Document of
The World Bank

FOR OFFICIAL USE ONLY

Report No: 111769-RW

PROJECT APPRAISAL DOCUMENT

ON A

PROPOSED CARBON FINANCE TRANSACTION

IN THE AMOUNT OF US$7.65 MILLION

TO THE

REPUBLIC OF RWANDA

FOR AN

IMPROVED COOKSTOVES PROJECT (P158411)
February 21, 2017

Environment and Natural Resources Global Practice
Africa Region

CURRENCY EQUIVALENTS
(Exchange Rate Effective December 1, 2016)

Currency Unit	=	Rwandan franc (RWF)
RWF	=	US$ 0.001202
US$	=	RWF 832.090

FISCAL YEAR
July 1 – June 30

ABBREVIATIONS AND ACRONYMS

ACCES	Africa Clean Cooking Energy Solutions Initiative
ALRI	Acute Lower Respiratory Infections
BFP	Biomass Fuel Pellet
BIX	Bottom of Pyramid Impact Exchange Fund
BoP	Base of the pyramid (lowest income group)
CDM	Clean Development Mechanism
CER	Certified Emissions Reduction
Ci-Dev	Carbon Initiative for Development
CME	Coordination and Managing Entity
CPS	Country Partnership Strategy
DALY	Disability Adjusted Life Year
DHRI	DelAgua Health Rwanda Implementation
EEP	Energy and Environment Partnership
EDPRS	Economic Development and Poverty Reduction Strategy (of Rwanda)
ERPA	Emissions Reductions Purchase Agreement
ESMAP	Energy Sector Management Assistance Program
GDP	Gross Domestic Product
GHG	Greenhouse gas
HAP	Household air pollution
HH	Household/s
ICS	Improved cook stove
Km^2	Square kilometers
LSHTM	London School of Hygiene and Tropical Medicine
LPIP	Local Program Implementation Partner
MOH	Ministry of Health
MOU	Memorandum of Understanding
MRV	Monitoring Reporting and Verification
NDP	National Development Plan for 2015-1019
OP	Operational Policies of the World Bank
PDO	Program Development Objective
PoA	Program of Activities
PM 2.5	Particulate matter with diameter less than 2.5 µm
REDD+	Reducing emissions from deforestation and forest degradation, and the role of

	conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries
REG	Rwanda Energy Group
R-PP	Readiness Preparation Proposal
SADC	Southern African Development Community
SCD	Systematic Country Diagnostic
SORT	Systematic Operations Risk Rating Tool
SSA	Sub-Saharan Africa
UNFCCC	United Nations Framework Convention on Climate Change

Regional Vice President:	Makhtar Diop
Country Director:	Diarietou Gaye
Senior Global Practice Director:	Karin Kemper
Practice Manager:	Magda Lovei
Task Team Leaders:	Stephen Ling, Svetlana Khvostova, Kirtan Sahoo
Deal Manager:	Affouda Leon Biaou/Xiaoyu Chang

REPUBLIC OF RWANDA
Improved Cookstoves Project

TABLE OF CONTENTS

PAD DATA SHEET

REPUBLIC OF RWANDA

Improved Cookstoves Project (P158411)

PROJECT APPRAISAL DOCUMENT

AFRICA

Report No.: 111769-RW

Basic Information			
Project ID	EA Category		Team Leader(s)
P158411	B - Partial Assessment		Stephen Ling Svetlana Khvostova (Co-TTL) Kirtan Sahoo (Co-TTL)
Lending Instrument	Fragile and/or Capacity Constraints [ ]		
Carbon Offset	Financial Intermediaries [ ]		
	Series of Projects [ ]		
Project Implementation Start Date	Project Implementation End Date		
February 17, 2017	Implementation ends in December 2021, carbon finance payment ends in 2024		
Expected Effectiveness Date	Expected Closing Date		
March 1, 2017	December 31, 2024		
Joint IFC: No			
Practice Manager	Senior Global Practice Director	Country Director	Regional Vice President
Magda Lovei	Karin Kemper	Diarietou Gaye	Makhtar Diop

Approval Authority
Approval Authority: Country Director : Diarietou Gaye
Borrower: Not applicable Host Country: Republic of Rwanda
Responsible Agency: DelAgua and Inyenyeri

Contact Person: Eric Reynolds Telephone No.: +250787484974 Contact Person: James Beaumont Telephone No.: +44 7879 844 899	Fax No.: Email: eric.reynolds@inyenyeri.org Fax No.: Email: james.beaumont@delagua.org

Project Financing Data (in US$, millions)

[ ]	Loan	[ ]	IDA Grant	[ ]	Guarantee
[ ]	Credit	[ ]	Grant	[X]	Other (Carbon Finance)

Total Project Cost:	27.65	Total Bank Financing:	7.65
Financing Gap:	0.00		

Financing Source	**Amount**
Carbon Initiative for Development (Ci-Dev) Carbon Finance[1] :	7.65
Inyenyeri (Private Company)	
Equity Contribution (Series A investors)	5.00
Grant (EEP Africa)	0.50
Loan from various sources (including BIX Fund)	8.50
DelAgua Health Rwanda (Private Company)[2]	
Equity Contribution (Signina Capital AGmVK)	4.00
Loan from Commercial Banks	2.00
Total	27.65

Expected Disbursements (in US$)

	FY17	FY18	FY19	FY20	FY21	FY22	FY23	
Annual	0.00	130,356	692,634	1,614,420	2,251,726	2,251,726	709,137	
Cumulative	0.00	130,356	822,991	2,437,410	4,689,137	6,940,863	7,650,000	

[1] Ci-Dev money is paid upon delivery of carbon credits and is used as a revenue stream rather than an upfront investment.

[2] For its overall business target, DelAgua is mobilizing US$35 million in equity and US$20 million in debt. As Ci-Dev is considering to support 200,000 stoves out of about 1.48 million stoves, the amount in this PCN is pro-rated accordingly.

Institutional Data

Practice Area (Lead)

Environment and Natural Resources (GENDR)

Contributing Practice Areas

Energy (GEEDR) and Health (GHNDR)

Cross Cutting Topics

[X] Climate Change

[ ] Fragile, Conflict & Violence

[X] Gender

[ ] Jobs

[ ] Public Private Partnership

Sectors / Climate Change

Sector (Maximum 5 and total % must equal 100)

Major Sector	Sector	%	Adaptation Co-benefits %	Mitigation Co-benefits %
Energy and mining	Other Renewable Energy	100	–	100%
Total		100	–	–

☐ I certify that there is no Adaptation and Mitigation Climate Change Co-benefits information applicable to this project.

Themes

Theme (Maximum 5 and total % must equal 100)

Major theme	Theme	%
Environment and natural resources management	Climate Change	50
Environment and natural resources management	Pollution management and environmental health	25
Gender	Gender	25
Total		100

Proposed Development Objective(s)

The project development objective is to reduce the use of woody biomass for cooking in targeted households.

Components

Component 1: Introduce Advanced Cook Stove Technology and standardized fuel to replace inefficient charcoal and wood	**US$19.65 millions**

Component 2: Scaling up Intermediate Cookstove Technologies in Rural area	**US$8.0 million**
TOTAL	**US$27.65 million**

Systematic Operations Risk- Rating Tool (SORT)	
Risk Category	**Rating**
1. Political and Governance	Low
2. Macroeconomic	Moderate
3. Sector Strategies and Policies	Low
4. Technical Design of Project	Moderate
5. Institutional Capacity for Implementation and Sustainability	Low
6. Fiduciary	Low
7. Environment and Social	Low
8. Stakeholders	Substantial
9. Other	Moderate
OVERALL	**Moderate**

Compliance		
Policy		
Does the project depart from the CAS in content or in other significant respects?	Yes [ ]	No [X]
Does the project require any waivers of Bank policies?	Yes [ ]	No [X]
Have these been approved by Bank management?	Yes [ ]	No [ ]
Is approval for any policy waiver sought from the Board?	Yes [ ]	No [X]
Does the project meet the Regional criteria for readiness for implementation?	Yes [X]	No [ ]

Safeguard Policies Triggered by the Project	**Yes**	**No**
Environmental Assessment OP/BP 4.01	X	
Natural Habitats OP/BP 4.04		X
Forests OP/BP 4.36	X	
Pest Management OP 4.09		X
Physical Cultural Resources OP/BP 4.11		X
Indigenous Peoples OP/BP 4.10		X
Involuntary Resettlement OP/BP 4.12		X
Safety of Dams OP/BP 4.37		X
Projects on International Waterways OP/BP 7.50		X

Projects in Disputed Areas OP/BP 7.60		X

Legal Covenants

Name	Recurrent	Due Date	Frequency
Condition for payment (to be detailed in the Emissions Reductions Purchase Agreement)	X	June 1 of each calendar year	Annual

Description of Covenant
Monitoring, reporting and verification of Certified Emissions Reductions generated in accordance with provisions of the Design Documents and an agreed Operations Manual.

Conditions

Name	Type

Description of Condition

Team Composition

Bank Staff

Name	Role	Title	Specialization	Unit
Stephen Ling	Task Team Leader (ADM Responsible)	Senior Natural Resources Management Specialist	Natural Resources Management	GEN01
Kirtan Sahoo	Co-Task Team Leader	Senior Carbon Finance Specialist	Carbon Finance	GCCCF
Svetlana Khvostova	Co-Task Team Leader /Environmental Safeguards Specialist	Natural Resources Management Specialist	Natural Resources Management	GEN01
Xiaoyu Chang	Deal Manager	Carbon Finance Analyst	Carbon Finance	GCCCF
Belinda Mutesi	Team Assistant	Program Assistant	Team Assistant	AFMRW
Ian Muir	Team Member	Consultant	Energy Specialist	GEN01
Inka Schomer	Gender Specialist	Operations officer	Gender Specialist	GCGDR
Tharcisse Musabyimana	Social Safeguards Specialist	Consultant	Social Development	GSURR
Rui Liu	Team Member	Consultant	Health	GHNDR

Locations

Country	First Administrative	Location	Planned	Actual	Comments

	Division				
Rwanda		Kigali, Eastern Province and three districts across the Western Province, namely Rubavu, Nyabihu and Musanze	–	–	–
Consultants (Will be disclosed in the Monthly Operational Summary) NO					

I. STRATEGIC CONTEXT

A. Country Context

1. Rwanda has a strong record of robust GDP growth, with a GNI per capita of US$700 (2015), but the country still ranks amongst the poorest in the world with high levels of vulnerability. It is a small land-locked country of 26,338 km^2 in area and a population of 11.7 million people (national census, 2012). It is densely populated in comparison to other African countries: at 480 people per km^2, population density is similar to the Netherlands and South Korea (World Bank statistics). Even though population growth has come down substantially over the past fifteen years, with a projected 2.5% annual growth rate according to the United Nations, Rwanda will need to accommodate roughly 7.8 million additional people by 2030, underscoring the importance of introducing environmentally friendly technologies.

2. Strong policies have helped Rwanda achieve outstanding economic progress and introduce progressive reforms in various sectors. Prudent fiscal and monetary policies geared towards maintaining macroeconomic stability, coupled with an emphasis on building institutional capacity, promoting good governance, and creating a business-friendly environment, contributed to low inflation and average annual economic growth above 8% over the last decade. Rwanda's macroeconomic performance has generally outperformed its regional peers and earned the country a spot on the list of the 10 fastest-growing economies in the world, and has recently been ranked the seventh most efficient government globally (Global Competitive Report, 2014-2015). The country has also made important strides in poverty reduction and is introducing reforms to strengthen its social protection system by expanding coverage and improving efficiency to reach more vulnerable groups. The country-defined poverty rate fell from 59 to 45% during the previous decade and extreme poverty dropped from 40 to 24%.

3. The decrease in poverty has also been assisted by large-scale social protection programs, particularly the flagship Vision 2020 Umurenge Program, which reaches a growing number of poor and vulnerable households through cash transfers, public works and microcredit loans. Targeting of government social assistance programs is based on the Ubudehe system of categorizing household by relative poverty.

4. Population and economic growth is leading to rapidly increasing demand for energy and relative scarcity of natural resources. Energy demand growth is particularly being felt in the biomass sector (the dominant energy source for the country), where sustainable production of wood fuel has been assessed to fall short of consumption. Rwanda lost 37% of its forest cover (around 117,000 ha) between 1990 and 2010.[3] Recent efforts by the government to increase tree cover appear to be having positive results, but outside of a small number of protected areas, only tiny fragments of natural forest remain.

[3] Sustainable Energy for All, Rapid Assessment Gap Analysis for Rwanda, November 2014.

B. Sectoral and Institutional Context

5. More than 700 million Africans (82%) use solid fuels for their primary cooking needs, a number that is expected to reach 850-950 million by the end of the decade. This high level of solid fuel use combined with household reliance on inefficient and unsafe traditional cookstoves cause a first order public health crisis: Household air pollution (HAP) from solid fuel cooking emissions kill nearly 600,000 Africans annually, especially affecting women and children, and is now recognized as the second largest risk factor for death and disability in the region. Solid fuel cooking also imposes significant costs on African households and economies, with a mid-range estimated opportunity cost of 3% of regional annual GDP – including avoidable spending on solid fuels, productivity losses due to firewood collection, economic costs of increased mortality and morbidity, and the environmental and climate costs of deforestation and carbon emissions. While the negative health impact of solid fuel based cooking is well understood with clear evidence methodologies for evaluating the positive health impacts of cleaner cooking interventions, especially interventions focusing on improved cookstoves are still evolving.

6. Africa has a significantly lower rate of access to clean and improved cooking solutions (about 25%) than any other region globally. The clean and improved cooking sector in Sub-Saharan Africa (SSA) has evolved significantly but is still highly underdeveloped. Only 11% of Africans use clean stoves that run on modern fuels like LPG (5%), or electric stoves (6%). Stoves that run on renewable fuels like biogas, ethanol and solar are uncommon (less than 1%). A growing number of SSA households (about 3.5%) use intermediate improved cook stoves (ICS, e.g. rocket stoves) which are more fuel efficient than traditional 3-stone stoves, and contribute to PM 2.5 emissions reductions needed to realize health benefits. Another 9-10% of SSA households have access to both basic ICS and legacy cookstoves that offer only moderate improvements in fuel efficiency and emissions reductions over traditional cooking technologies. Although no biomass cookstove technology eliminates or even addresses the majority of the burden of disease from biomass smoke exposure, many ICS can reduce the burden of disease cost-effectively, achieving a discernible improvement over the traditional 3-stone stoves widely used by the rural poor. The performance of biomass stoves are rated for efficiency, emissions and safety according to tiers established by a working group of the International Organization for Standardization, from tier 0 (roughly equivalent to traditional 3-stone fires) to tier 4 (equivalent to non-biomass, clean stoves).[4] Penetration of advanced biomass gasifier cookstoves that may come close to reaching tier 4 performance is still at an incipient stage (i.e. less than 0.1% of households).

7. Wood (biomass) is the dominant household fuel in Rwanda, accounting for 93% of fuel use in rural areas and 45% in urban zones, with charcoal accounting for another 51%. This huge dependence on wood fuels mainly for cooking causes major health issues and deforestation. Over 80% of the country's firewood and charcoal, mainly for urban areas, is currently believed to come from Eucalyptus trees in artificial and dedicated plantations and agro forestry programs. However, estimates of sustainable harvest of biomass vary considerably. According to a 2012 report by the Global Alliance, the annual demand for woody

4 Global Alliance for Clean Cookstoves, IWA Tiers of Performance: http://cleancookstoves.org/technology-and-fuels/standards/iwa-tiers-of-performance.html; see Annex 6 for more details.

biomass in Rwanda is estimated at 2.9 Mt, which is more than double the available sustainable production of 1.1 Mt.[5] A World Bank report[6] cites the estimated sustainable wood-fuel supply as between 1.5 and 2.5 million ton/year or 55 to 95% of demand. The UNFCCC[7], estimates the nonrenewable fraction of the biomass at 98%, pointing to very high unsustainable harvest of biomass. Although estimates of sustainable biomass supply are increasing (with higher resolution remote-sensing imagery, and perhaps with increased silviculture), the high dependence on wood, rapidly growing population and limited land resources undoubtedly mean that the sustainability of wood fuel production remains a serious concern. Prices of charcoal in Rwanda have also increased rapidly, generating negative spillover effects on the urban economy, and suggesting that all wood fuel production may be more costly.

8. The potential market for improved cookstoves in Rwanda is estimated at about 2.4 million households. In the past, the Rwandan Army installed basic cookstoves in many rural households. More recently, ceramics cooperatives in several parts of the country have been trained to produce an improved wood-burning stove, locally referred to as *canarumwe*. Despite being sold for only a few dollars, the demand for canarumwe stoves remains modest. Their performance and longevity are low, and the small profit margins don't give cooperatives an incentive to invest in quality improvement. Although it is claimed that about 50% of households have adopted some form of improved cookstoves (ICS), the actual performance of these ICS in energy savings and other benefits vary considerably and most are only marginally better, if at all, than traditional 3-stone open fires and traditional metal charcoal stoves.[8] However, more recent designs of ICS have better efficiency, durability and usability, and a large potential demand has been assessed in market surveys.

