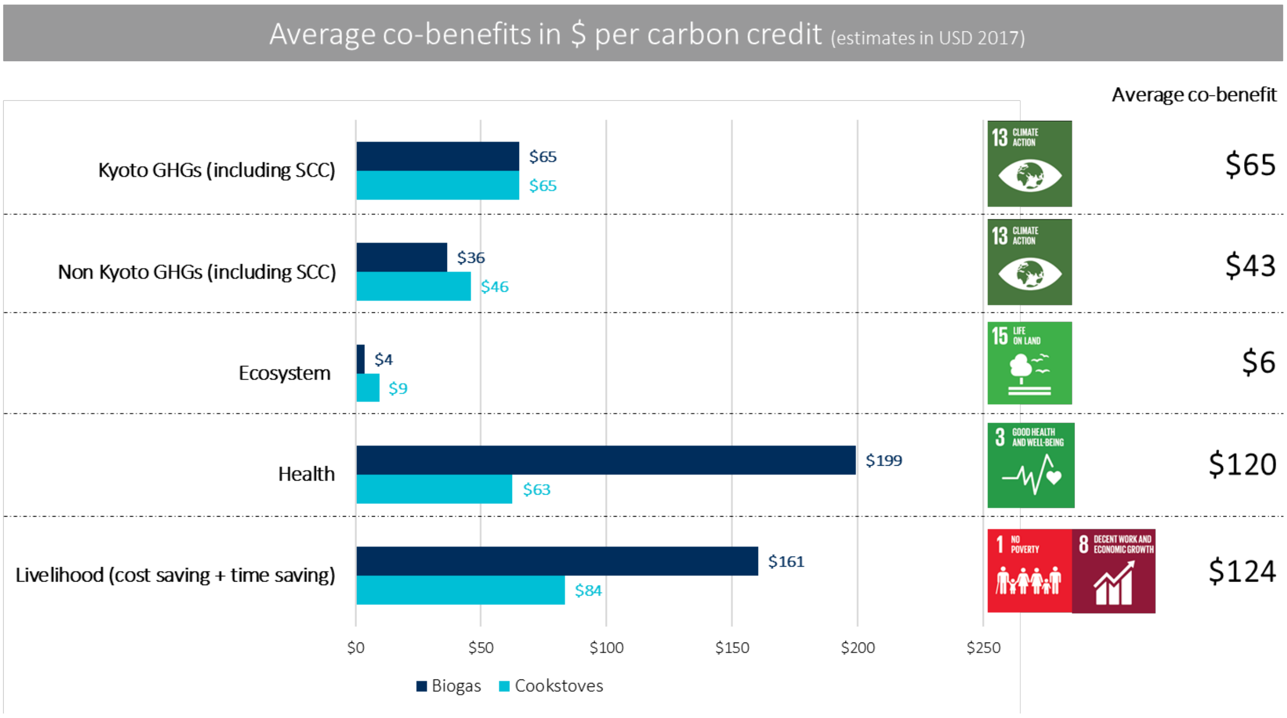
The analysis shows that the largest benefit for all projects combined are livelihood benefits (SDG1 and 8), totalling $903 million per year, followed by health benefits (SDG3) at $674 million per year (Figure 4). The livelihood benefits combine the cost savings (for example due to the reduction of charcoal needed), and the value of time savings from fuel collection and cooking. The health benefits of the GSF's ICS projects incorporate the monetary value of the reduction in household air pollution. The analysis assumes that ecosystem benefits accrue only for ICS projects that reduce the amount of wood used for charcoal, and the financial value of tropical forest that is consequently preserved.

As the monetised impact varies greatly across projects,[7] the co-benefits are also set out in terms of average $ impact per issued carbon credit, which provides a weighted average for the created value. Figure 4 demonstrates that, on average, livelihood and health benefits are almost equal in terms of added value per credit and dwarf the benefits accruing in the other impact channel.