9. From the health perspective, evidence is robust and compelling: exposure to household air pollution (HAP) is responsible for a staggering number of preventable illnesses and deaths each year. Epidemiological studies have established exposure-response relationships between inhalation of particulate matter, carbon monoxide, and other harmful products of incomplete combustion of bio-fuel cooking, and diseases including acute lower respiratory illness and pneumonia, chronic obstructive pulmonary disease and lung cancer, and ischemic heart disease. Particulate matter of less than 2.5 micrometers in diameter ($PM_{2.5}$) is the primary cause of health problems from household air pollution, followed by carbon monoxide in an increasing number of studies. Evidence is also growing on the relationship between biomass smoke exposure and cerebrovascular disease, premature and underweight births, cataracts, deteriorated eyesight, asthma, tuberculosis, adverse pregnancy outcomes, pediatric sleep disorders, bacterial meningitis, depression and headaches. Physical injuries, substantial time and additional nutritional demands associated with firewood collection, and burns from open fires add to the negative health impact of traditional cooking practices. The World Health Organization (WHO) estimates that exposure to smoke from cooking fires is the fourth leading risk factor for disease in developing countries, and causes 4.3 million premature deaths per year – exceeding deaths attributable to malaria or tuberculosis. In addition, tens of millions more fall

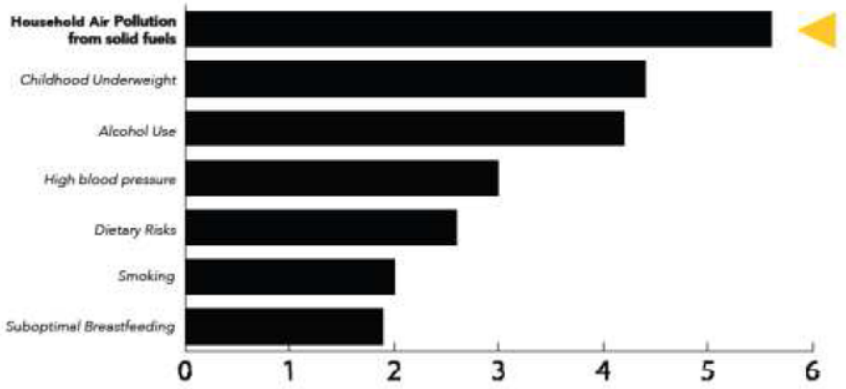
[5] Global Alliance for Clean Cookstoves Rwanda Market Assessment Sector Mapping April 2012
[6] Feasibility Study for Establishing a Green Charcoal Value Chain in Rwanda, World Bank,2012.
[7] https://cdm.unfccc.int/DNA/fNRB/index.html.

[8] Rwanda Market Assessment Sector Mapping (April 2012), Accenture Development Partnerships

sick with illnesses that could be prevented with improved adoption of clean and efficient cookstoves and fuels. Cleaner burning more efficient cookstoves can help alleviate some of this huge burden, and the associated costs of health care, productivity loss, and reduced quality of life.

10. With more than 95% of the total population using biomass fuel for cooking, HAP exposure is the leading behavioral health risk factor in Rwanda and accounts for nearly 6% of the total burden of illness (Figure 1). Rwanda has one of the highest incidence of HAP-related morbidity in Sub-Saharan Africa, at 63 HAP-associated Disability Adjusted Life Years (DALYs)[9] per 1000 people. The risk to health damage from widespread use of harmful cooking technologies and fuel types is intensified by cooking behavior – notably, a relatively higher tendency than in many other SSA countries to cook indoors in unventilated kitchens. Studies in Rwanda, provide estimates that there are from 5,680 deaths a year related to household air pollution, 94% of which are children[10], to around 12,500 deaths and 493,000 DALYs are attributable to solid fuel use.[11] Respiratory and other illnesses caused by HAP reduce productivity and quality of life, generate costs for health system, and result in additional demands on health personnel. The relatively high number of DALYs and deaths attributable to HAP present a strong case for cleaner cookstove interventions in Rwanda.

Figure 1: Top Seven Behavioral Health Risk Factors by Contribution to Disability Adjusted Life Years in Rwanda



DALY: number of years lost due to ill-health, disability or early death
Source: Global Burden of Disease Country Profile: Rwanda
http://www.healthdata.org/sites/default/files/files/country_profiles/GBD/ihme_gbd_country_report_rwanda.pdf

11. Efficient cookstoves also improve household welfare by reducing the time and energy burden of biomass collection and supporting better nutrition by enabling more food to be cooked when fuel is scarce. The burden of biomass collection is reduced both by reducing fuel needs by half to three quarters, and because a greater range of biomass can be burnt efficiently in many improved stoves, making usable fuels of crop residues and small twigs, which are available closer to village communities. Introduction of cookstoves by community

[9] One DALY can be thought of as one lost year of "healthy" life. The sum of these DALYs across the population, or the burden of disease, can be thought of as a measurement of the gap between current health status and an ideal health situation where the entire population lives to an advanced age, free of disease and disability. (Source: World Health Organization (WHO): http://www.who.int/healthinfo/global_burden_disease/metrics_daly/en/).
[10] Global Burden of Disease Report, 2010.
[11] Global Alliance for Clean Cookstoves, Rwanda Market Assessment, Sector Mapping.

health and agricultural workers offers an opportunity to combine awareness raising and nutritional support to promote behavior change and support sustained use.

12. The benefits of reduced exposure to toxic pollutants, and other health and welfare impacts from use of biomass stoves, accrue predominantly to women and young children, who are responsible for most cooking and biomass collection. Women and girls spending two or more hours a day gathering wood suffer from chronic muscle and spinal strain from the burden of carrying wood over long distances, and may be subject to physical abuse and other risks while walking alone. Reduced risks, as well as productivity gains for women and time freed up to attend school for girl children are important outcomes of fuel-efficient cookstoves. ICS interventions also present an opportunity for female empowerment engagement in stove design, household purchase decision making and income-generating opportunities along the value chain. A recent study commissioned by the Global Alliance for Clean Cookstoves [12] found that consumers who purchased a cookstove from a female entrepreneur were significantly more likely to report the cookstove as being much easier (63% vs 45%), safer (55% vs 26%) and better (74% vs 62%) than their traditional cookstove.

C. Higher Level Objectives to which the Project Contributes

13. The Government of Rwanda (GoR) Energy Sector Strategic Plan (2013-2018) identifies dissemination of improved cookstoves (ICS) as one way to reduce fuel wood consumption. The long-term goal of the government is to reduce fuel wood consumption from current 94% to 50% of total energy use. The Rwanda Energy Group (REG)[13] is targeting 80% of households to have access to improved cookstoves by 2017 and 100% of households by 2020.[14] The Government is supportive of private sector efforts to promote and distribute more advanced ICS, and has agreed to waive import duties and VAT on cookstoves that are performance-rated at tier 2 or above, in recognition of the social benefits they bring. The Energy Sector Strategic Plan also calls for encouraging female participation in energy related education, training, planning and decision-making, specifically including programs related to fuel wood collection and cooking, and for strengthening monitoring systems to capture sex-disaggregated data.

14. Rwanda's Third Health Sector Strategic Plan (July 2012-June 2018) recognizes the importance of indoor air pollution and the need to put in place appropriate environmental health strategies and interventions (i.e. national behavioral change communications strategy; national plan for surveillance of health and the environment; peer to peer group sensitization through existing community networks; tapping the network of community health workers and building their capacity to promote behavior change). A multi-sectoral environmental health policy and strategy has been designed and is being implemented through strong coordination mechanisms involving all sectors at the national, district and community levels. The Environmental Health Desk of the MOH leads the technical working subgroup handling issues related to household sanitation, and hygiene promotion. The Environmental Health Program

[12] https://cleancookstoves.org/binary-data/RESOURCE/file/000/000/356-1.pdf
[13] The Rwanda Energy Group Limited (REG Limited) incorporated in July 2014 with 100% government shareholding and its two subsidiaries, The Energy Utility Corporation Limited (EUCL) and The Energy Development Corporation Limited (EDCL) entrusted with energy development and utility service delivery.
[14] Energy Sector Strategic Plan (2013-2018), Govt. of Rwanda.

consists of a variety of interventions, including drinking water quality surveillance, indoor air pollution, and climate change.

15. Rwanda's Economic Development and Poverty Reduction Strategy (EDPRS) 2013–*2018* specifically includes the aim of "rural households using more efficient cooking methods". The EDPRS notes that biomass needs to be used in a sustainable, safe and efficient way, and therefore "use of improved energy efficient cooking stoves will be promoted…working with the private sector." (EDPRS paragraph 3.78). EDPRS II is also focused on sector strategies that enable women and men to participate, access, control and benefit equally from growth processes in a way that recognizes their different needs in terms of e.g. access to finance, exposure to gender-based violence and control of assets.

17. The joint UN-WB Sustainable Energy for All initiative carried out a Rapid Assessment Gap Analysis for Rwanda, which emphasizes the rural economic benefits from sustainable biomass energy. Sustainable biomass supply has much higher employment and other net economic benefits than importing more petroleum fuels to meet the energy demand. Therefore, improving the efficiency of cookstoves in order to close the gap between supply and demand, and to reduce the environmental effects of biomass cooking, in particular household air pollution, is a crticial part of the strategy.

16. The World Bank Country Partnership Strategy (CPS) 2014-2018 recognizes the likely consequences for natural resources and the environment that the changes associated with Rwanda's rapid growth paths may have. Sustaining growth of over 7.5% per year implies changes in how land and other natural resources are used. High reliance on wood fuels and biomass energy has the potential to deplete soils and reduce water catchment effectiveness, requiring greater use of sources from sustainably managed forests and on-farm forestry integrated with conservation agriculture. The CPS identifies biomass energy as an opportunity under its Theme 1: accelerating economic growth that is private sector driven and job creating. The project is also aligned with the objective of Theme 2: increasing the productivity of the poor. In addition to its climate mitigation benefits, the project will assist locally with the Bank's twin goals through improvements to the health and welfare of the poorest[15], reducing energy expenses to urban households, and improving the sustainability of domestic energy supply.

II. PROJECT DEVELOPMENT OBJECTIVES

A. PDO

18. The project development objective is to reduce the use of woody biomass[16] for cooking in targeted households.

[15] I.e. rural women and children, and urban domestic workers. The CPS noted that public health objectives in Rwanda were very much aligned with the twin goals.

[16] "Woody biomass" refers to wood and other lignified plant matter (i.e. branches and twigs).

B. Project Beneficiaries

19. The project is expected to benefit the households that adopt improved cookstoves by offering reductions in environmental health risk factors and savings in productive time that is otherwise used for collecting wood for cooking. The project will also contribute to the creation of job opportunities, for both men and women, in the areas of marketing, sales and after sales services for improved cookstoves and customized fuel. Finally, the project will contribute to countrywide efforts to reduce deforestation, while benefitting the global community through its contribution to climate mitigation. The project will target Rwanda's Eastern Province and three districts across the Western Province, namely Rubavu, Nyabihu and Musanze, and potentially Kigali City.

C. PDO Level Results Indicators

20. Progress toward achieving the PDO will be measured by the following indicators:
(i) Reduction in use of woody biomass;
(ii) Net greenhouse gas reductions; and
(iii) Number of direct project beneficiaries (both customer household members and people benefiting from additional employment), and percentage of female beneficiaries.

III. PROJECT DESCRIPTION

21. Two Rwanda-based private companies – Inyenyeri and DelAgua – were selected for funding from the Carbon Initiative for Development (Ci-Dev) Trust Fund, a carbon facility that supports innovative business models through purchase of certified emissions reductions. Their two proposals were selected as the most promising and innovative of 25 cookstove projects submissions received by Ci-Dev internationally. The proposals are based on contrasting business models, largely targeting different market segments and making use of different stove technologies, and are both associated with sophisticated studies of the reduction of HAP and the potential health benefits in beneficiary households. The two companies would expand the improved cookstove sector in Rwanda in quite different ways (see description of components below).

22. Ci-Dev will purchase carbon credits up to 0.60 million certified emissions reductions (CERs) from Inyenyeri and up to 0.32 million CERs from DelAgua, and with an option for an additional purchase of 0.50 million CERs from each company. Both projects rely on carbon finance to achieve the scale and demonstration effects that will establish viable businesses (see Annex 5).

A. Project Components

23. Component 1: **Introduce Advanced Cook Stove Technology and standardized fuel to replace inefficient charcoal and wood stoves (up to US$5.65 m Ci-Dev, US$8.5 m loan, US$5.0 equity, US$0.5 m Energy and Environment Partnership (EEP) Africa grant).** Under this component the Bank would support Inyenyeri, a local energy utility company in Rwanda, to scale up an innovative business model through purchase of emissions reductions. The business

model consists of the free lease to customers of an advanced fan-driven forced-draft biomass gasifier stove (considered the cleanest & most efficient type of solid biomass stove), on the condition that they may only use it with Inyenyeri's Biomass Fuel Pellets (BFPs: produced from compressed woody biomass). Urban (previously charcoal-using) customers purchase BFPs through Inyenyeri's BFP delivery network. Rural (or peri-urban) customers receive BFPs in exchange for supplying raw biomass (mostly small eucalyptus branches, although reeds and sawdust are also accepted) through a network of collection points. The combination of standardized BFPs and the high efficiency fan-driven gasifier stove allows Inyenyeri to provide fuel to three or more urban households (HHs) from the biomass supplied by each rural customer, while still requiring those rural HHs to collect less biomass than they would otherwise need. The high efficiency of the system and the price of charcoal mean that Inyenyeri can charge a sufficiently high price to recover the cost of the leased stoves in a reasonable time period, whilst urban HHs still pay less for BFPs than they would for the same amount of charcoal-based cooking (around US$9 a month instead of US$15). Overall, the amount of woody biomass required across customer households is expected to decrease by around 90% once they are using the stove and pellets.

24**.** Inyenyeri's business model appears complex, but has evolved through trial and error during a multi-year pilot phase in Gisenyi. The program has been well received, and now that they are switching to a new stove model with even higher efficiency and lower emissions, they are confident of their ability to grow rapidly in further urban markets, particularly Kigali, given sufficient capital. Their model is dependent on the willingness of existing charcoal users to purchase BFPs, which appears to be the case as long as BFPs remain functionally cheaper, given the additional benefits of cleaner and faster cooking from adoption of their stoves. Peri-urban customers have also shown a high level of willingness to exchange biomass for BFPs, although the company may explore alternate sources of biomass (e.g. professionally managed plantations) as their operations expand. Inyenyeri have support from government for their program, including agreements on VAT exemption for stove imports. Ci-Dev will support the scale up of the business by purchasing 0.6 million CERs with an option to buy additional 0.5 million if this component is able to scale up and deliver more CERs.

25. Component 2: Scaling up Intermediate Cookstove Technologies in Rural Areas (up to US$2.0 m Ci-Dev, US$4.0 m equity, US$2.0 m commercial loans[17]): Under this component the Bank would support DelAgua to build rural demand and markets for cost-effective, intermediate-technology improved cookstoves (Tier 2 and above in thermal efficiency)[18], through purchase of emissions reductions. DelAgua has already distributed around 100,000 EcoZoom stoves to ubudehe category 1 & 2 (i.e. the poorest) HHs in western Rwanda through a partnership scheme with the Ministry of Health (MoH). The Ministry's network of community health workers promote the stoves and providing training and follow-up on their use. Going forward, DelAgua will gradually move to the distribution of ICS models on a purely commercial basis.

[17] The equity and debt that DelAgua can mobilize has been scaled down to reflect the potential impact of a lower value of carbon transaction that Ci-Dev has agreed to offer for the DelAgua project (US$ 2.0 Mil).

[18] Global Alliance for Clean Cookstoves, IWA Tiers of Performance: http://cleancookstoves.org/technology-and-fuels/standards/iwa-tiers-of-performance.html.

26. DelAgua proposes to leverage the demand-creation and market-understanding derived from its free/concessional distribution phase to develop a retail operation, ultimately offering a range of ICS models. DelAgua will initiate an international competitive bidding process to procure different stoves with minimum Tier 2 thermal efficiency. Establishing commercial rural ICS markets is likely to be more challenging, but research commissioned by DelAgua on the basis of their pilot scheme in Western Rwanda concluded that close to 50% of rural HHs could be potential customers for retail sales. DelAgua will explore locally appropriate financing options and retail models through partnerships with savings and credit cooperative (SACCOs).

27. DelAgua will support awareness raising campaigns, behavioral change education and advocacy (particularly focused on the health benefits of shifting to outdoor cooking), training, repair and maintenance. In order to assist DelAgua in its effort to gradually transition to a retail business, Ci-Dev would consider to purchase up to a total of 0.32 million emissions reductions from stoves that it will sell through retail channels.

28. The DelAgua project has already registered its intervention in Rwanda as a Clean Development Mechanism (CDM) Program of Activities (PoA) with UNFCCC to claim the carbon credits, whereas the Inyenyeri project plans to claim the carbon credits through another CDM PoA that is registered and managed by a third party company Atmosfair. The legal agreement between Atmosfair and Inyenyeri will deal with the terms of engagement and issuance as well as transfer of carbon credits to Inyenyeri who can then transfer them to Ci-Dev.

29. Evaluation of health and gender outcomes is expected to complement the project and to promote sustainability and replicability. Both companies are already involved in sophisticated randomized clinical trials (RCTs) to determine the health outcomes of their at-scale pilot interventions. The London School of Hygiene and Tropical Medicine (LSHTM), Emory University, Oregon Health Science University, and Portland State University are implementing the health impact evaluation of Delagua's program, with funding from private donors to LSHTM (US$1.9m). The University of North Carolina is implementing the health impact evaluation of Inyenyeri's program, with funding from a National Institute of Health research grant and the Global Alliance for Clean Cookstoves (US$2.9m). Both studies measure HAP levels, personal exposure to pollutants and disease incidence in program and control HHs. The study of Inyenyeri's will also look at impacts on household time/energy budgets for cooking-related tasks (i.e. cooking, cleaning pots, fuel collection, etc.). Both studies will provide gender-disaggregated estimates of these impacts. Initial results are encouraging; the DelAgua study found greater than 70% reduction in PM 2.5 exposure levels when families cooked outdoors on their improved stoves.

30. Subject to confirmation of the funding, the Bank team will mobilize additional Bank-executed funds to enhance the assessment of health and gender impacts to promote the sustainability and replicability of the project:

i. A modest amount of additional resources from the Ci-Dev readiness trust fund and ESMAP's Efficient and Clean Cooking and Heating (ECCH) initiative would be used to (a) complete the assessment of the health impacts of DelAgua's pre-project distribution programs (the researchers are facing a funding shortfall to complete the analysis of

survey data and local health centers records in target districts), (b) ground-truth the Gold Standard Methodology for estimating health outcomes against a large field data set, and (c) estimate the potential for averted Disability Adjusted Life Years (aDALYs) markets to contribute to the long-term financial sustainability of both programs based on the estimated health impacts.

ii. The Africa Renewable Energy Access Program's Gender and Energy program[19] will support a gender assessment of the business model of Inyenyeri and DelAgua to both capture best practice and assess what opportunities exist in the current approach to close gaps in job opportunities for both men and women in the areas of marketing, production, sales and after sales services for improved cookstoves and customized fuels. This overall assessment will also include looking at consumer finance issues e.g. with SACCOs and the supply chain for raw biomass to ensure equitable benefit sharing around decision making, skills and sourcing of BFPs at the community level through the Inyenyeri business approach. Based on the overall assessment of Inyenyeri and DelAgua, additional training and capacity building activities will be designed in order to strengthen the firms' ability to deliver equitable development outcomes.