[7] Depending on number of households targeted, the baseline situation, technology-fuel combination of the intervention, adoption rate and other contextual factors

Figure 4 Benefits of GSF ICS portfolio per impact channel, linked to the SDGs



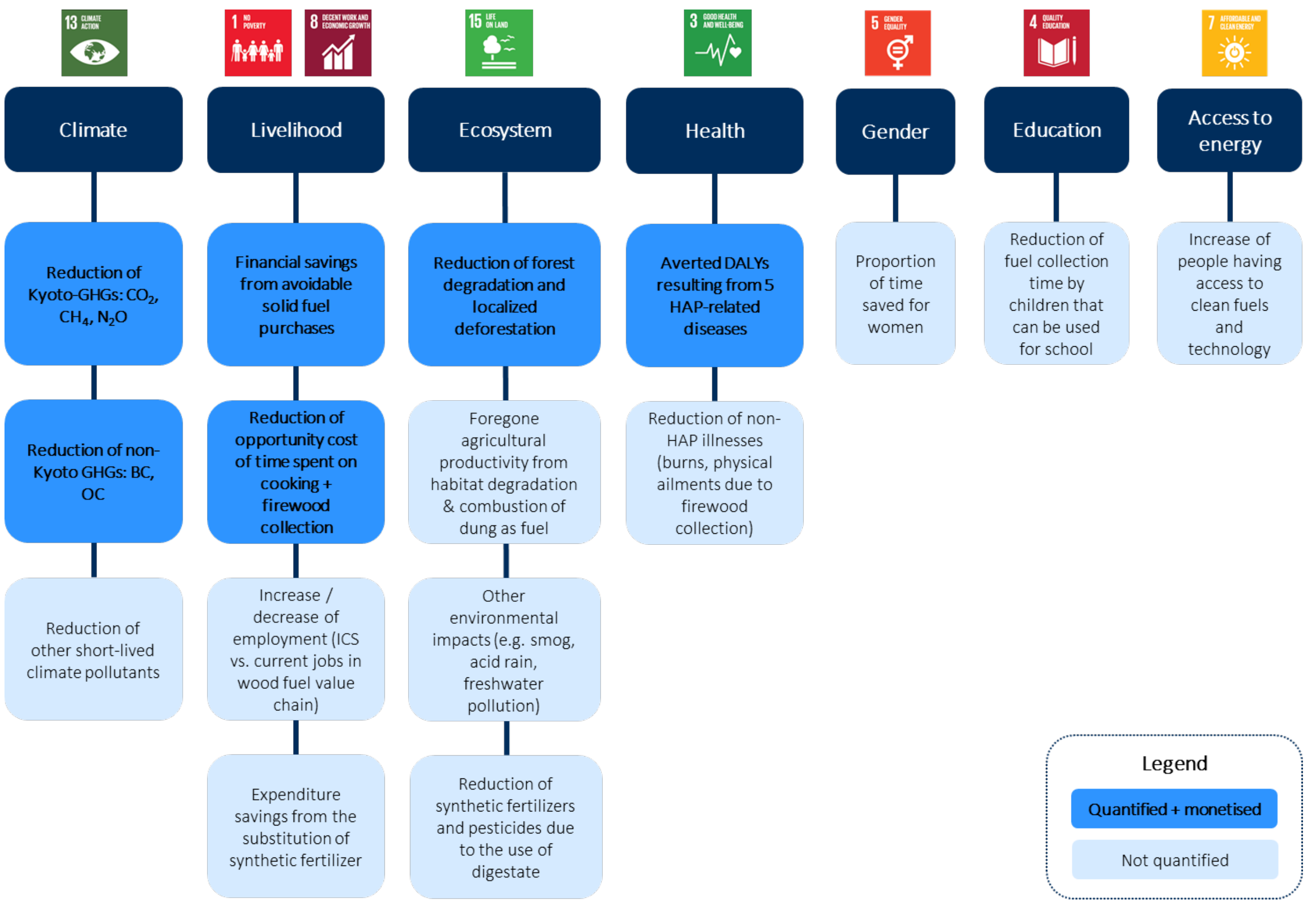


Note: SCC stands for social cost of carbon
Source: Vivid Economics

The methodology distinguishes and monetises four impact channels through which ICS projects advances the SDGs