B. **Project Financing**

Lending Instrument

31. There will be no lending involved in the proposed project. Inyenyeri and DelAgua will provide the required upfront financing to implement their respective project components, and recover partially the cost of their operations through carbon revenues for a specific amount of time. A total of up to US$7.65 million will be disbursed to the project, with up to US$2 million for CERs generated by Delagua and up to US$5.65 million for CERs generated by Inyenyeri.

32. Both DelAgua and Inyenyeri have credible strategies to mobilize financing from commercial and social impact investors. Both projects are counting on the carbon credit purchase agreement with Ci-Dev to leverage this financing, however.

33. Proposed contractual arrangements. Ci-Dev proposes to sign an Emissions Reduction Purchase Agreement (ERPA) with DelAgua and Inyenyeri to secure forward purchase of up to 0.32 million CERs and 0.60 million CERs respectively. The price for the CER will be determined through application of Ci-Dev Pricing Guidelines and will be negotiated with the counterparts. Both companies will have an obligation to monitor and report the sales of stoves according to CDM requirements.

C. **Lessons Learned and Reflected in the Project Design**

34. The World Bank's recent feasibility study on greening the charcoal sector in Rwanda suggests a strategy that not only focuses on promoting ICS but also on introducing entirely new highly efficient stoves that can also burn agricultural residues without smoke.

[19] Technical assistance will also be provided by the Efficient, Clean Cooking and Heating initiative on the gender related issues.

The report also acknowledges that highly efficient stoves can be expensive.[20] To reduce the cost of the stoves and create economic incentives to replace old inefficient cookstoves, the report recommends the promotion and distribution of ICS should be linked with climate-related funding and the monetization of other benefits from deployment of clean efficient cookstoves.

35. About half of the households in Rwanda have limited disposable income and limited ability or willingness to pay for an ICS. The Cookstoves Market Assessment Report for Rwanda prepared by Global Alliance in 2012 defined four market segments in the country depending upon their present energy use, and concludes that about 56% of the population still use 3 stone fires, or traditional and self-made mud stoves, and have a limited willingness to pay for an ICS (Figure 2 and Table 1). Categories 1 and 2 – about 42% of households – are a good potential market for commercial sales of ICS.

Figure 2 Rwanda Household Market Segments, by Energy Use for Cooking (2012)

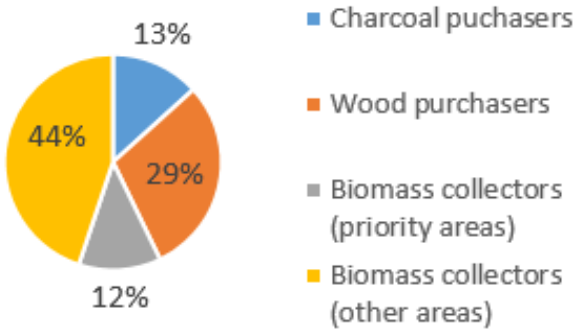


Table 1. Willingness to pay for different market segments

Category	Market segment	No. Households	Current cooking device	Willingness to pay for ICS
1	Charcoal purchasers	316k (13% of population),	Charcoal stove, traditional or improved, sometimes LPG	High, can afford to pay for simple ICS out of pocket
2	Wood purchasers	711 k (29% of population)	Traditional stoves, improved wood stoves	Medium, possibly can afford to pay for simple ICS out of pocket
3	Biomass collectors (priority areas)	305 k (12% of population)	3 stone fire, traditional self-made mud stove	Low due to lack of disposable income, but sometimes do not have a choice due to lack of biomass
4	Biomass collectors (other	1.1 M (44% of population)	3 stone fire, traditional self-made mud stove	Low, little to no disposable income

[20] Costs have fallen, but Tier 2 or 3 stoves still cost in the range of US$30-60 wholesale, which represents a major capital expenditure for poor households.

	areas)			

Source: Global Alliance, Cookstoves Market Assessment Report for Rwanda, 2012.

36. Consumers' limited willingness to pay for higher cost clean and improved cookstoves and fuels is the greatest long-term obstacle to broader adoption of clean cooking in Africa, but many consumers can potentially be reached with appropriate approaches. The Landscape Report on Clean and Improved Cooking in Sub-Saharan Africa, prepared by the Energy Sector Management Assistance Program (ESMAP) and the Africa Renewable Energy Access Program recognizes the emerging opportunities to encourage increased investment in clean and improved cooking businesses across the region. Its key findings include: (i) the clean and improved cooking sector in SSA has evolved significantly but is still highly underdeveloped; (ii) many of the WTP issues can be addressed by offering ICS products that are demonstrated and perceived as meeting consumers' cooking needs and preferences, as well as consumer education and awareness building and marketing solutions that enhance end-user trust; (iii) 15-20% of all African consumers will view improved solutions as being absolutely unaffordable or will have no interest in adopting a new stove under any circumstances; and (iv) disrupting the status quo will require stepped-up investment and a differentiated approach.

37. Understanding and penetration of effective ICSs in Rwanda remains very low. Therefore market creation needs to be the initial focus. International experience suggests the following are key to establishing viable ICS markets:

- The cost of the stoves should be kept low and affordable through continued innovation in design and manufacturing**.**
- Momentum and incremental benefits can be maintained through intermediate and basic ICS technologies, where advanced ICS solutions are not feasible or affordable in the near term. However, various recent studies in the cookstoves sector studies, and by Lighting Africa, have documented that people are more likely to invest in new products if they deliver noticeable financial savings and are aspirational in terms of design and function.
- Innovative financing and payment models are also needed (e.g., layaway plans, "pay-as-you-go" pricing, fuel/stove rental or leasing models, etc.). The higher cost of clean cooking solutions can be mitigated to some extent with carbon finance or monetization of other clean stove benefits, and through the use of "cash on delivery" or results-based grant financing rewarding independently verified livelihood, health, and productivity improvements beyond climate benefits.
- While direct consumer subsidies can be unsustainable and may lead to counter-productive market distortions, targeted subsidies are needed for extending access to clean cooking solutions, for example, in humanitarian aid contexts or to the poorest segments of the population, where downstream financing and business model innovation alone are unlikely to meaningfully expand market-based access to higher cost clean cooking technologies. Temporary subsidies may also help to establish markets sufficiently to gain from economies of scale.

38. Market based intervention with government creating uniform policy and incentive structure for all players yields better outcomes. However, in the specific case of Rwanda, the market is still in its infancy, and local private sector capacity in implementing workable cookstove business model is very limited. It therefore makes sense to directly engage with

selected companies that are willing to take risks and make investments to build the market from scratch. Ci-Dev has therefore, through a call for proposal process, identified two companies that have implemented smaller pilots and are ready to take their business model to next levels in terms of scale to demonstrate commercial viability. As experience builds, it is likely that more and more local companies could participate in the market.

39. **Behavioral change is key to the sustainability and impact of activities.** Interventions should be designed to educate and drive consumer behavior changes, as merely distributing cleaner cookstoves will not lead to improved health and environmental outcomes. Development of standards is key to allowing consumers to understand benefits of different models. Choice of technology such as selecting the right stove that meets the expectation of the households is incorporated into the business models of the companies, through consumer trials. Specific emphasize will be placed on ensuring that the gap between men and women's ability to pay for technologies and the differences in preferences is considered in the gender assessment.

IV. IMPLEMENTATION

A. Institutional and Implementation Arrangements

Institutional Arrangements

40. Inyenyeri: Component 1 of the project will be implemented by Inyenyeri, a for-profit social enterprise registered in Rwanda in 2011. It has 84 staff, all but one of whom are locally based in Rwanda. The company has spent the last 3-4 years developing and refining their business model in their Rubavu pilot site.

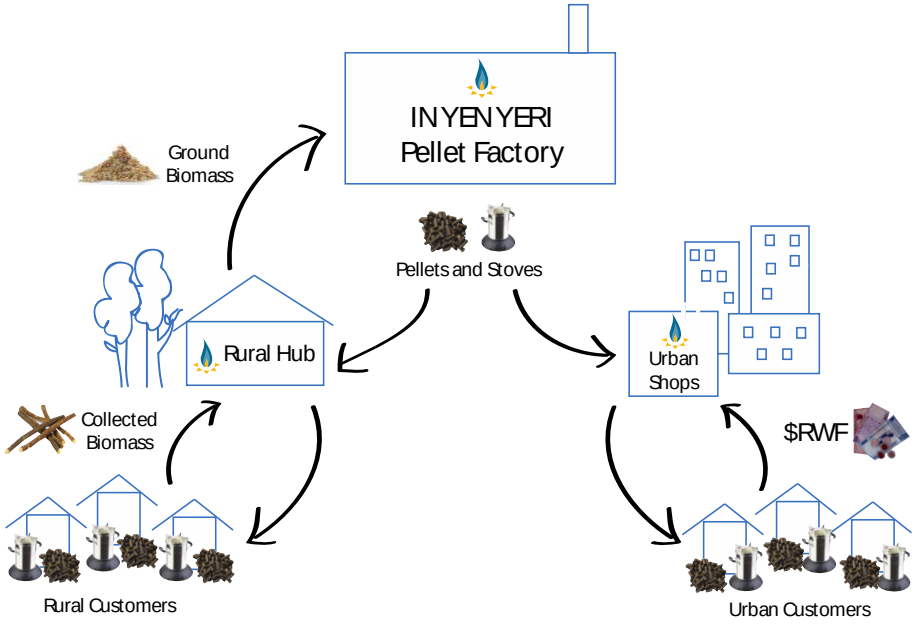
41. All components of the Inyenyeri operation, except the Clean Development Mechanism (CDM) processing, will be directly implemented by Inyenyeri. These include: marketing and promotion, procurement and dissemination of stoves, production and sale of Biomass Fuel Pellets (BFPs), collection and pre-processing of biomass at biomass collection centers, repair and maintenance as well as replacement of stoves. Inyenyeri has a detailed staffing plan for expansion of its network of shops and biomass collection hubs to support company growth. It anticipates adding around 100 staff per year if sales grow as projected, and also adding more local staff to its small management team.Its BFP production plant in Gisenyi has 3 pelletizing lines and employs eight staff per shift: a shift manager, one assistant manager, machine manager, two biomass manager, and two pellet managers.

42. The carbon aspects including verification and issuance of carbon credits from the project is proposed to be managed by Atmosfair GmbH as the Coordinating and Managing Entity (C/ME) of their registered Program of Activity (PoA). Atmosfair GmbH has already demonstrated its capacity to manage the carbon process by successfully completing several verification and issuances for both Gold Standard and CDM.

43. All key contracts have been signed or are in the final stages of negotiation with key suppliers including Buskirk (for the pelletizing equipment) and Mini Moto for the provision of

stoves. Full Financial closure is expected to occur concurrently with the signing of an ERPA with Ci-Dev. Inyenyeri is in an advanced stage of discussions with financiers and is waiting on the signing of the Ci-Dev ERPA to close additional financing deals.

Figure 3 Flow chart of Inyenyeri's operations



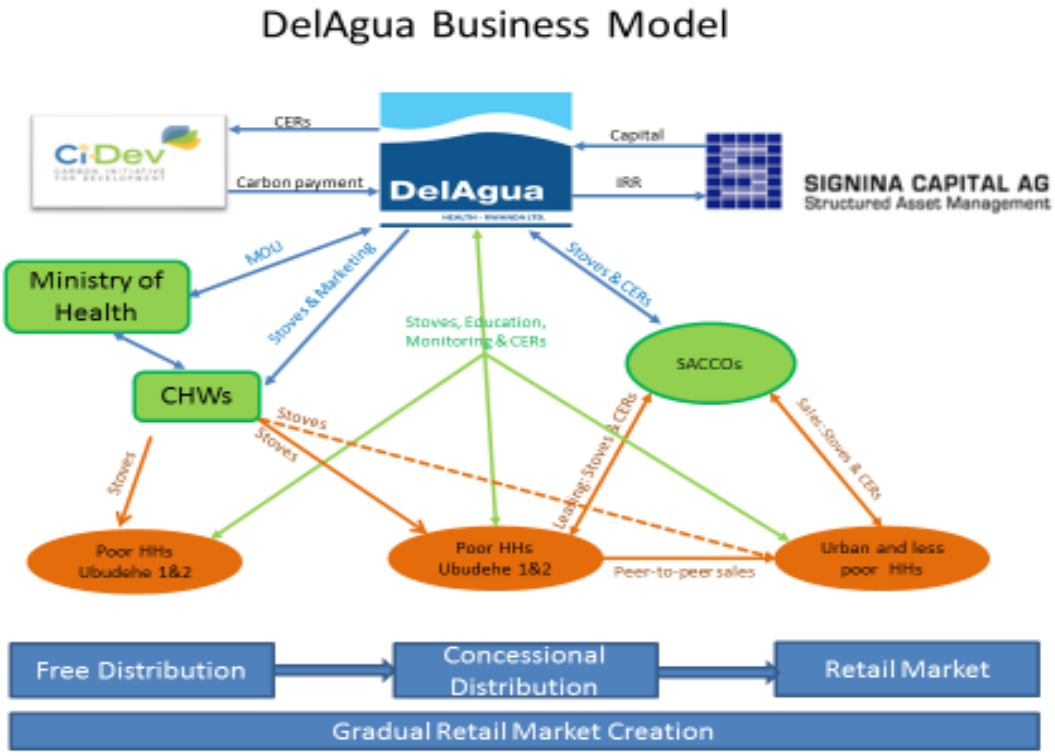
44. DelAgua Health Rwanda Implementation (DHRI): Component 2 of the project will be implemented by DHRI, which is registered to operate in Rwanda and a wholly owned subsidiary of DelAgua Health Rwanda, which is itself a wholly owned subsidiary of DelAgua Health. The group has prior experience in dealing with health related products. The group's business started with portable water quality monitoring kits in 1985 and the group is committed to providing services and products to enable the provision of clean drinking water for everyone around the world. To this end, the group bought Manna Energy Limited (MEL) in 2012 and formulated DelAgua Health.

45. DelAgua Group is owned: 68% Neil McDougall – UK National; 32% James Beaumont – UK National. These two shareholders are also the only two statutory directors for the group. DelAgua Group, DelAgua Health and DelAgua Health Rwanda were all incorporated at Freeport in the Commonwealth of the Bahamas on May 17, 2012. DHRI was incorporated at the same location on June 12, 2012. DHRI is also registered to operate and pay taxes in Rwanda. All components of the DelAgua operation including the CDM aspects will be directly implemented by DHRI itself.

46. DelAgua's retail business plan considers two main channels for stoves sales. The first channel is a direct sales by through DelAgua Mobile Shops and DelAgua sales staff. While DelAgua Mobile Shops will be tied to regional DelAgua staff and roam based on opportunities and events in a given territory (market days, holidays, church festivals, etc.), DelAgua Sales Staff will identify opportunities for high-volume sales through developing partnerships with Government, institutions, and enterprises. DelAgua estimates that about 10% of sales could happen through the direct sales and costumers are expected to make upfront payment of the stoves. The second channel is the indirect sales where SACCOs will provide sales conduit and finance to credit-worthy customers. Their total workforce, including community health workers,

currently numbers around 1,700. This is expected to grow moderately to around 2,000 over the next few years.

Figure 4 Flow chart of DelAgua's business model



B. **Results Monitoring and Evaluation**

47. Inyenyeri and DelAgua will be responsible for monitoring and reporting on the results indicators. Both companies have designated monitoring specialists. Monitoring and reporting of the CERs will be conducted by the companies annually in accordance with their monitoring plans as described in the respective registered design documents (CPA-DDs). Additional data required for the results framework, e.g. gender-disaggregated beneficiaries data, will be incorporated in the annual monitoring according to agreed annual formats.

48. The annual monitoring reports based on the monitored data will be subject to the Bank's review and comments. Once finalized, the monitoring report will be submitted for verification by a third party auditor. This auditor, who should be accredited by the UNFCCC EB, will verify the report through a desk review, on-site checking, and interviews in line with relevant verification standards by UNFCCC.

49. Disbursements will be made based on delivery of Certified Emissions Reductions (CERs) to be issued by UNFCCC to the respective projects.

50. While some of the results indicators will be directly monitored by the project entities (e.g. number of beneficiary HHs (rural and urban), number of women beneficiaries, etc.), the indicator on reduction in woody biomass will be determined in the following way.

a. For the households using traditional biomass stoves in the baseline (typically rural households), the consumption of woody biomass is fixed ex-ante at 183 kg/HH/month[21], which represents consumption of fire wood in a traditional fire stove having efficiency of 10%.
b. For HHs using charcoal stoves in the baseline (typically urban HHs), the equivalent amount of woody biomass consumed in the baseline is fixed ex-ante at 534 kg/HH/month.
c. Consumption of woody biomass in the improved cookstoves under the project will be determined according to the higher efficiency of the ICSs as measured in use, and the actual degree to which use of traditional stoves is displaced as verified through field surveys covering a sample of participating households.
d. The difference between baseline consumption and consumption in the project case will determine the reduction in consumption of woody biomass achieved due to project intervention.

51. Estimation of gender-disaggregated health and welfare impacts of the project will be made under the Bank-executed activities, based on projection of results of the impact assessments for the pre-project interventions onto the project households.

C. **Sustainability**

52. The sustainability of the intervention relies upon customer households continuing to use their improved cookstoves in the shorter term, and in the viability of the business models of the two companies in the longer term (seeing as individual stoves will inevitably need replacing eventually (estimated functional life is around 3-4 years). DelAgua and Inyenyeri therefore both need to (a) provide a reliable product or service that is behaviorally/culturally appropriate for local cooking practices, and (b) establish a viable business model that (i) provides that product/service at a locally affordable cost whilst still generating operating profit and (ii) attracts financing that allows the companies to cover the investment cost of early development and growth phases.