The methodology covers four main 'impact channels' by which ICS deliver benefits: climate, ecosystems, livelihoods, and health, focusing on drivers that can be quantified and monetised based on relatively robust existing evidence (Figure 5). For example, the reduction in GHG emissions brought about by ICS can be quantified and the monetary value of those emissions reduction can be estimated, while broader environmental impacts like smog, acid rain and freshwater pollution are much harder to isolate and therefore quantify and monetise reliably per project. The methodology acknowledges other important impacts, such as gender, education and universal access to energy, but these are not taken into account in a quantitative manner, which means that the analysis should be treated as an underestimate of the true shared value. Gender impacts are not included in the analysis separately as they are already accounted for in the impact channels livelihood and health. ICS projects as a rule contributes to universal access to energy but the advantages of universal access are taken into account by all other impact channels. Education is not taken into account due to a lack of quantitative evidence and difficulties translating the evidence into meaningful impact value.

Figure 5 Quantified and monetised co-benefits of ICS projects accrue across four impact channels



Source: Vivid Economics

For the climate impact channel, the analysis distinguishes between the emission of Kyoto and non-Kyoto GHGs. Kyoto GHGs (CO_2, CH_4, N_2O) are included in the GS carbon credit methodologies and accounted for in the marketable value of the credit. Apart from Kyoto GHGs, the analysis includes the two most important non-Kyoto GHG contributors to baseline and project emissions: black carbon (BC) and organic carbon (OC).[8] To convert BC and OC emissions into CO_2 equivalents, we use 20-year global warming potentials (GWPs).[9] The value of a CO2 equivalent (CO2e) reflects the social cost of carbon (SCC), adopted from a recent US EPA study.[10]

Depending on the fuel type of the baseline scenario, the main livelihood impact driver from ICS is either the financial savings from reduced fuel purchases, or the saved time from less burdensome fuel collection and cooking. The analysis accounts for the possibility that the intervention scenario has both negative and positive livelihood impacts. For example, a switch from wood to charcoal has both positive livelihood impacts (because it saves wood collection time) and negative livelihood impacts (because charcoal has to be purchased). For financial savings, the analysis uses computed nominal average prices for key cooking fuels, disaggregated by region, where applicable adjusted for inflation and converted to 2017 $ using a GDP deflator. For saved time, the intervention scenario delivers a time efficiency relative to the baseline scenario (for both fuel collection and cooking). Conservatively, only 28% of time savings are assumed to be redeployed for income-generating activities.[11] The median income of each country represents the monetary value of the opportunity cost of time,[12] which reflects the fact that most ICS beneficiaries will tend to have a relatively low-medium income generating potential compared to others in the economy.[13]

The ecosystem impact channel reflects the value that ICS projects create by reducing the amount of wood used for charcoal, and the financial value of tropical forest that is consequently preserved. Generally, the collection of wood for domestic use leads to localised forest degradation rather than deforestation.[14] By contrast, charcoal production generally relies on cutting live trees from natural tree stands and therefore directly contributes to localised deforestation, as well as degradation. The FAO Global Forest Resources Assessment allows for conversion of forest volume to above-ground biomass, disaggregated by region.[15] The analysis uses estimates of the value of a range of ecosystem services[16] associated with forest in tropical zones.[17]

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[8] The literature suggests that advanced stove-fuel combinations could provide substantial climate benefits through reducing BC emissions, net of the change in OC emissions, but not in all cases. The BC and OC emission factors differ per technology-fuel combination. The analysis uses averages per technology-fuel combination based on the latest field research (if field test results were not available, we have used lab results).