53. The extensive pilot programs of both companies have allowed them to develop stoves and related services (i.e. training, and in the case of DelAgua, provision of BFPs) that have very high rates of retention and use, and to generate increasing customer demand from those experiences. Although DelAgua promoted cost-effective intermediate stove technology ("EcoZoom" or "EZ cookstove") in its free and concessional distribution phase, it has plans to introduce higher tier stoves (such as gasifier cookstoves) gradually as market response improves. The higher tier cookstoves are likely to be aspirational and would result in higher uptake as well as higher wood savings for the households. After considerable experimentation, Inyenyeri has adopted and helped to develop a stove that is being claimed to be the cleanest biomass stove currently available. The stove design has been honed with user feedback from Inyenyeri customers. More technical details on the stoves are provided in Section VI.B.

[21] Crispin Pemberton-Pigott, Technical Consultant estimates the baseline consumption of wood fuel for a Rwandan HH to be an average 183 kg of wood per month. This is in line with the literature: The values for average fuelwood consumption in rural Rwanda are estimated by various sources to be between 138 kg/month and 202 kg/month air dried wood for a household of 5 people.

54. DelAgua intends to position its sales staff within SACCOs, and their associated communities to push for the marketing of the products. DelAgua's profit margin from these retail sales will be used to sustain all of the other associated services (stock purchasing, warehousing, cost of sales, education campaigns, monitoring, post-sales support, etc.). DelAgua is in advanced negotiations with the two nationwide SACCOs to tap in their existing large customer base. The SACCOs also have adequate capital reserve to provide financing to new customers once the project scales up. Standard financing agreement could be signed by DelAgua customers. Currently, the interest rates offered by SACCOs in Rwanda range from 13%-24%. The SACCO engagement is evolving. While the Bank team will closely monitor the progress made in SACCO engagement during supervision of the project, it also proposes to include several action oriented requirements into the carbon purchase agreement to push for concrete results.

55. DelAgua will procure and import the stoves and make them available to customers and will also retain all responsibilities for the post-sales care of the customer. Each product is backed by a warranty that will be honored by DelAgua in Rwanda, with additional replacement parts available for purchase as necessary for issues outside of the warranty agreement. DelAgua will repair or replace defective product with a new or like new product or parts that are equivalent to new in performance and reliability. Ci-Dev's support to DelAgua operation proposes to purchase CERs only from stoves that are sold on a retail basis to incentivize a faster transition to retail sales.

56. Under Inyenyeri's business model, the stoves are only leased to the households, while Inyenyeri retains ownership. The repair and maintenance responsibility thus remains with the company, who are incentivized to fix or replace the stoves promptly in order to maintain BFP sales. Inyenyeri has already demonstrated the ability to generate an operating profit by selling BFPs at a margin that will cover the cost of the stove over a small number of years. Their challenge is to grow the business to scale at which overhead and sunk costs are reasonable, whilst servicing the debt for that expansion.

57. Ci-Dev support is considered to be critical for the overall viability of both companies, both in terms of the direct payments provided at an above-market carbon price, and also in terms of allowing them to secure additional equity and debt finance. The financial viability of the companies is discussed further in Section VI.A.

V. KEY RISKS AND MITIGATION MEASURES

A. Risk Rating Summary Table

Risk Categories	**Rating – High (H), Substantial (S), Moderate (M), Low (L)**
1. Political and governance	L
2. Macroeconomic	M
3. Sector strategies and policies	L
4. Technical design of project	M
5. Institutional capacity for implementation and sustainability	L
6. Fiduciary	L
7. Environment and social	L
8. Stakeholders	S
9. Other	
Overall	**M**

B. Overall Risk Rating Explanation

58. **The project's overall risk is rated Moderate.** The risks are largely associated with the viability of the companies' business models to achieve proposed implementation scale and sustainability, and the perception that the Bank's intervention may be distorting the market or disadvantaging local cookstove companies. Key risks are summarized below:

Macroeconomic (M). Both companies' financial models are based on an assumed 5% annual depreciation rate of the Rwandan franc against the US dollar. Recently, rapid devaluation has taken place at a rate of around 10% per annum. Sensitivity analysis was carried out to assess whether a long-term 10% per annum devaluation scenario would impact the companies' viability. In summary, both companies would be impacted by the higher costs of importing stoves, but these impacts are offset by expectation that the dollar prices of stoves will also fall in the long-term, and the facts that DelAgua already have a lot of stock at hand and that local costs also fall with devaluation. Overall, the risk is not considered major (see Annex 5 for more details).

Technical design (M). Successful implementation of the Inyenyeri proposal hinges on ability of the project to produce and supply sustainably the unique biomass fuel pellets (BFPs) to HHs at a price below the charcoal price, but still high enough to recoup the costs of supplying stoves. The model appears complex, but has evolved from the commercial-scale pilots in Rubavu, which demonstrated very high levels of adoption (roughly 70% of target HHs) and success particularly with the newest, most efficient stove models. The company has a detailed understanding of the cooking fuel requirements of individual households and can detect if their stoves are used with other fuels, to reduce the chance of free-riders benefiting from free stoves without buying BFPs. Inyenyeri are highly confident of their ability to achieve similar rates of acceptance with

new major urban markets. This expansion will need to be balanced with development of their biomass collection network, but their greatest constraint at present is capital to expand operations.

DelAgua are also demonstrating effective adoption of their rocket stoves amongst ubudehe category 1 & 2 families[22], and the awareness of the benefits this creates is generating new demand for ICS amongst rural communities. A market assessment they commissioned estimated that up to 50% of rural households would be potential customers for commercial sales of stoves. However, establishing a viable rural retail market remains a major challenge. DelAgua will work with the SACCOs to offer financing schemes to make the stoves affordable to consumers, and is prepared to test acceptability of a range of ICSs including more advanced gasifier models. Ultimately, the DelAgua program represents an opportunity to study in detail the extent to which viable rural ICS markets can be developed, and if significant ongoing subsidies appear likely, to assess the role that aDALY markets could play in this. Some stove adoption issues have been encountered in their first phase of distribution, but these appear to be mostly limited to local condition in specific areas, particularly access to dry sources of fuel in areas with high rainfall.

Stakeholder risk (S). One criticism that may be heard from some stakeholders is that carbon finance subsidies unfairly favor larger, international companies who know how to navigate carbon markets at the expense of local ICS operations. This is particularly the case with business models that are perceived to operate on the basis of "free" distribution, as has been the case with DelAgua's distribution of rocket stove to ubudehe 1 & 2 HHs. The need for targeted subsidy for very poor households is widely advocated in many reports published in the ICS sector, including the most recent ESMAP publication, and subsidies for poor households are also well accepted in the health sector, and other social protection schemes in Rwanda, such as the free access to *mutuelle* community health insurance schemes for ubudehe 1 & 2 HHs. Nevertheless, some criticism is expected, and would be addressed through the following arguments:

- Support to DelAgua is specifically conditioned on agreement to move to a commercial business model.
- All CERs that Ci-Dev will purchase from DelAgua will be generated from stoves that are sold on retail basis.
- DelAgua will implement appropriate monitoring system for proper identification of stoves disseminated through different channels
- To provide a level playing field for access to carbon credits, both companies will be required to institute a mechanism for customers who no longer wish to be part of their programs to withdraw and return any leased equipment, so that they may partake in a competing carbon-financed stoves scheme.

[22] In some cases, however, local conditions are challenging. One community was visited where the DelAgua stoves were not being widely used due to issues with wet fuel stock (this was in the wettest part of the country), and local resistance to cooking outdoors (perhaps linked to the absence of closed yards). DelAgua have promised to investigate the specific issues within this community.

- There is in fact limited competition between DelAgua's concessional distribution scheme and other ICS actors in Rwanda, as only the poorest 20-25% of rural HHs are eligible for stoves without payment, and these HHs are least able to afford to buy stoves. *Canarumwe* woodstoves manufactured by local cooperatives have been promoted by a number of development programs (including with earlier Bank support), but have yet to achieve a high level of performance or market penetration. Other firms (including Inyenyeri) are focused on urban charcoal-consumer markets, and have no short-term prospects of successfully reaching the majority of rural HHs. Most local stove manufacturers are not in direct competition with DelAgua or Inyenyeri as these companies are distributors, not manufacturers. In the longer run, these companies represent a significant opportunity to local manufacturers as they are building demand and functional markets for ICS. The presence of companies such as Atmosfair means that carbon finance is potentially available to local ICS operations. The barrier is that local operators do not have the scale, product performance requirements, or distribution and monitoring networks needed to receive carbon credits.
- DelAgua have agreed to explore and develop the use of local companies in maintenance of their cookstoves, or eventually in the manufacture of components. This is less likely to be feasible for Inyenyeri given the more sophisticated stove technology that they are using.

VI. APPRAISAL SUMMARY

A. Economic and Financial Analyses

59. Details of the economic and financial analysis can be found in Annex 4. The analysis concludes that over a period of five years and a discount rate of 15%[23], being an Inyenyeri customer is highly beneficial to urban households. BFPs cost less than the equivalent cooking costs with charcoal, and this price differential contributes to a significant portion (86%) of the average annual net benefit of US$45 for urban households (equivalent to a 5-year NPV of US$178). The remainder of the benefits accrue from more modest estimates of savings from reduced cooking time and morbidity.[24] Rural households participating in Inyeneri's biomass collection scheme receive a lower average annual net benefit of US$12 (equivalent to a 5-yr NPV of US$56) because the estimated reduction in wood collection costs for these families is less than the savings from switching from charcoal to BFPs.

60. Rural households purchasing DelAgua stoves experience a reduction in wood collection costs slightly higher than for Inyenyeri rural household, but which is offset by the purchase price of stove. They are expected to receive an average net benefit of US$66 per year (equivalent to a

[23] A rural discount rate of 12% is often used, but for this analysis, 15% was used as the private discount rate for participating households, as that is a typical interest rate for small household loans through savings and credit cooperatives, and is therefore expected to be the rate at which financing for DelAgua stoves will be available in future. For the economic analysis, a social discount rate of 6% was used, as recommended in World Bank guidelines.

[24] Standard values for health and welfare benefits are used in the economic analysis for both Inyenyeri and DelAgua, although the higher efficiency of the Inyenyeri stoves probably means that the benefits will be large. Health and welfare benefits for both programs will be much better characterized once the respective studies are completed.

5-yr NPV of US$225). Sensitivity analysis suggests that that overall pattern of benefits is robust, but the Inyenyeri model is sensitive to cost of BFP (which must be kept below that of equivalent charcoal), and the net benefits for DelAgua stoves are sensitive to large changes in the cost of time for wood collection.

61. An economic analysis was conducted, which, under the assumption that 70% of household participate in the project and emissions reductions are valued at a social cost of carbon of US$30 tCO2e results in an economic net present value of benefits of (ENPV) of US$84.8 million, with economic internal rate of return (EIRR) 103%; without valuing certified emissions reduction benefits at a social cost of carbon of US$30 tCO2e, the ENPV is US$13 with an EIRR of 29%. The social benefits in addition to carbon emissions reductions strengthen the rationale for Bank involvement, and the relatively high carbon price offered by Ci-Dev, in comparison to the general state of carbon markets at present, make this transaction critical to the viability of the business growth models for both companies (see next section for further details).

Financial Viability of Business Models

62. DelAgua sub-component: DelAgua's business model involves a multi-phase approach – starts with building awareness and market creation through free and concessional distribution followed by retail sales. DelAgua plans to shift to retail sales in 2017, which is the key to financial viability and project sustainability. Although Ci-Dev's transaction (purchase of carbon credits) will be limited to stoves that will be sold in the retail market, the financial viability of DelAgua's operation has been analyzed at the level of the overall business model that targets to disseminate a total of about 830,000 stoves by 2023 involving a total project cost of about US$94.0 million. To assess the financial viability, a benchmark financial internal rate of return (FIRR) of 6.67% for DelAgua project is determined based on the company's weighted average cost of capital (WACC). The project IRR was then calculated and compared to the benchmark FIRR. Without carbon revenues, the project IRR is shown as negative, indicating the project itself would not be financial viable, which indeed justifies the need for carbon finance support. The carbon price is thus estimated in order for the project to bridge its funding gap and meet the benchmark FIRR.

63. This full business model is based on an optimistic scenario of raising US$94.0 million, which relies in part on obtaining additional carbon finance beyond the CERs that will be purchased by Ci-Dev. As an alternate, conservative scenario, it is estimated that the US$2 m carbon finance transaction with Ci-Dev will allow DelAgua to leverage a minimum of US$8.0 m in additional debt and equity financing. This would be adequate to disseminate a total of 63,000 stoves, about half of which on a retail basis. The Ci-Dev transaction remains critical to DelAgua to leverage additional finance, reach positive cash flows by 2018 and develop a viable retail model with economies of scale, to allow further scale up of the business beyond the initial Ci-Dev transaction.

64. Inyenyeri sub-component: As a pure local energy company, Inyenyeri's operational structure involves leasing highly efficient fan gasifier stoves to the customers with minimal costs while requiring the customers to use Biomass Fuel Pellets (BFPs) produced by the company. Inyenyeri plans to expand its customer base to 188,000 households by 2020 from its current scale

of 1500 households. Regarding financial viability, the debt servicing capacity instead of the financial return is assessed in this case considering that (1) the company is relatively novice with limited track record in the market (2) the business model is yet to be proved viable at larger scale in Rwanda (3) the projected business expansion is aggressive which requires large financing. The debt service coverage ratio (DSCR) is used as the key indicator to assess Inyenyeri's ability to meet its debt obligation especially in the early years of the business expansion. The analysis suggests Inyenyeri will achieve a positive cash flow by 2018, i.e. that they have a viable business model with only modest additional expansion and economy of scale. However, their ability to service the debt needed for ongoing expansion depends on CiDev purchases of their CERs. With CiDev, the DSCR will exceed 1 by 2020. Without it, the DSCR will not reach positive territory before the end of the project. In addition, the bulk of their debt financing is tied to the CiDev deal going ahead. The price of carbon is determined to be at a level to enable the average DSCR cross the threshold of 1.0 during the period of 2018-2020. The carbon revenues will thus ensure sufficient cash flow to finance the growth of the business while satisfying the debt obligations. The carbon contract with Ci-Dev is expected to assist Inyenyeri in raising the required finance to implement the project.

B. Technical Analysis

65. The project aims to introduce and promote multiple cookstove technologies (improved and advanced gasifier cookstoves) as alternatives to traditional wood and charcoal based stoves. These stoves are expected to bring health benefits and save cooking time as well as time required to collect the fuel wood while contributing to reducing deforestation. The two companies promote different technologies, each one having distinct advantages. DelAgua's present (EcoZoom) and intended future stove modelswill use unprocessed biomass readily collected by rural households. The stove model that Inyenyeri promotes requires production of biomass pellets, but is able to burn this standardized fuel much more efficiently. The requirement for customers to purchase a unique fuel has opened up the potential for Inyenyeri to develop a service-based business model, in which they sell the recurrent input (pellets) whilst leasing the hardware for free, and hence avoid the need to request a high capital purchase by customers. The low production cost of pellets, the establishment of a minimum monthly purchase, and their ability to determine if unauthorized fuels have been used, allow Inyenyeri to sell enough pellets to recover the costs of their stoves, whilst still reducing household fuel costs in relation to purchasing an equivalent amount of charcoal. The DelAgua stoves are lit and used like traditional wood stoves. The Inyenyeri stove is a little more complicated to operate, but provides better control and power adjustments while in use.

DelAgua sub-component

66. DelAgua is at present distributing EcoZoom Dura stove, which has a ceramic combustion chamber in a rolled steel housing with a cast iron stove top and reinforced door frame. Included with the stove are a "stick support" on which fuelwood is placed to promote air flow and a "pot skirt" which increases thermal transfer efficiency. In the field, performance is variable but when properly used, the EcoZoom will reduce fuelwood use by at least 50%, although reductions in indoor air pollution vary between fuel types and use (Johnson, et al., 2013). The thermal efficiency of this stove is reported to be 38% (Aprovecho Research Center, 2012).

67. While the EcoZoom stove is claimed to be among the best rocket stoves, rocket stoves do not reach Tier 4 (Refer to Annex 6 for the Tier classification criteria) in HAP reduction. Hence, while the reduction in smoke can be considerable, they reach only HAP Tier 1, or Tier 2 under optimum use. To achieve the desired health impact, DelAgua invests considerable resources in behaviour change, particularly focused on ventilation – that is – cooking outside, or in the doorway of kitchen areas where there is a separate kitchen. This can be a considerable change for some people, but it is facilitated by the portability of the EcoZoom.

68. DelAgua has agreed to move from their present free and concessional distribution to pursuing commercial sales in line with the findings on market development under the Lessons Learned above (i.e. need for effective, aspirational products, access to rural finance, etc). Given that the cookstove sector is rapidly evolving, and recent advances in gasifier and fan-forced stoves are cost-effective HAP Tier 4 stoves with appropriate in-field reliability may soon be in reach, the Bank team has discussed the potential for selling a more advanced and aspirational stove. Although the technical and other criteria are yet to be finalized/agreed, DelAgua has in principle agreed to include advanced stoves in their retail business, which are expected to meet the following:

a. at least conform to Tier-3 classification for indoor emissions;
b. be at a price point that is feasible for the Rwandan market; and
c. have sufficient proven reliability to justify the investment risk.

69. An initial tranche of gasifier stoves will be tested in the field for reliability, and DelAgua will closely monitor World Bank stove trials in Uganda and elsewhere to identify the most promising new technologies.

70. Different stove types deliver different emissions reductions and CERs, and accordingly the CDM monitoring and reporting requirements require and enable differentiation between CERs from different stove types. Practically, this means that each stove will have a bar-code that uniquely identifies it, along with the GPS coordinates of each HH and name of HH head being recorded in an online database for verification.

Inyenyeri sub-component

71. Starting with gasifier stoves from Philips, Inyenyeri is now using the Mimi Moto fan gasifying stove, which is claimed to be the best biomass gasifier stove available today with a Tier 4 performance, when specifically optimized for a standardized fuel, such BFPs.. In order to ensure fully functioning stoves at all time and to prevent stove stacking, Inyenyeri's business model does not involve selling of stoves rather stoves are leased to the HHs, while Inyenyeri takes care of the maintenance. Viability of the business model is ensured through sale of BFPs, which is safeguarded by the ability of Inyenyeri staff to tell if other fuels have been used in the stove.

72. Rural customers that are not connected to the national electrical grid receive an accompanying solar panel. To date, urban customers have all been connected to the electrical grid so therefore not in need of a solar panel to charge the stove. Fan gasifying stoves are modularly constructed, meaning that each part of the stove can be replaced in an ongoing fashion.

73. The rural customers bring raw biomass for trade at Inyenyeri Hubs, and in exchange receive the BFPs for free at a pre-agreed exchange rate. This model may not be able to sustain a very rapid scale-up of the business if Inyenyeri are successful in breaking into other major urban markets, such as Kigali. However, other sources of biomass could be found, such as government timber plantations, which would probably be cheaper. Urban customers purchase BFPs and contribute to the viability of the business model.

C. Financial Management

74. According to "Carbon Finance - Guidelines on Due Diligence Aspects of Carbon Finance Operations," Carbon Finance (CF) Operations due diligence does not include assessments relating to the application of the Bank's fiduciary policies, including procurement, financial management, and disbursements. The fiduciary operational policies (OP/BP 10.00) do not apply to CF Operations as these operations do not involve direct Bank financing of the underlying activities or investments. Nevertheless, the Bank team will review annual financial reports and audits of the two companies.

D. Procurement

75. The up-front program cost will be borne by the project entity and does not involve direct Bank financing of the underlying activities or investment. There is no public procurement involved.

E. Social Safeguards

76. The project is not planning land acquisition and there is no involuntary resettlement anticipated under the proposed activities, therefore OP 4.12 is not triggered. In the event that Inyenyeri achieves very high growth, there may be some economic displacement of charcoal production that would impact charcoal producers. However, given the local and regional demand for charcoal, this is unlikely to be a rapid change, and the Bank will also be providing livelihoods support to charcoal cooperatives close to Gisyenyi through a Nordic Development Fund grant attached to the Landscape Approach to Forest Restoration and Ecosystem Conservation project. Overall, given population pressures, the demand for wood products is unlikely to fall, and charcoal producers would be well placed to shift to other forms of processing, if necessary.

F. Environmental Safeguards

77. The project was assigned as EA Category B, and triggers OP 4.01 – Environmental Assessment, however, the project is expected to have significant positive impacts and very minimal negative impacts related to health and safety aspects of using the cookstoves. The positive impacts are envisioned to be achieved by directly reducing exposure to household air pollution (HAP), reducing time spent on cooking and related activities, and reducing demand for woody biomass, through the introduction and promotion of a range of improved and advanced cookstoves. Reduction in biomass demand will in turn contribute to countrywide efforts to reduce deforestation, while benefitting the global community through its contribution to climate mitigation**.** Given the nature of the interventions, negative environmental impacts likely to be

caused by the project are minimal. There is a possibility that construction of small storage and fuel pellet manufacturing facilities may be required as the companies expand their operations. In this case a simple environment management plan will be produced for each facility identified. Disposal of quantities of damaged or obsolete cookstoves may also be required. Import of internationally manufactured stoves into the country may lead to some perceived negative social impacts in form of displacing small local entrepreneurs and artisan stove manufacturers. However, the market share of such players is small, the potential for direct competition is limited and the potential for beneficial effects through piggybacking on market develop is real. There is also a possibility during the life of the project, that Inyenyeri may move from their current model of crowd-sourcing minor biomass to sourcing from commercial plantations to support fuel pellet production. Therefore the Bank Forests Policy (OP 4.36) has been triggered as a precautionary measure, and a TOR developed in the event that further due diligence on the sourcing of biomass is needed.

78. Each company produced an Environment and Social Management Plan (ESMP), based on the health and safety information on the operation of the cookstoves, shared it with stakeholders, and publicly disclosed it on the DelAgua and Inyenyeri websites respectively on January 3, 2017. The project will also continue sharing of these materials directly with the cookstove users.

Annex 1: Results Framework and Monitoring

Country: Republic of Rwanda

Project Name: Improved Cookstoves Project (P158411)

Results

PDO: to reduce the use of woody biomass for cooking in targeted households.												
PDO Level Results Indicators*	**Core**	**Unit of Measure**	**Baseline 2016**	**Cumulative Target Values**					**Frequency**	**Data Source/ Methodology**	**Responsibility for Data Collection**	**Description (indicator definition etc.)**
				Dec 2017	**Dec 2018**	**Dec 2019**	**Dec 2020**	**Dec 2021**				
1. Reduction in use of woody biomass for cooking in targeted households	☐	Tons	0	25,046	109,754	209,741	350,971	492,201	Annual	Surveys of stove use	Inyenyeri and DelAgua	This figure will be calculated (as dry biomass equivalents) on the basis of assessment of the degree of use of the stoves, in accordance with approved CDM methodologies.
1a. Of which contributed by DelAgua	☐	Tons	0	7,918	41,244	33,326	66,651	99,977				
1b. Of which contributed by Inyenyeri	☐	Tons	0	17,128	68,511	176,415	284,320	392,225	Annual	Surveys of stove use	Inyenyeri	
2. Net greenhouse gas emissions	☒	Tons CO_2 equivalents	0	-15,000	-90,000	-275,000	-500,000	-750,000	Annual	Calculated from reduction in woody biomass use	Inyenyeri and DelAgua	This is a Corporate Results Indicator. It is reflected as a negative number as the project will generate net emissions reductions. The volume of the emissions will be based on the agreed methodology for monitoring, reporting and verification of CERs.[25]
3. Direct project beneficiaries[26]	☒	Number	1,785	1,785	1,850	40,000	145,000	200,000	Annual	Customer records	Inyenyeri and DelAgua	Direct project beneficiaries include all members of households using improved cookstoves, plus persons employed on Inyenyeri & DelAgua cookstoves programs in the project target areas. The gender of

[25] Note that the cumulative targets are based on the total of emissions reductions expected to be generated by the end of each calendar year, although the related CERs are not expected to be fully accounted, verified and paid until the following year. By the end of the implementation period, the expected total emissions reductions are still lower than the total size of the carbon transaction because additional CERs can still be generated and bought until 2024.

[26] The numbers of beneficiaries shown in this table are at HH level.

												the person primarily responsible for cooking activities (typically over 80%) and the number of infants under the age of 5 (typically over 20% of HH members) will also be recorded for beneficiary HHs to provide more information on the primary beneficiaries of health impacts, but no targets are set for these a priori.
3a. Of which female	☒	Percentage	48	48	48	54	54	54	Annual	Customer records	Inyenyeri and DelAgua	At least 50% of both companies' employees are expected to be female by the end of the project. Household beneficiaries are expected to be around 52% female in urban areas and 58% female in rural areas.

Intermediate Level Results Indicators

Intermediate Results Indicators*	**Core**	**Unit of Measure**	**Baseline 2015**	**Cumulative Target Values****					**Fre-quency**	**Data Source/ Methodology**	**Responsibility for Data Collection**	**Description (indicator definition etc.)**
				Dec 2015	**Dec 2016**	**Dec 2017**	**Dec 2018**	**Dec 2019**				
Component 1: Results-based carbon finance payment												
Additional cookstoves provided by Inyenyeri in use	☐	Number	0	0	0	6,891	20,672	43,411	Annual	Customer records	Inyenyeri	
Component 2: : Health impact and financial evaluation												
Additional cookstoves provided by DelAgua in use	☐	Number	0	0	0	4,912	20,674	20,674	Annual	Customer records	DelAgua	

Annex 2: Monitoring, Reporting and Verification

1. The Improved Cookstoves Project will result in reduction of carbon emissions through reducing the use of non-renewable biomass fuels, i.e. charcoals and fuelwood. To verify the emissions reductions (ERs) generated by the project, Inyenyeri and DelAgua need to follow a formal process established by the UNFCCC, the international climate change governance body. The companies will follow the monitoring and sampling plan defined in their respective CPA-DDs in line with the methodology approved by UNFCCC EB, i.e. "switch from non-renewable biomass for thermal application by the user".

2. The ERs are assessed as the difference between a baseline emissions scenario and the actual project. In this project, the baseline is continued use of traditional inefficient stoves, which would be displaced by the use of improved and efficient cookstoves under the project. The baseline scenarios is calculated on the basis of ex-ante data, which are usually default values approved by UNFCCC and are recorded in the registered design documents and remain unchanged through the crediting period. Some of the ex-ante parameters include the emission factor of the non-renewable biomass (tCO2/TJ), net calorific value of the non-renewable biomass (TJ/t charcoal), thermal efficiency of the old stoves (%), etc. Calculation of the actual ERs generated by the project relies on monitoring several key parameters during the project, including (1) number of household participating in the cookstoves program, (2) utilization rate of the cookstoves vis-à-vis traditional cooking methods, and (3) efficiency of the improved cookstoves in the project setting.

3. Both companies will maintain a database of customers that includes basic information on the household and its members. The ICS use and efficiency estimates will be generated through regular survey-based sampling of a subset of participant households. The sample size and survey frequency will be set in line with CDM rules, and as defined in the Monitoring Plan of the registered CPA-DD. Survey will be carried out for each monitoring period (usually annual) Results of the survey are included in the Monitoring Reports. In addition, an independent verification / audit process will review and confirm data reported in the annual (usually) Monitoring Reports.

Annex 3: Implementation Support Plan

1. **Strategy and approach for implementation support.** The strategy for implementation support has been developed on the basis of the nature of the project and response to its complexities.

Implementation Support Plan

2. The Bank team members will be based at headquarters and in the Rwanda country office to ensure timely, efficient, and effective implementation support to the client. Formal implementation support missions and field visits will be carried out at least twice a year.

3. **Technical.** The Bank's team, which will include a health specialist will provide the required assistance, advice, and guidance for the evaluation studies focusing on health outcomes. The team will also include a gender specialist. The Bank's team will conduct site visits, which will take place during important stages of the project implementation.

4. **Financial management.** As part of its project implementation support missions, the Bank will conduct risk-based financial management implementation support and monitoring within a year from project effectiveness, and then at appropriate intervals. During project implementation, the Bank will monitor the project's financial management arrangements in the following ways: (a) review the underlying projects' annual audited financial statements and auditor's management letters and remedial actions recommended in the auditor's management letters. As required, a Bank-accredited financial management specialist will participate in the implementation support process.

5. **Environmental and social safeguards.** The environmental and social development specialists will closely supervise implementation of the ESMPs. The environmental and social specialist will conduct field visits on an annual basis to monitor implementation of safeguards policies.

Table 1. Implementation Support Plan

Time	Focus	Skills Needed	Resource Estimate (staff weeks)
First 12 months	Task management	Senior environmental economist/senior carbon finance specialists (2) and supported by an operations officer	10
	Private Sector Specialist	Private Sector development	3
	Financial management	Senior financial management specialist	1
	Environmental supervision	environmental specialist	3
	Social supervision	Social development specialist	4
	Gender	Gender and energy specialist	3
12–36 months	Task management	Senior environmental economist/senior carbon finance specialist/Environmental Specialist	15
	Private sector management specialist	Private Sector development	4
	Financial management and disbursements	Senior financial management specialist	2
	Environmental supervision	Senior environmental specialist	4
	Social supervision	Senior social development specialist	6
	Gender	Gender and energy specialist	4

6. The staff skills mix and focus with regard to implementation support is summarized in table 2.

Table 2. Skills Mix Required

Skills Needed	Number of Staff Weeks	Number of Trips	Comments
Task management (for two co-task team leaders)	25	2 supervision mission per year	Headquarters and country based
Senior financial management specialist	3	Field trips as required	County office based
Environmental specialist	9	2	Country office based
Social specialist	12	2	Country office based
Operational Officer	20	Field trips as required	Country office based

Annex 4:Economic and Financial Analysis

1. **The economic and financial analysis demonstrates range of quantifiable and non-quantifiable benefits and cost of adopting ICS to households and the national economy.** The analysis consist of three parts: (a) Overview of quantifiable and non-quantifiable benefits of introducing improved cookstoves. (b) Financial analyses for households who adopt the improved cookstoves, to demonstrate incentives to switch to the new technology. The net incremental benefits of the improved cookstove technologies are presented. (c) Economic analysis that captures the benefits and cost of the project to the economy and assesses the net incremental benefits of the intervention compared to a baseline. Quantitative assessments will be made to the extent possible based on national and regional data.

1. OVERVIEW OF BENEFITS

2. Introduction of ICSs has the potential to generate following benefits: (a) global environmental benefits by reducing greenhouse gas emissions – due to decreased wood fuel collection, forest degradation and deforestation; (b) private benefits on household-level in the form of health benefits due to reduction of indoor air pollution, and associated gender benefits; (c) on-site public benefits due to restoration of ecosystem services by reducing forest degradation.

(a) Global environmental benefit: Reducing woodfuel related GHG emissions.

3. **Recent estimates suggest that Rwanda's share of unsustainable woodfuel harvest is above global average values.** The main drivers of forest degradation in Africa is unsustainable fuelwood collection and charcoal production for cooking, causing 48% of degradation.[27] However, the link between woodfuel collection, forest degradation and climate change impacts is not straight forward: There are uncertainties in measurements of how forest degradation affects changes in carbon stock,[28] and the extent of unsustainable woodfuel collection compared to sustainable collection is a matter of debate. The World Bank (2012) reports that sustainable wood supply in Rwanda stems from private and public plantations and ranges between 1.1-2 million tons of biomass per year, which is about 40-75% of the estimated demand of 2.7 million tons/year.[29] Bailis et al. (2015) arrive at similar estimates: Worldwide, they find that 27-34% of wood fuel harvest was unsustainable, stemming from non-renewable biomass (NRB). For Rwanda, they find an expected fraction of NRB (fNRB) of 64.7% and 52%, for the low and high plantation productivity variety respectively. While these values exceed the global estimate of unsustainable harvest of 27-34%, they are below the value suggested by the UNFCCC, which is 98%. Many carbon-offset projects use similar values proposed by the UNFCCC of ca. 90%.[30] The sensitivity analysis should consider variations in the GHG emissions reduction potential.

[27] Hosonuma, N, Herold, M, De Sy, V, De Fries, RS, Brockhaus, M, Verchot, L, Angelsen, A, Romijn, E. (2012): An assessment of deforestation and forest degradation drivers in developing countries. Environ. Res. Lett. 7.

[28] At the same time, measuring forest degradation and related forest carbon stock changes are more complicated and more costly than measuring deforestation. Countries can measure current rates of degradation through field data and/or remote sensing data; a combination of the two types of data provides the strongest estimates. However, developing countries frequently lack consistent historical field data (M. Herold, R.M. Román-Cuesta, V. Heymell, Y. Hirata, P. Van Laake, G.P. Asner, C. Souza, V. Avitabile and K. MacDicken). A review of methods to measure and monitor historical carbon emissions from forest degradation.

[29] World Bank (2012). Establishing a green charcoal value chain in Rwanda.

[30] Bailis et al (2015) reviewed 305 carbon projects in 45 countries, which reveal a median fraction of NBR (fNBR) of 90%, which is equivalent to values suggested by UNFCCC. However, Bailis et al. (2015) identified only four countries in which the sub-national fNBR exceeds 80% as a results of wood fuel demand, and that only 8% of existing bio carbon projects fall into these areas.

4. **Woodfuel harvest is estimated to contribute up to 84% to total emissions in Rwanda.** In 2009, emissions from wood fuels was estimated 1-2.3% of global emissions or 3.5-4.3% of emissions in pan-tropic region, which is ca. 1-1.2 $GtCO_2$ per year. Rwanda's average contribution of woodfuel to total emissions is 82-86%[31], thus relatively high compared to 56-66% in Burundi, 47-56% in Kenya and average 6-11% in sub-Saharan Africa.[32] The mitigation potential of ICS is suggested to be considerable. The Global Alliance for Clean Cookstoves suggests that 100 million improved cook stoves, could reduce emissions by 11-17% by 2020; valued at US$11 per tCO_2 this can lead to a value of US$ 1 billion (assuming that black carbon was integrated in the carbon market).

(b) Private benefits on household-level: Health benefits

5. **Household air pollution (HAP) has tremendous damaging health effects, in particular on women and children who are disproportionately exposed to the gases.** ICS reduce exposure to household air pollutants (HAP) for cooks, which are mostly women and accompanying children. HAP is the fourth most significant risk factor for premature death globally and even the second risk factor in sub-Saharan Africa.[33] HAP is linked to low birth weight, lung conditions, tuberculosis, cancer and nutritional deficiencies. Rwanda has one of the highest incidents of HAP related morbidity in SSA, at 63 HAP-associated disability-adjusted life years (DALY) per 1000 people. HAP accounts for nearly 6% of the burden of illness.[34] Global studies identify HAP from solid fuels as being responsible for 3.5 million premature deaths globally,[35] and indoor air pollution as the single largest environmental risk factor for female mortality, causing 5% of all female deaths in the developing world.[36] Thus, the introduction of ICS can have disproportionately large health benefits for women and children who are largely responsible for household chores including cooking.[37]

6. **However, health benefits depend critically on the frequency, efficiency and correct use of the ICS.** Benefits from ICS are limited if ICS are used incorrectly, inconsistently or not exclusively. The adoption of ICS can lead to a median reduction of 48% of 24-hours PM2.5 concentrations in the cooking area. These values are comparable to projects in Ghana and Kenya (52 and 33%). At the same time, to reach the pollution threshold of PM2.5 in the kitchen, it is also sufficient to use a three stone file for less than 1 hour. This implies that non-exclusive use of ICS drastically reduces health benefits.[38] While there is little detailed information on uptake and regular use of ICS, the impact of stacking has to be taken into account.