[9] GWPs normalise the impact of a warming or cooling species to the equivalent impact of CO_2 over 20 years. The analysis uses 20 years (instead of 100) because a similar approach has been applied in previous studies (Garland et al., 2017; MacCarty, Ogle, Still, Bond, & Roden, 2008). The calculation is done as follows: mass CO_2 equivalent = (mass of pollutant) x (GWP). The GWPs for BC and OC are default factors published by the International Panel on Climate Change. and are applied over different geographies.

[10] Depending on which value is allocated to the social cost of carbon (SCC). The SCC is a measure, in dollars, of the long-term damage done by a tonne of CO2 emissions in a given year. In this analysis we have assumed a conservative value of $56/tonne of CO2e, which is the average 2015 number, using 2.5% discount rate, derived from a recent US EPA study which systematically compares and combines the estimates coming out of the three main integrated assessment models (DICE, FUND and PAGE) (US EPA, 2015).

[11] The opportunities for income-generation vary significantly across geographies, location of the household and the level of access to both formal and informal economic activities outside the household. 28% is based on a systemic review of household survey data from Africa and Asia (Putti, et al., 2015).

[12] As there is no reliable data for the bottom quartile of incomes or a similar metric, the analysis uses the median monthly income in each country, which was were calculated by the Center for Global Development, based on World Bank PovcalNet (global poverty database).

[13] Urmee and Gyamfi (2014), *A review of improved Cookstove technologies and programs*

[14] Most firewood supply for domestic use consists of dead material from non-forest sources, or from plantations. Even firewood that does come from forests, if it is not already dead material, is usually collected from small understory trees or shrubs. This implies that, even if the absolute amount of wood collected for domestic cooking use may be large, it is not generally causing deforestation (Putti, et al., 2015; Morton, 2007). However, it can cause forest degradation, defined as a human-induced reduction in forest carbon stocks from the natural carbon carrying capacity of forest ecosystems, without a net reduction of forest area.

[15] FAO (2000), *Global Forest Resources Assessment 2000*

[16] Specifically: water provisioning, regulating services including air quality, disturbance moderation, regulation of water flows, waste treatment, erosion prevention, nutrient cycling, pollination and biological control, excluding climate regulation, and habitat services nursery service and gene pool protection. de Groot, et al. (2012), *Global estimates of the value of ecosystems and their services in monetary units*

[17] The FAO's Global Ecological Zones suggests that the vast majority of GSF projects take place in tropical zones.

For the health impact channel, this analysis calculates the risk of disease, at a given pollution exposure, before and after the project, using the HAPIT 3.1.1 tool.[18] ICS projects can substantially reduce household air pollution (HAP) from solid fuel cooking, an important source of disease and mortality in developing countries primarily among women and children.[19] In order to calculate the risk of disease, the HAPIT tool gives the number of averted Disability-Adjusted Life Years (DALYs) as output, only including the diseases with the highest correlation between HAP and risk of disease.[20] One DALY can be thought of as one lost year of "healthy" life. The value of a DALY is then calculated on the basis of the human capital approach, using 1.5 times GDP per capita,[21] disaggregated by country.

As baseline scenarios vary greatly across ICS projects, the valuation approach of the GSF portfolio and the forward-looking tool allow for variety of baseline scenarios across the key determinants. The region in which a project is situated influences the types of fuel available prior to ICS intervention; whether fuel needs to be gathered or can be bought; and which food is cooked, which in turn determines which baseline cookstove technology type used prior to the ICS project intervention. These factors then collectively determine the emission profiles of the baseline scenario. This variation in baseline takes account of an extensive literature review corroborated with information in the GSF portfolio of cookstove and biogas projects.[22]

The analysis takes user behavioural factors into account. Behavioural factors are crucial aspects that influence the improved cooking solutions' effectiveness.[23] The analysis builds on primary evidence from the GSF Project Design Documents and Monitoring Reports to incorporate the most important behavioural factors (that vary by project): drop off rate,[24] leakage[25] and continued use of baseline technology next to the project ICS (often referred to as "stacking").

In general, the principle of conservativeness has been applied across all impact channels. If multiple alternatives or a range of values were available in terms of assumptions and inputs, the analysis typically opts for the conservative option, so as to reduce the risk of overestimating impact.

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[18] https://hapit.shinyapps.io/HAPIT/. More details on the exact methodology used in HAPIT can be found in Pillarisetti, A; Mehta, S; Smith, KR. (2016), *HAPIT, the Household Air Pollution Intervention Tool, to evaluate the health benefits and cost-effectiveness of clean cooking interventions*

[19] Smith, K. R., Bruce, N., Balakrishnan, K., Adair-Rohani, H., Balmes, J., Chafe, Z., et al. (2014). *Millons Dead: How do we know and what does it mean? Methods used in Comparative Risk Assessment and Household Air Pollution*

[20] Household air pollution causes a range of diseases, including chronic obstructive pulmonary disease, ischemic heart disease, stroke, and lung cancer in adults and acute lower respiratory infection in children.

[21] Most public agencies have only qualitative views on the value of DALYs. However, in health economics the human capital approach to value a DALY or QALY (quality-adjusted life-year) is most commonly used to compare costs and benefits. This approach amounts to multiplying the estimated DALYs by approximately 1-3 times the GDP per capita of the country, reflecting estimates of "societal willingness to pay" (ICER, 2018; Marseille, Larson, Kazi, Kahn, & Rosen, 2015). Under this approach, promoted by the World Health Organization, a health project that costs less than 3 times the national annual GDP per capita is considered cost-effective (WHO-CHOICE program: Cost effectiveness and strategic planning). Given the general principle of conservativeness, the analysis uses 1.5 times the GDP per capita to valuate a DALY.

[22] There may be other factors that influence the baseline situation, for example variation in the end use of the technology (commercial, household or institutional cooking). However this study focuses on household cooking only and discounts other usage types as the GSF portfolio includes only a very small number of other activities. In the forward-looking tool the project developer can account for this if this information is available.

[23] ESMAP (2015), *Beyond Connections: Energy Access Redefined*; Hanna, R., Duflo, E., Greenstone, M. (2016), *Up in Smoke: The Influence of Household Behavior on the Long-Run Impact of Improved Cooking Stoves*

[24] The percentage of people to which the project ICS is disseminated but are expected not to use the project ICS. The drop-out rate is often interchanged with usage rate, which can be calculated as: 1 – DO rate (or vice versa).

[25] The percentage of project leakage, e.g. due to giving away the old cookstove to family or neighbours or using cookstove for gatherings

Working on a better understanding of the impact of ICS projects

This analysis builds on the latest evidence and research on improved cooking solutions to understand the $ contribution of GSF projects to the SDGs. Earlier work commissioned by the Gold Standard Foundation estimated a total of $231 million co-benefits per year for GSF's ICS portfolio, with $177 million in livelihood benefits and $84 million in health benefits.[26] This translated into $96 per carbon credit for livelihood, and $55 for health co-benefits. Table 1 gives an overview of the two different studies, outlining the reasons for the large differences in impact valuation between the previous and this analysis.

Table 1 Comparison between this analysis and the earlier impact valuation work commissioned by the GSF