7. **Despite benefit, the ICS adoption rates are relatively low.** It is estimated that ca. 50% of households in Rwanda have already adopted improved cookstoves. However, the actual performance and energy savings vary considerably and many ICS are only marginally better than

[31] Note that these estimates are based on an estimated fraction of NRB (fNRB) of 64.7% and 52.5%, for the low and high plantation productivity variety respectively (Bailis et al. 2015).
[32] Bailis et al. (2015)
[33] Shankar et al. (2014)
[34] Chang and Biaou (2016)
[35] Rosa, G., Majorin, F., Boisson, S., Barstow, C., Johnson, M., Kirby, M., Ngabo, F., Thomas, E., Clasen, T. (2014): Assessing the impact of water flters and improved cook stives on drinking water quality and household air pollution: A rabdomised controlled trial in Rwanda. OLoS ONE 9(3):e91011
[36] Miller and Mobarak (2014)
[37] At the same time it need sto be acknowledged that no information on intra-household decision making and benefit sharing available to understand how monetary benefits and cost from introducing ICS are split between male and female household members.
[38] Shankar et al. 2014

traditional stoves.[39] While Inyenyeri states to have a retention rate of ca. 90%[40], a recent study showed that 41% of Rwanda's ICS owners never used their stoves, 11% used them irregularly and only 48% at all times.[41] A randomized control trial in Rwanda reported that ca. 76% of households continue to use their traditional stoves, due to unavailability of fuels or preference for traditional cooking.[42] Similarly, a recent project in Peru, states that the low ICS adoption rate of 45% was caused by problems with stove quality, lack of expected gains in fuel efficiency, and difficulty in changing cooking methods.[43] A study in Uganda showed that as long as the resource continued to be available in a community, the demand for fuelwood remained inelastic, demonstrating that households do not have sufficient incentives to switch to woodfuel substitutes.[44] Shankar et al. (2014) find that uptake of ICS is limited if women have limited access to assets and credit. Women are nearly always responsible for cooking and disproportionately suffer the health related consequences, but rarely have decision making power over purchasing decision. Men may not internalize the health benefits of the investments and are found to be less willing to pay for the ICS.[45] Adoption is often impeded by household's financial barriers to pay for the large upfront cost or lack of knowledge about health benefits.[46]

8. **Other benefits.** Further health benefits, which will mainly arise to women, stem from reduced burns and eye disease. In Uganda the introduction of ICS reduced acute respiratory diseases by 21%, eye diseases by 36%, and burns by 90%.[47] ICS typically have higher efficiency and require less wood fuel, which can translate into considerable time savings for women and children. Non-quantifiable benefits arise from acquisition of knowledge and skills, improvements of community life, enhancement of the social status of women, greater social recognition for women's tasks and increasing time available for children for learning or playing.[48]

(c) On-site public benefits due to reduction of forest degradation and loss

9. Forest and watershed protection are key determinants of (i) soil conservations, control and reduce soil siltation, resulting in decreased on-site and off-site sedimentation; (ii) water flow regulation including flood and storm protection, decreased water run-off which could otherwise lead to localized flooding and could have critical consequences for downstream fisheries and reservoirs and water supply or water quality regulation; (iii) microclimate regulation, in particular provided by humid rainforests, which is a natural protection against fire.[49] These ecological functions will be improved by reduction in deforestation.

10. Several economic valuations of reducing forest degradation have been conducted in Rwanda: In Rwanda's Nyungwe National Park, the annual economic value of watershed

[39] Jeuland and Pattanayak (2012).
[40] Chang, X, Biaou, L (2016): Inyenyeri Improved Cookstove project. Initial Financial Due Diligence Review Note. Ci-Dev
[41] World Bank (2012), page 52
[42] Rosa et al. (2014)
[43] Jeuland and Pattanayak (2012)
[44] Egeru, AS (2014): Rural Households' Fuelwood Demand Determinants In Dryland Areas of Eastern Uganda. Energy sources, Part B, 9:39-45.
Dresen, E, De Vries, B, Herold, M, Verchot, L, Mueller, R (2014): Fuelwood savings and carbon emission reductions by the use of Improved Cooking stves in an Afromontane Forest, Ethiopia. Land 2014, 3, 1137-1157.
[45] Miller and Mobarak (2013)
[46] Jeuland, M., Pattanayak, S.K. (2012): Benefits and costs of improved cookstoves: Assessing the Implications of variability in health, forest and climate impact. PLoS ONE 7(2): e30338. Doi: 10.137/journal.pone.0030338; Miller, G, Mobarak, AM (2013): gender differences in preferences, intra-household externalities, and the low demand for improved cookstoves. Working paper.
[47] Habermel (2007)
[48] Habermehl, H. (2007): Economic evaluation if the improved household cooking stove dissemination programme in Uganda. On behalf of the German Agency for technical Cooperatio (GTZ), Household Energy programme.
[49] Cavatassi, R. (2004): Valuation methods of Environmental Benefits in Forestry and Watershed Investment projects. ESA WP No. 04-01. FAO, Rome.

protection services is assessed at US$118 million. The Rwandan Environmental Management authority (2012) found that investment in watershed management is capable of increasing household income from agriculture by 30% and investors – primarily form tea industry and power producers – could expect an increase in revenue of 7% per year. They conclude that every Franc invested, generates three Francs by 2020. Masozera (2008) estimated that 100,000 ha forest in Nyungwe, service as flood protection, avoided flood related cost in the Rwandan tea industry of ca. ca. US$14 million.[50] Watershed services reduce sedimentation and benefit power producers by avoiding loss of generation capacity and associated costs. Masozera (2008) also finds that annual cost associated with sedimentation of a hydropower plant in Gishwati is approximately US$1.15 million equating the energy loss of 38% of total production. For instance, between 1997 and 2005, the cost of energy per kWh has increased from US$7.5 cents to US$20 cents; and will likely rise as demand for clean water and energy in Rwanda increases.[51]

2. FINANCIAL ANALYSIS AT THE HOUSEHOLD LEVEL

11. The financial analyses assess household's incremental net benefits related to the adoption of ICS and incentive to participate in the project. Analysis are conducted over a period of 5 years, lifetime of the project, and 10 years, lifetime of a stove for Inyenyeri and DelAgua. The discount rate is 15%.[52] For the Inyenyeri model, two scenarios are analyzed: (i) households bear all capital and variable costs themselves; (ii) households lease ICS and are required to buy BFP/exchange woodfuel for BFPs. Data stems from Inyenyeri's and DelAgua's financial due diligence reports and from literature review.[53] A **rural wage rate** for unskilled labor of US$1/personday is assumed.[54] It is further assumed that only 25% of the time saved due to improved cooking and reduced wood fuel collection could be used for productive activities, resulting in a wage rate of US$0.25.[55] A stove utilization ratio of 70% is assumed.

12. Cost items. Following costs are considered in the analyses:

(i) **Rural households' woodfuel demand.** A rural household collects on average 183 kg of wood fuel per month.[56] This is in line with the literature: The values for average fuelwood consumption in rural Rwanda are estimated between 138 kg/month and 202 kg/month air dried wood for a household of 5 people.[57] Fuelwood use for a Kigali household is estimated 109 kg/month and 182 kg/month per household of five for normal and intensive cooking intensity respectively.[58] World Bank (2012, p.51) suggests a monthly consumption per households of 147 kg/month for a traditional three-stone stove

[50] Rwanda Environment Management Authority (2012) and Masozera, M. (2008): Valuing and capturing the benefits of ecosystem services in Nyungwe Watershed, SW Rwanda; cited in Ministry of Natural Resources - Rwanda (2014): Forest Landscape Restoration Opportunity Assessment for Rwanda. MINIRENA, IUCN, WRI.
[51] Andrew, G., Masozera, M. (2010): Payment for Ecosystem Services and Poverty reduction in Rwanda. Journal of Sustainable Development in Africa. Vol 12(3).
[52] Reported by DelAgua Health, Ipsos Public Affairs, The social research and corporate reputation specialist (2015): A report for a market research study for large scale distribution of water filters and cookstoves. Conducted for DelAgua Health Rwanda implementation Ltd.
[53] Jeuland and Pattanayak (2012) provide a comprehensive review of benefits and cost of improved cookstoves. They provide for several cost and benefit items estimates as found in the literature in the range: low, medium, high.
[54] A recent study reports wage rates for different types of activities in the Rwaliko district: working for better off farmers yielded a daily wage between 300 RWF (often for women and children) - 700 RWF; harvesting at a coffee plantation between 200RW-400RWF; construction work between 500-700 RWF. collecting grass for animals between 4,000 RWF-8000 RWF per month. At 2007 exchange rate, this results between USD0.54 and USD1.2/day (Rizzo, M. (2011): Rural wage employment in Rwanda and Ethiopia: A review of the current policy neglect and a framework to begin addressing it. Working Paper 103. International Labor Organization. Policy Integration Department, Geneva)
[55] For instance, Habermehl (2007) assumes that not the entire day, but 50% of the time saved are actually used for productive activities by the women, such as farming and household activities improving the living conditions of their families, child caring, participating in social community activities as well as income generation. They further assume that of time saved from cooking 25% were assumed to be time effectively saved (thus 0.455 hours/day).
[56] Biao, L., Chang, X. (September 7, 2016): Inyenyeri Improved cookstove project: Updated Due Diligence Review Note
[57] Ndayambaje, JD, Mohren, GMJ (2011): Fuelwoos demand and supply in Rwanda and the role of agroforestry. Agroforestry Systems 83:303-320.
[58] Drigo, R, Munvehirwe, A, Nzabanita, V, Munvambundu, A (Agriconsulting S.p.A) (2013): Update and upgrade WISDOM Rwanda and woodfuels value chain analysis. As a basis for the Rwanda Supply Master Plan for fuelwood and charcoal. Final Report prepared for the Rwanda Ministry of Natural Resources

in Rwanda. Studies from neighboring countries suggest similar values for firewood consumption: ca. 170 kg/month/household[59], or 225 kg/month/household[60], or between 202 and 262 kg/month/household[61] in Uganda, in Kenya 250 kg/month/household and in Ethiopia, for baking injera, even 440 kg/month/household.[62] In the financial models, the possible variation in monthly consumption of woodfuel is captured in a sensitivity analysis.

- With *Inyenyeri*, each rural household is required to collect on average 152 kg/month of fuelwood in exchange for the required amount of BFP, which constitutes a 17% reduction in firewood.[63]
- *DelAgua* customers use gasifier stoves, for which no information on wood demand is provided.

(ii) **Woodfuel cost**. Woodfuel is traded largely informally. In the period 04-05/2012 the price ranged between US$0.01/kg for non-commercial fuelwood consumed in rural households and US$0.02/kg for fuelwood consumed by larger consumers. The price of commercialized woodfuel, including production, cutting, packing and transport to the roadside is between US$0.04/kg in rural areas and US$0.13/kg in Kigali. In Uganda, a market price of ca. US$0.05/kg in 2006.[64] Jeuland and Pattanayak's (2012) review suggests cost of fuelwood between US$0.03 and 0.2/kg.

- It is reported that *DelAgua* customers spend on average US$11 per month to buy wood for cooking (ca. US$0.06 per kg, if 183kg/month are bought), and could save up to 70% with new gasifier stoves resulting in US$3.3 per month.[65] Conservative savings of 50% are assumed. Woodfuel prices are assumed to increase by 5% each year.

(iii) **BFP cost.** On average, BFP sell at US$0.35/kg (US$0.18/kg in early 2016 to US$0.41/kg in 2020). While there are no reference prices for 1 kg of wood pellets in Rwanda, the price seems to be competitive and in line other markets, e.g. clean cooking revolution in South Africa referred to a price of US$0.51/kg and the price of pellets in Europe is US$0.3/kg.[66]

- *Inyenyeri* customers use on average 45kg of BFP/month thus US$10.5 and rural consumers who finance stoves themselves 30kg/month for ca. US$8.4/month.

(iv) **Cost of charcoal**. The charcoal price is expected to increases due to tighter government regulations (World Bank 2012). In the past decade charcoal prices tripled in many African countries. For examples in eastern province, charcoal prices have doubled from RWF5,500 to RWF9,000 per bag of 33kg.[67] Charcoal prices demonstrate high intra-annual fluctuation, with prices being ca. 30% higher between April and August than rest

[59] Habermehl (2007)
60 Dresen et al. (2014)
[61] Egeru, A. (2014): Ruralhousehold's fuelwood demand determinants in dryland areas of eastern Uganda. Energy Sources Part B Economics Planning and Policy. DOI: 10.1080/15567241003716688
62 Dresen et al. (2014)
[63] Chang and Biiaou (2016)
[64] Drigo et al. (2013), p. 79, 116
[65] Dempsey, A., Okumura, K., Biao, L. (September 7, 2016): DelAgua Improved cookstoves project. Updated Financial Due Diligence Note. CiDev.
[66] Chang, X, Biaou, L (September 7, 2016)
[67] Inyenyeri PIN; citing http://www.newtimes.co.rw/section/article/2015-05-09/188617/

of the year. A typical urban household spends average US$17 per month, translating in a retail price of US$0.41/kg of charcoal and ca. 42kg/month/household.[68]

- *Inyenyeri* suggest a price increase of 5%/year, from US$17 in 2016 to US$21/month in 2020. It is assumed that urban Inyenyeri customers use charcoal, but switch to BFP thus avoiding charcoal expenses of US$228/year.

(v) **Capital cost**. Capital cost of traditional stoves are assumed zero. *Inyenyeri's* Tier 4 Mimi Moto stove costs US$52.3 and US$58.3 for rural and urban households respectively; annualized over time of the project. *DelAgua* customers can purchase a gasifier stove (Tier 2 and above), with a 100% upfront cost of US$85 per stove.[69]

(vi) **Cost of delivery.** *Inyenyeri* suggests a registration fee of US$7 for an urban household for up to 3 stoves. Rural households are required to provide 100kg of raw biomass as a onetime contribution, which is collected in ca. 40 hours; valued at an opportunity cost of shadow wage, it results in US$1.5.[70] There is no registration fee for *DelAgua*.

(vii) **Operation and maintenance cost.** The maintenance cost for stoves was assessed at US$1.1 million in year 2020, when ca. 300,000 stoves will be delivered. This results in a per stove maintenance cost of US$3.7. Assuming this will be passed on to consumers with a slight mark up the final cost of US$5/year is used.[71] Maintenance cost of the traditional stoves are assumed to be US$1.5/year. O&M cost are weighted by the stove use factor.[72]

(viii) **Cost of learning.** The cost of learning is associated with the acquisition of the stove and captures the time and cost for the familiarization with the use of the new stove.[73] Accounting for learning and inconveniences is important as inconvenience in cooking is frequently cited as reason for not adopting the ICS. Or project duration, two days are assumed.

13. Benefits streams include:

(i) **Health improvements - reduced morbidity** due to reduced incident of acute respiratory illness (ARI) and reduced prevalence of obstructive pulmonary diseases. Evidence of reduction in other diseases such as asthma, visual impairment, lung cancer is less compelling. The cost of morbidity is assessed by multiplying the cost of illness per case by the decrease in expected monthly cases per household. The incident of ARI is suggested between 0.1-1 cases per household per year; the reduction in diseases from the use of improved wood-burning stove is between 10 and 70% for low and high efficiency stoves respectively. The cost of illness is assessed[74] between US$2 and US$60 per case.[75] Rwanda provides universal health insurance for a premium of less than US$5 per person

[68] World Bank (2012), page 49

[69] To cover the cost of EcoZoom stove households can either work as sales agents to pay stoves through active involvement in the community. This requires them to conduct 4 demonstrations which can last up to a day in two year. Or they pay the EcoZoome stoves upfront or in installments over the stoves' lifetime. The later case is assumed in this analysis.

[70] In Rwanda it is assumed that 5kg of fuelwood are collected in one trip of 2 hours (Drigo et al. (2013); shadow wage per hour is assumed at USD0.125/hour.

[71] Inyenyeri Due Diligence note, page 27

[72] Jeuland and Pattanayak (2012).

[73] Jeuland and Pattanayak (2012).

[74] The cost of illness typically includes: private and public expenses for diagnosis, treatment and hospitalization; other cost borne by patients such as transport; productivity loss for sick patients and caretakers during the period of illness and recovery. Jeuland and Pattanayak (2012).

[75] Jeuland and Pattanayak (2012). 51, 54

and year and patients incur an out of pocket spending on average US$8 per year and capita.[76] Lower respiratory diseases are the second leading cause of death since 1990,[77] it is thus assumed that 70% of the out of pocket spending is used as cost of illness per case treatment. The value is in line with neighboring countries. In Uganda the annual cost of health care (medication, other cost) due to HAP related diseases was 12 EUR per household using the traditional stove and 8 EUR per household using the ICS Rocket Lorena stoves.[78] In Kenya the mean private cost of managing ARI were US$17 per case, where medicine constituted the main driver of cost.[79] For four combinations of low/high incident of ARI and low/high rate of reduction of diseases due to ICS, health expenditures saved per household and year range between US$0.2 to US$14; an average of US$4 is used.

(ii) **Time savings in cooking.** The monthly time saved, is typically the product of baseline cooking time and time efficiency of the stove relative to the traditional stove, multiplied by the opportunity cost of time. Literature suggests the average daily cooking time with a traditional wood stove is suggested at 4 hours per day and time efficiency ratios between 0.35 and 1.5 for low and high efficiency stoves.[80] A study in Uganda found that ICS reduced average cooking time by 1.82 hours per day, of which 25% were assumed to be time effectively saved (thus 0.455 hours/day).[81] In this analysis, an average time efficiency ratio of 0.7 is assumed, resulting in savings of ca. 1hour/day.

(iii)**Time savings in wood collection.** In Rwanda it is assumed that 5kg of fuelwood are collected in one trip of 2 hours.[82] Thus 183kg/months are collected in ca. 2.4 hours/day. Similarly, Jeuland and Pattanayak (2012) suggest between 0.3 and 3 hours/day are spent collecting wood. Under the assumption that *Inyenyeri* customers buy BFP and stop woodfuel collection, this results in a total potential annual time saving of US$27. Rural households who collect 152kg biomass/month for Inyenyeri, achieve a time saving of ca. 1 hours/day, resulting in US$11/year. These variables are subject to sensitivity analyses.

14. **Results.** Over five years and a discount rate of 15%, rural Inyenyeri customers who pay for the ICS and the BFPs, bear an incremental loss compared to the without project scenario at a net present value (NPV) of -US$238; households who lease the stoves and exchange fuelwood for pellets, could achieve and an incremental net benefit at a NPV of US$56. The benefits stem from savings in health-related expenditure and productive use of a share of their time. For urban households the analysis yields NPV of incremental net benefits of US$128, if they pay for the ICS; and US$178 if the stove is leased, as the average annual cost savings from switching from charcoal to BFPs is about 20%. DelAgua customers could achieve a NPV of incremental net benefits of US$225, because they can achieve ca. 50% of wood fuel savings (Table 1).

[76] Ministry of Health (2010): Rwanda National Health Insurance Policy.
[77] Institute for Health Metrics and Evaluation, Human Development Network, The World Bank. The Global Burden of Disease: Generating Evidence, Guiding Policy— Sub-Saharan Africa Regional Edition. Seattle, WA: IHME, 2013.
78 Habermehl (2007)
79 Matu, MN (2015): Risk factor and cost of illness for acute respiratory infections in children under five years of age attending selected health facilities in Nakuru county, Kenya. Doctoral thesis. Jomo Kenyatta University of Agriculture and Technology.
[80] Jeuland and Pattanayak (2012).
[81] Habermehl (2007)
[82] Drigo et al. (2013); In Uganda, a shadow price of USD0.012/kg is reported (Habermehl. 2007)

15. **Sensitivity analysis** (Table 2) shows that the participation in the project is largely feasible for household, except rural households if they are self-financing the stoves, and for increases in BFP price for urban households.

Table 1. Financial model for several household types. If appropriate the values are averaged over 5 years lifetime of the project. In US$.

		Inyenyeri				**DelAgua**
Category	**Items**	**Rural (self-financing)**	**Urban (self-financing)**	**Rural (leasing)**	**Urban (leasing)**	**Rural**
Capital cost	MimiMoto; EcoZoom[(a)]	10.5	10.5	0	0	17
Variable cost	Registration fee	5	7	5	7	0
	Maintenance cost	3.5	3.5	0	0	3.5
	Av. annual BFP cost	100.8	189	0	189	0
	Inconvenience cost	0.5	0.5	0.5	0.5	0.5
Avoided cost	Avoided charcoal cost	0	228	0	228	0
	Avoided woodfuel cost	0	0	0	0	73
Health benefits	Morbidity reduction	4.3	4.3	4.3	4.3	4.3
Time saved and put to productive use	Wood collection	27	0	5	0	0
	Cooking efficiency	9	9	9	9	9
Av. annual net revenue of incremental benefits		-79	31	12	45	66
Net present value (5 years)		-238	128	56	178	225
Net present value (10 years)		-389	177	84	478	388
Net present value (15 years)		-465	201	254	700	468

Note: (a) capital cost are presented annual over 5 years

Table 2. Sensitivity analyses for several variables and household types.

			Inyenyeri				DelAgua
Variable	**Change in Value**	**Indicator**	**Rural (self-financing)**	**Urban (self-financing)**	**Rural (leasing)**	**Urban (leasing)**	**Rural**
Stove utilization ratio (a)	-10%	Average net revenue	-81	29	9	43	64
		NPV (5 years)	-245	121	47	172	219
		NPV (10 years)	-399	167	72	458	378
	-30%	Average net revenue	-85	25	4	39	60
		NPV (5 years)	-258	108	31	158	205
		NPV (10 years)	-419	147	47	419	358
	-50%	Average net revenue	-89	21	-1	35	56
		NPV (5 years)	-271	95	15	145	192
		NPV (10 years)	-439	128	23	380	338
BFP price (Inyenyeri) increase	+ 10%	Average net revenue	-89	12	-	26	-
		NPV (5 years)	-271	67	-	117	-
		NPV (10 years)	-442	79	-	273	-
	+ 30%	Average net revenue	-109	-25	-	-11	-
		NPV (5 years)	-336	-56	-	-6	-
		NPV (10 years)	-547	-118	-	-137	-
	+ 50%	Average net revenue	-129	-63	-	-49	-
		NPV (5 years)	-402	-179	-	-129	-
		NPV (10 years)	-652	-315	-	-548	-
Rural woodfuel demand for traditional stoves	-10%	Average net revenue	-82	-	10	-	51
		NPV (5 years)	-247	-	49	-	177
		NPV (10 years)	-403	-	74	-	313
	-30%	Average net revenue	-87	-	6	-	22
		NPV (5 years)	-266	-	36	-	80
		NPV (10 years)	-431	-	55	-	163
	-50%	Expected net revenue	-93	-	2	-	-7
		NPV (5 years)	-284	-	23	-	-16
		NPV (10 years)	-458	-	36	-	13
Shadow wage /value of time [(a)]	-50%	Average net revenue	-97	27	5	41	61
		NPV (5 years)	-299	112	35	163	209
		NPV (10 years)	-481	154	53	431	364
	-100%	Average net revenue	-115	22	-1	36	57
		NPV (5 years)	-360	97	14	147	193
		NPV (10 years)	-573	130	22	384	340
Price increase for DelAgua stoves	+25%	Average net revenue	-	-	-	-	61
		NPV (5 years)	-	-	-	-	207
		NPV (10 years)	-	-	-	-	369
	+50%	Average net revenue	-	-	-	-	57
		NPV (5 years)	-	-	-	-	188
		NPV (10 years)	-	-	-	-	351

Note: (a) The stove utilization ratio in the baseline scenario is 70%. (b) The base value is 25% of daily wage rate US$1, implying that 25% of the saved time could be used for productivity activities.

3. ECONOMIC ANALYSIS

16. For the economic analysis, the financial models are aggregated over 10 years, and below benefits and cost are considered. Economic price are used and traded items (i.e. cookstoves) are adjusted by the shadow exchange rate factor to convert to domestic price level. The discount rate is 6%, recommended by a World Bank guidance note, the phasing of project cost and

beneficiaries is available in Table 3. It is assumed that recurrent cost of 2% apply from project year 6 to 11.

17. Benefit streams include:

(i) **The economic benefits of reduced mortality** can be estimated by multiplying the value of statistical life[83] by the decrease in the expected monthly risk of death per household due to the diseases. The incident is weighted by the fraction of diseases that are lower respiratory illness (ALRI) based on evidence that ALRI is the main contributor of mortality. The value of statistical life ranges between US$10,000-US$50,000; the fraction of ALRI was found to be between 0.04-0.25 and case fatality between 0.01 and 0.05 lives lost per case. For an average value of statistical life (US$30,000) and average incident of ARI (0.55 cases per person/year), the reduction of economic cost of mortality ranges between US$10 and US$330 per year and household.[84] The conservative value of US$10 is used which results in on average US$2.2 million/year.

(ii) **Value added in the retail/distribution chain.** For each cookstove sold by DelAgua, the value added is estimated at US$5 per unit sold.[85]

(iii) **Incremental net benefits accruing to households.** These values stem from the aggregation of the financial analysis for DelAgua and Inyenyeri. A moderate scenario with 70% adoption rate, 70% stove utilization rate are assumed. DelAgua plans to gradually roll out 63,483 cookstoves and Inyenyeri plans to reach 94,500 households between 2017-2021, thereof 25% in rural and 75% in urban areas. One stove per household is assumed. Assumptions of beneficiary roll out are presented in Table 3.

(iv) **Reduced benefits to producers and distributors of charcoal and charcoal stoves.** In 2011, the woodfuel sector employed about 20,000 people.[86] The displacement of charcoal by biofuel pellets and improved woodfuel stoves will result in loss to the sector.[87] The average charcoal consumption per household is 504kg/year, sales price in Kigali US$0.41/kg in 2016, which are is assumed to increase 5% per year until 2025. The resulting loss is assumed at 50%; leading to an average net benefit of US$0.25per kg. The average annual loss is US$0.9 million.

(v) **Greenhouse gas emissions reductions ER.** For DelAgua it is expected to deliver ca. 317,000 CER by 2022 and Inyenyeri ca. 2,305,152 CER by 2022 (Table 3). Under the applicable World Bank Guidelines, the social cost of carbon[88] is valued at US$30 per tCO_2e.

[83] The value of statistical life is obtained by looking at individual's risk-wage trade-offs of expenses on private goods that reduce mortality risks. The expected risk of death is a function of the disease case fatality rate for ARI.

[84] Jeuland and Pattanayak (2012).

[85] Estimate taken from Madagascar – Ethanol Clean Cooking Climate Finance Program (P1154440).

[86] 7,000 loggers, about 8,000 charcoal burners, about 200 to 300 transporters and 2,000 charcoal vendors in the urban areas. World Bank (2012)

[87] https://cdm.unfccc.int/DNA/fNRB/index.html.

[88] The SCC is an estimate of the economic damages associated with a small increase in carbon dioxide (CO2) emissions, conventionally one metric ton, in a given year. The climate change damages includes changes in net agricultural productivity, human health, property damages from increased flood risk, and changes in energy system costs, such as reduced costs for heating and increased costs for air conditioning. The SCC is assessed with three integrated assessment models; estimates for 2020 for discount rates between 5% and 2.5% are US$12, US$43, and $62 per ton of CO2-equivalent emission. The World Bank proposes a social cost of carbon of US$30 for 2015 to include in the economic analysis. (Cp.: United States Environmental Protection Agency Technical documentation available n: http://www3.epa.gov/climatechange/EPAactivities/economics/scc.html; January 2016; and World Bank (2014): Technical guidance note on the social value of carbon; or: http://www.worldbank.org/en/topic/climatechange/brief/integrating-climate-change-world-bank (Accessed January 2016)

18. **Results and sensitivity analyses**. For moderate scenario with 70% adoption rate, results show that project can achieve an economic NPV (ENPV) of US$84.8 million over 10 years, at a discount rate of 6%, and an economic internal rate of return (EIRR) of 103%. Average aggregated household benefits have share in total benefits, 25%, emissions reduction, 73%, reduced mortality 5% and reduced charcoal benefits 2%. Without emissions reduction benefit, the NPV is US$13 million and ERR 29% (Table 4). Sensitivity analyses are conducted for key variables, for situation with and without certified emissions reduction (CER) credits (Table 5). Without accounting for emissions reduction credits at a social cost of carbon of US$30 tCO2e, the EIRR for reduction in adoption rate to 50% or reduction in overall benefit by 30% become low and close to the assumed discount rate of 6%.

Table 3. Phasing of project beneficiaries and cost

	2017	**2018**	**2019**	**2020**	**2021**	**2022**	**Total**
Project Cost (US$)							
DelAgua's Project Financing	1,425,669	4,574,331	-	-	-	-	**6,000,000**
Inyenyeri's Project Financing	2,642,857	4,285,714	7,071,429	-	-	-	**14,000,000**
Carbon Finance Transaction	-	431,311	2,211,015	5,007,674	-	-	**7,650,000**
Total	**4,068,526**	**9,291,356**	**9,282,444**	**5,007,674**	**-**	**-**	**27,650,000**
Beneficiaries (Number)							
DelAgua stoves roll out plan	15,084	48,399	-	-	-	-	63,483
Inyenyeri roll out plan	15,000	30,000	49,500	-	-	-	94,500
Total	**30,084**	**78,399**	**49,500**	**-**	**-**	**-**	**157,983**
Certified Emissions Reductions (tCO2e)							
DelAgua	-	7,041	43,716	88,900	88,900	88,900	317,457
Inyenyeri	-	41,090	205,450	505,408	776,602	776,602	2,305,152
Total	-	**48,131**	**249,166**	**594,308**	**865,502**	**865,502**	**2,622,609**

Table 4. Benefits and cost streams in million US$, for adoption rate of 70%

	PY2	**PY3**	**PY4**	**PY5**	**PY6**	**PY7**	**PY8**	**PY9**	**PY10**
Benefits of reducing mortality	0.21	0.76	1.11	1.11	1.11	1.11	1.11	1.11	1.11
Value added from DelAgua cookstoves	0.08	0.24							
Households' benefits (Inyenyeri and DelAgua)	0.71	2.96	7.19	6.80	6.60	6.78	6.81	6.81	6.81
Reduction in benefits charcoal value chain.	0.10	0.30	0.66	0.70	0.73	0.77	0.81	0.85	0.89
GHG emissions reduction, US$30/tCO2e	0.00	1.01	5.23	12.48	18.18	18.18	18.18	18.18	18.18
Sum	0.99	4.97	13.53	20.39	25.89	26.06	26.10	26.10	26.10
Project cost	4.07	9.29	9.28	5.01	0.55	0.55	0.55	0.55	0.55
Net benefits (with GHG benefits)	-3.17	-4.62	3.58	14.68	24.60	24.74	24.74	24.70	24.65
Net benefits (without GHG benefits)	-3.17	-5.63	-1.65	2.20	6.42	6.57	6.56	6.52	6.48

Table 5. Sensitivity analyses for with and without inclusion of GHG ER benefits valued at a social cost of carbon; ENPV in US$ and ERR in percentage

Variables	Rate of change/value	with ER		without ER	
		ENPV	EIRR	ENPV	EIRR
Base scenario					
Adoption rate	***70%***	***$84.81***	***103%***	***$13.28***	***29%***
Sensitivty analysis					
Adoption rate	**100%**	$134.70	170%	$32.51	67%
	90%	$117.96	145%	$26.00	53%
	50%	$52.08	66%	$0.98	8%
Increase in total project cost	**10%**	$82.38	91%	$10.85	23%
	20%	$79.96	82%	$8.43	18%
	30%	$77.53	74%	$6.00	14%
Reduction in benefits	**-10%**	$73.90	90%	$9.52	22%
	-20%	$63.00	78%	$5.77	16%
	-30%	$52.09	66%	$2.02	9%
Decreased shadow wage	**-50%**	$81.85	97%	$10.32	24%
	-100%	$78.89	91%	$7.36	19%
Reduction in emissions reductions	**-10%**	$72.13	96%		
	-20%	$61.20	88%		
	-30%	$51.81	81%		

4. CONCLUSION

19. The financial and economic analysis demonstrate a positive ENPV and EIRR, and thus the profitability of the intervention from a household as well as societal point of view, even for sensitivity analyses scenarios. For a conservative scenario with an adoption rate and stove utilization rate of 70% the project can achieve a net benefits of US$84.8 million over 10 years with an EIRR of 103%. Without emissions reduction benefits, the ENPV is US$13 million and EIRR 29%. The sensitivity analyses show that ENPV and EIRR can drop sharply if emissions reduction benefits, valued at a social cost of carbon, are not factored in and adoption rates or total benefits are low. The financial analysis on household level shows that rural households, who finance the adoption of ICS themselves, do not have sufficient financial incentive to do so. While the project provides sufficient incentives, the profitability of the adoption critically depends on price of BFP and the efficiency of their current stove, as well as their opportunity cost of time. If households have no rural employment opportunities at all, net benefit may be small and stem from reduced health expenses or the difference between the BFP and charcoal price. It is expected that women, who are the main users of the stoves, may benefit most from increased time saving and decreased exposure to fumes. However, too little is known about intra-household level decision making to understand to which extent women are involved in household decision making and gain any monetary benefits from switching to ICS.

Annex 5: Analysis of Business Models Viability

FINANCIAL VIABILITY OF BUSINESS MODELS

Overall Approach to Analysis : Given the two business models proposed by DelAgua and Inyenyeri are different, and the two companies have different short and long term goals, the financial viability analysis has been carried out separately for the two business models. In the case of DelAgua, Financial Internal Rate of return (FIRR) is chosen as the indicator for financial feasibility, while in the case of Inyenyeri, Debt Service Coverage Ratio (DSCR) is adopted for the same purpose. Sensitivity analysis is also conducted and the impact on carbon price by key parameters are also looked into. The financial analysis for DelAgua and Inyenyeri are shown separately in the section below.

DelAgua Business Model:

- **Inputs & Assumptions**

Total project cost and financing plan for DelAgua sub-component are shown in Table 1 below. The total amount of cash outflows to be covered during the period 2016-2013 is US$94 million, which will be initially funded based on a 1:2 debt/equity ratio with Maji [89]providing the debt financing and with an equity investment that will be arranged in the future.

Table 1. Project costs and Financing plan

Project Costs (2016-2023)			Financing Plan (2016-2023)		
Cash Uses	**Amount**	**%**	**Cash Sources**	**Amount**	**%**
Operating & Investment Expenses			**Debt**		
Cost of Stoves	42,585,805	45%	Maji Loan	10,000,000	9%
Other Operating Expenses	43,409,930	46%	Short-Term Debt	1,734,001	2%
Capital Expenditures	5,040,000	5%			
Interest Expense	2,999,549	3%	**Equity & CER Sales**		
			Equity Financing	20,000,000	18%
			Cash Flow from Stove Sales	58,547,656	54%
			CER Sales - Ci-Dev	2,000,000	2%
			CER Sales - Retail CER Market	15,884,796	15%
Total	**94,035,284**	**100 %**	**Total**	**108,166,453**	**100%**

The Financial Projections are made based on the project costs and the estimated sales schedule shown in Table 2.

Table 2: Projection of Unit Sales and CER Generation

[89] Maji Holding AG (Maji Holdings) is based in Switzerland and its investors partially overlap with original investment group to DelAgua, i.e. Signina investment which was liquidated. On April 27, 2016, Maji Holdings signed a $10 million loan agreement with DelAgua Health Rwanda Ltd.