	This analysis	Earlier impact valuation work by GSF (2014)[27]
Scope	289 projects included (all projects that issued credits), both cookstove and domestic biogas up to 1 June 2018. $ impact estimates given in 2017 $	34 cookstove and 13 biogas projects included. Only projects that issued credits as of January 2014 were valued. $ impact estimates are given in 2013 $
Granularity	• Regional disaggregation is included for all impact channels • Both baseline and intervention scenario impact is disaggregated for different technology-fuel combinations across all impact channels	• No regional disaggregation • No disaggregation for different technologies or fuel types
Climate	Includes both valuation of Kyoto GHGs (CO_2, CH_4, N_2O) and non-Kyoto GHGs (black carbon and organic carbon), using the social cost of carbon to value a tonne of CO_2-equivalent	Does not include climate benefits
Livelihood	• Includes financial savings from reduction of fuel use and opportunity cost from reduced time needed for collecting firewood and cooking • Does not include employment benefits.[28]	• Only financial savings incorporated in valuation (with indicator of financial savings based on 6 projects out of 34) • Reduction of time spent collecting firewood only used in 1 case study, assuming 50% of time spent for income-generating activities • Reduction of cooking time not included • Includes employment benefits, using increased job count data reported by project developers
Ecosystem	Includes value of ecosystem services (as a result of reduced amount of wood needed for charcoal production)	Does not include ecosystem benefits
Health	• Includes both valuation of reduced mortality and reduced illness, using averted Disability-Adjusted Life Years • Builds on HAPIT tool, enabling the calculation (per project) of the risk of disease, at a given pollution exposure, before and after the project	Includes reduced mortality as a result of respiratory illnesses, assuming: • A linear relationship between PM2.5 increase and the risk to health of those exposed). "Exposure-response" function applied to all cookstove projects was extrapolated from one specific project in Ghana for a typical type of cookstove (52% reduction in PM2.5 levels) • Cookstoves used outdoors deliver 25% of the health benefit delivered by improved indoor cookstoves, and mixed indoors/outdoors deliver 50% • 3 people per household impacted (where families are typically larger)

Source: Vivid Economics

[26] Gold Standard Foundation (2014), *The real value of robust climate action: Impact investment far greater than previously understood*
[27] Gold Standard Foundation (2014), *The real value of robust climate action: Impact investment far greater than previously understood*
[28] Although increases in employment are reported by some GSF project developers and several independent studies, it is difficult to isolate this impact. While jobs may be created by the ICS value chain, for example in manufacturing, there may be a negative impact on the current wood/charcoal value chain as jobs are lost there. This reflects the informality of the wood fuel value chain where economic data is often not recorded.

More research is needed to improve the understanding of the impact of ICS projects. Although this analysis incorporates a broader set of impact channels and allows for more granularity, there are still many aspects of the complex system of cooking that are not captured sufficiently in this methodology. For instance, as more granular primary data is collected, it might be possible to robustly quantify and monetise some of the currently non-quantified drivers set out in Figure 5. There is also some evidence of the impact of ICS projects in refugee camps, which found that ICS interventions have had measurable success in reducing women's fuel collection trips, which, as well as time and distances travelled, reduces exposure to the risk of gender-based violence.[29] Furthermore, the adoption, use and impact of an ICS intervention is greatly dependent on household decision-making and in particular how women's preferences and welfare are reflected in those decisions.[30] As insight on the dynamics of adoption of ICS interventions increases and technology and fuel types evolve, this valuation methodology will need to be updated.

[29] GACC (2014), *Statistical Snapshot: Access to Improved Cookstoves and Fuels and its Impact on Women's Safety in Crises*. An evaluation of the Dadaab firewood project in Kenya found that during the days households were fully supplied with firewood there was a decrease of 45.2% of rapes while collecting firewood, while overall frequency of reported rape during the coverage period decreased between 0-10%. UNHCR (2011), *Evaluation of the Dadaab Firewood Project, Kenya*

[30] Köhlin, Sills, Pattanayak and Wilfong (2011), *Energy, Gender and Development What are the Linkages? Where is the Evidence?*

Company profile

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We are a premier consultant in the policy-commerce interface and resource- and environment-intensive sectors, where we advise on the most critical and complex policy and commercial questions facing clients around the world. The success we bring to our clients reflects a strong partnership culture, solid foundation of skills and analytical assets, and close cooperation with a large network of contacts across key organisations.

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