Dashboard	2016	2017	2018	2019	2020	2021	2022	2023	2024	Total
Unit Sales:										
EZ Stove - Concessional	263,200	0	0	0	0	0	0	0	0	**263,200**
Gasifier - Concessional	2,500	100,000	0	102,000	0	263,200	0	0	0	**467,700**
Gasifier - Retail	0	6,550	25,800	64,784	60,248	56,032	58,658	74,260	111,292	457,624
Total Unit Sales	**265,700**	**106,550**	**25,800**	**166,784**	**60,248**	**319,232**	**58,658**	**74,260**	**111,292**	**1,188,524**
Cumulative Unit Sales	*265,700*	*372,250*	*398,050*	*564,834*	*625,082*	*944,314*	*1,002,972*	*1,077,232*	*1,188,524*	
CER Ready for Sale From:										
EZ Stoves - Concessional	0	332,345	223,459	335,189	410,624	39,139	0	0	0	1,340,757
Gasifier - Concessional	0	5,313	108,906	163,359	217,813	326,188	478,656	893,364	884,580	3,078,178
Gasifier - Retail	0	0	0	12,126	67,068	188,599	317,873	431,180	441,379	1,458,225
Total CERs Generated	**0**	**337,658**	**332,366**	**510,674**	**695,504**	**553,926**	**796,530**	**1,324,544**	**1,325,959**	**5,877,160**
Cumulative CERs Generated	*0*	*337,658*	*670,023*	*1,180,698*	*1,876,202*	*2,430,128*	*3,226,658*	*4,551,202*	*5,877,160*	
Summary of Ci-Dev Purchase										
CERs for Sale from Retail Gasifier Stoves	0	0	0	12,126	67,068	188,599	317,873	431,180	441,379	1,458,225
Ci-Dev CER Purchases	**0**	**0**	**0**	**12,126**	**67,068**	**188,599**	**49,667**	**0**	**0**	**317,460**
Cumulative CER Purchases	*0*	*0*	*0*	*12,126*	*79,194*	*267,793*	*317,460*	*317,460*	*317,460*	

In order to discourage DelAgua to continue with free/concessional distribution of stoves, CERs generated from retail sale of stoves (Tier 2 and above in thermal efficiency) will only be purchased by Ci-Dev. It was estimated that CER generation will start in 2019 for conservativeness. Although the exact model of the stoves are not yet finalized, DelAgua has considered gasifier stoves for its retail phase. The 457,624 retail gasifier stoves to be disseminated under the program are expected to generate 1,458,225 CERs between 2019 and 2024 (please refer to Table 2 above). Ci-Dev intends to purchase only 317,460 CERs resulted from the sales and use of 213,414 gasifier cookstoves (see table 3 below).

Table 3. Projection of retail sales, CER generation and Ci-Dev purchase

	2016	2017	2018	2019	2020	2021	2022	2023	2024	Total
Summary of Ci-Dev Purchase										
Gasifier - Retail	0	6,550	25,800	64,784	60,248	56,032	58,658	74,260	111,292	457,624
CERs for Sale from Retail Gasifier Stoves	0	0	0	12,126	67,068	188,599	317,873	431,180	441,379	1,458,225
# of Stoves Underlying Ci-Dev ERPA		6550	25800	64784	60248	56032				213,414
Ci-Dev CER Purchases	**0**	**0**	**0**	**12,126**	**67,068**	**188,599**	**49,667**	**0**	**0**	**317,460**

Based on the project costs and sale projections, the detailed income statement are produced and shown in Table 4 below. The Project has three revenue sources: 1) stove sales via concessional and retail distribution, 2) revenue from CERs generated from 213,414 stoves under a potential Ci-Dev ERPA, and 3) CER sales – after delivery of Ci-Dev's firm and options volumes, including those generated from water filters – to other carbon buyers in the market. A carbon price of US$6.30 is determined for the Base Case based on the viability gap, which is explained in the following paragraphs. The summary of the balance sheet and cash flow statement is included in the Table 4.

Table 4. Summary of the project base case financials

Income Statement	2016	2017	2018	2019	2020	2021	2022	2023	2024
Sales Revenue	8,160,364	5,707,971	2,394,756	11,215,251	5,289,112	16,768,257	5,149,527	6,519,211	9,770,213
Carbon Revenue - CiDev	0	0	0	76,392	422,530	1,188,174	312,904	0	0
Carbon Revenue - Retail	665,123	1,783,713	1,417,301	1,870,880	2,220,461	1,271,890	2,399,669	4,255,759	4,260,305
Cost of Sales	(130,050)	(5,891,421)	(1,691,066)	(9,552,320)	(3,485,931)	(15,328,244)	(3,358,042)	(4,163,143)	(6,311,182)
Maintenance, Monitoring & Education	(4,254,244)	(4,747,454)	(5,156,338)	(4,660,316)	(4,580,331)	(4,580,347)	(2,360,363)	(2,360,379)	(2,560,395)
Distributions	(590,867)	(319,140)	(264,000)	(264,000)	(264,000)	(264,000)	(264,000)	(264,000)	(264,000)
Stock Movement	(8,193,521)	280,544	80,527	202,204	99,950	154,381	125,724	71,085	178,494
Gross Margin	**(4,343,196)**	**(3,185,788)**	**(3,218,821)**	**(1,111,909)**	**(298,209)**	**(789,888)**	**2,005,419**	**4,058,533**	**5,073,436**
Operating Expense	(1,612,920)	(1,646,462)	(1,152,504)	(722,504)	(632,504)	(632,504)	(632,504)	(632,504)	(632,504)
EBITDA	**(5,956,116)**	**(4,832,250)**	**(4,371,325)**	**(1,834,413)**	**(930,714)**	**(1,422,393)**	**1,372,915**	**3,426,029**	**4,440,932**
Depreciation	(71,933)	(209,067)	(277,933)	(291,134)	(316,533)	(335,533)	(369,534)	(399,533)	(412,733)
Interest Expense	(600,000)	(600,000)	(600,000)	(360,000)	(250,548)	(255,022)	(106,285)	(227,695)	0
Net Income	**(6,628,049)**	**(5,641,317)**	**(5,249,258)**	**(2,485,547)**	**(1,497,795)**	**(2,012,947)**	**897,096**	**2,798,801**	**4,028,199**
Balance Sheet	2016	2017	2018	2019	2020	2021	2022	2023	2024
Current Assets	10,568,080	23,561,576	14,028,259	8,856,619	5,486,560	3,226,420	3,136,960	5,053,961	9,292,525
Property, Plant, and Equipment	1,588,067	3,139,000	2,961,067	2,889,933	2,973,400	2,737,867	3,068,333	2,768,800	2,576,067
Total Assets	**12,156,147**	**26,700,576**	**16,989,326**	**11,746,552**	**8,459,960**	**5,964,287**	**6,205,293**	**7,822,761**	**11,868,592**
Current Liabilities	8,784,196	8,969,942	8,507,950	9,158,257	9,179,064	9,479,200	8,823,110	7,641,776	7,659,409
External Long-Term Debt Financing	10,000,000	10,000,000	6,000,000	2,592,466	782,862	0	0	0	0
Total Liabilities	**18,784,196**	**18,969,942**	**14,507,950**	**11,750,723**	**9,961,926**	**9,479,200**	**8,823,110**	**7,641,776**	**7,659,409**
Retained Earnings	(6,628,049)	(12,269,366)	(17,518,624)	(20,004,171)	(21,501,966)	(23,514,913)	(22,617,817)	(19,819,016)	(15,790,817)
Paid-In Capital	0	20,000,000	20,000,000	20,000,000	20,000,000	20,000,000	20,000,000	20,000,000	20,000,000
Total Liabilities and Equity	**12,156,147**	**26,700,576**	**16,989,326**	**11,746,552**	**8,459,960**	**5,964,287**	**6,205,293**	**7,822,761**	**11,868,592**
Cash Flow Statement	2016	2017	2018	2019	2020	2021	2022	2023	2024
Cash Flow from Operations	(5,442,823)	(8,304,380)	(3,493,625)	(1,611,639)	1,614,604	1,418,469	60,999	3,195,562	4,268,479
Cash Flow from Investment	(1,660,000)	(1,760,000)	(100,000)	(220,000)	(400,000)	(100,000)	(700,000)	(100,000)	(220,000)
Cash Flow from Financing	0	20,000,000	(4,000,000)	(2,907,534)	(1,214,604)	(1,318,469)	639,001	(1,198,394)	0
Beginning Cash Balance	10,000,000	2,897,177	12,832,797	5,239,172	500,000	500,000	500,000	500,000	2,397,168
Change in Cash	(7,102,823)	9,935,620	(7,593,625)	(4,739,172)	0	0	0	1,897,168	4,048,479
Ending Cash Balance	2,897,177	12,832,797	5,239,172	500,000	500,000	500,000	500,000	2,397,168	6,445,647

- **Benchmark Financial Internal Rate of Return (FIRR)**

Considering the nature and sources of funding proposed by DelAgua, the Weighted Average Cost of Capital (WACC) for the project is calculated to be 6.67%. A minimum of FIRR of 6.67% is therefore considered as the bench mark for the purpose of assessing the project's financial feasibility. The FIRR of the project without carbon revenue is below 6.67% indicating the need for carbon revenues. This has formed the basis of pricing the carbon for DelAgaua project. Tye analysis shows that at a carbon price of US$6.3/CER, the DelAgua project can earn an FIRR of 6.67%.

Several factors/parameters could impact the carbon price indicated above. To determine this impact, a sensitivity analysis has been conducted to assess the effects of variations in key parameters on the levels of CER prices required to fill the viability gap in the base case. Tables 5 and 6 below summarize the sensitivity analysis of variations in three key parameters (retail gasifier sales volume, volume of CERs generated per stove sold, and retail stove cost) that affect the carbon price:

Table 5. Price per CER Given Volume Sensitivities

		Price per CER (US$)				
		CER/Stove				
		+10%	+5%	0%	-5%	-10%
Retail Sales Volume	0%	$5.77	$6.03	$6.30	$6.63	$6.96
	-10%	$6.50	$6.79	$7.11	$7.45	$7.84
	-20%	$7.28	$7.60	$7.96	$8.34	$8.77

Table 6: Price per CER Given Retail Stove Cost

Price per CER ($)				
Retail Stove Cost				
-5%	0%	+5%	+10%	+15%
$5.80	$6.30	$6.79	$7.22	$7.68

Conclusion:

Although the business model is assessed to be viable with carbon finance revenues, the team considers DelAgua's proposal of raising US$94.0 mil to disseminate 830,000 stoves by 2023 very optimistic, as the ability to raise finance is linked to purchase of carbon credits. The team has therefore assessed the feasibility of DelAgua implementing a much smaller size project (with emphasis on retail sales) that can be supported through a carbon transaction of US$2.0 mil, and other sources of funding that could be leveraged. Based on information provided by DelAgua, the team concludes that, with the help of US$2.0 mil. carbon transaction with Ci-Dev, DelAgua can potentially raise about US$ 8.0 mil. funding. This would be adequate to disseminate a total of 63,000 stoves, around half of which being sold purely on retail basis, with profit margins that would subsequently allow DelAgua to pursue more retail sales.

Under a viable model with modest expansion and economies of scale, positive cash flow and the ability to service debt are dependent on CERs, and on the CiDev deal. Ci-Dev's carbon off-take agreement would thus enable DelAgua to access the required financing and kick start the retail sales while gradually scaling up the business as new carbon off-take arrangements are made beyond this limited Ci-Dev transaction.

There are various uncertainties over the establishment of retail markets amongst rural customer, and the team also examined the likelihood of achieving the intended outcome in an adverse scenario. It is estimated that with 27,566 stoves being sold and distributed by 2018 (only 13% of their actual sales target), DelAgua could achieve the emission reductions volume required by Ci-Dev by the end of 2022 which is 2 year ahead for the term of Emission Reduction Purchase Agreement (ERPA). Considering the presence and resource mobilization ability of DelAgua in Rwanda's coosktoves market, it is thus the team's opinion that the ER delivery target set for the project is moderate and realistic to be achieved, even if their business plan is not fully realized.

Inyenyeri Business Model :

Inputs and assumptions : The main investment cost for Inyenyeri involves (1) purchasing fan gasifying cookstoves based on customer base growth, (2) building new pellet plants to produce BFPs, (3) constructing new shops and hubs while customer base continues to grow and (4) procuring trucks and other vehicles. The investment for the project is made throughout the project cycle instead of only at the beginning. This is mainly due to the increased financial needs caused by increases in the customer base and fan gasifying cookstoves over time. In addition, it is assumed Inyenyeri will need to purchase new stoves to replace the retired ones every 4 years to maintain the existing customers. Based on the customer growth projection (shown in the Section 1), the investment costs during 2016-2020 are estimated and presented in the Table 7 below as per Inyenyeri's financial model.

Table 7. Projection of Investment Costs – up to 2020 (US$)

	2016	2017	2018	2019	2020	Total
Cost of stoves	1,017,500	1,523,700	2,880,310	5,381,630	7,182,000	17,985,140
New Hubs and Stores	5,300	246,200	515,400	782,900	1,296,000	2,845,800
New plants and lines	75,000	3,000,000	900,000	600,000	1,500,000	6,075,000
New trucks and vehicles	160,000	120,000	410,000	780,000	1,180,000	2,650,000
Total	**1,259,816**	**4,891,917**	**4,707,728**	**7,546,549**	**11,160,020**	**29,555,940**

To finance its business model, Inyenyeri is actively seeking debt and equity financing amounting to US$9 million and US$5 million, respectively. According to the financial model, Inyenyeri is planning to secure an initial loan – currently proposed to come from the BIX Fund[40] – to cover the costs of the fan gasifying stoves purchased till 2018. Inyenyeri has estimated the loan amount needed on a per stove basis and each stove would require US$60 debt financing to cover the stove price as well as the overhead cost incurred. Through multiplying the number of the purchase stoves till 2018 by US$60 loan/stove, the total value of the loan is estimated to be US$5.2 million. Table 8 below presents the breakdown of the financing plan.

Table 8. Financing plan and status

Donor/Investor	Date of closure	Status	Amount	Instrument
Grant			**$500,000**	
EEP Africa	2015	Closed	$500,000	Grant
Total Debt			**$8,500,000**	
BIX Fund	2016	Contingent on Ci-Dev	$6,000,000	Debt
Debtor 1	2016	In Negotiation	$500,000	Debt
Debtor 2	2016	In Negotiation	$150,000	Debt
Debtor 3	2016	Planned	$350,000	Debt
Debtor 4	2016	Planned	$1,500,000	Debt
Total Equity			**$5,000,000**	
Series A Investors	2016	Planned	$5,000,000	Equity
Total			**$14,000,000**	

Apart from the role of carbon finance as a determinant to raise the needed financing for the implementation business model, the viability of the project is based on the generation of enough revenues from the sale of BFPs to cover the investment cost and operation costs and repay debts. The table below summarizes the different sources of revenues. The main source of revenue is the sales of biomass fuel pellets which represent about 80% of the total revenues. Other revenue streams not included in the Table 9 below are carbon revenues and grants.

Table 9. Revenue stream

Revenues	2016	2017	2018	2019	2020	Total
Sales of BFPs	481,509	2,076,589	5,455,851	10,976,343	20,332,208	39,322,500
Rural (Barter)[42]	100,582	433,776	1,139,667	2,292,836	4,247,172	8,214,033
Registration fees	54,811	101,678	238,104	443,827	825,685	1,664,105
Total	638,918	2,614,060	6,835,640	13,715,025	25,407,085	49,210,728

- **Financial viability and Carbon Pricing**

Debt service ability is essential for the company to continue operation in the foreseeable future. Inyenyeri has demonstrated its solvency to serve its debt via debt service coverage ratio (DSCR). Table 10 presents the DSCR over the project lifetime without considering the carbon revenue. It clearly shows the debt paying ability of Inyenyeri continues to improve with greater operating cash flow and less debt to be paid off over time. The reviewer notices that Inyenyeri has taken into account the investment cash flow required as the numerator in the DSCR calculation. The reviewer confirms the approach is conservative as opposed to adopting only operating cash flow as numerator.

Table 10. Debt Service Coverage Ratio without Carbon Revenues

Key Financial Data	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Operating Cash Flow (A)	-$324,928	-$741,820	$655,102	$3,895,475	$9,416,279	$15,390,918	$19,914,331	$24,577,010	$29,271,177	$33,951,176
Interest payment (B)	$39,407	$152,825	$423,885	$559,447	$477,007	$463,087	$463,087	$416,778	$333,422	$266,738
Investment Cash flow (C)	$ (1,257,800)	$ (4,969,860)	$ (4,705,708)	$ (7,544,531)	$ (11,158,005)	$ (13,568,987)	$ (18,091,982)	$ (22,614,978)	$ (27,137,973)	$ (31,660,969)
Operating Cash + Interest + Investment cash flow (A+B+C)	-$1,543,321	-$5,558,855	-$3,626,721	-$3,089,609	-$1,264,719	$2,285,018	$2,285,436	$2,378,810	$2,466,626	$2,556,945
Debt Service (Repayment & Interest) (D)	$741,511	$746,599	$1,989,469	$2,381,561	$2,600,640	$2,161,994	$1,822,212	$1,504,078	$1,203,262	$657,610
DSCR based on EBIT (A+B+C/D)	(2.1)	(7.4)	(1.8)	(1.3)	(0.5)	1.1	1.3	1.6	2.0	3.9

A minimum DSCR of 1 is required for Inyenyeri to meet its debt obligation. The Table 10 above shows that Inyenyeri would have insufficient cash to serve its debt if prioritizing its investment need during the early years of the business (i.e. 2016-2020). While the debt requirements in 2016 and 2017 are relatively small and could potentially be met through equity or grant in the short run, it is critical that the debt obligations in 2018 and beyond need to be satisfied by healthy operating cash flow. Additional cash flow from other sources including carbon finance is thus quite essential. Based on the Inyeyneri's business plan, significant amount of funds will need to be secured to support the business expansion in Kigali region in early 2018. The reviewer has found that Inyenyeri will require at least a carbon price of **US$9.45/tCO2e** in order to generate adequate cash flow to support the business expansion and meet the DSCR threshold from 2018 and onwards (i.e. an average DSCR of 1 for the period of 2018-2020).

Table 11. Average DSCRs with and without Carbon Revenue

	2018	2019	2020	Average (2018-2020)
DSCR without carbon revenue	(1.8)	(1.3)	(0.5)	(1.2)
DSCR with carbon revenue (@$9.45/tCO2e)	(0.5)	0.7	2.8	1.0
DSCR with carbon revenue (@$10.37/tCO2e)	(0.4)	0.9	3.1	1.2

- **Sensitivity Analysis**

Through sensitivity analysis, the DSCR without carbon is calculated and the carbon price needed to achieve a minimum average DSCR is calculated. Two key parameters, i.e. BFP pellet price and ER generation volume are assessed for their impacts on the carbon price. Table 12 below presents the carbon price required under each pellet price scenario to reach the DSCR threshold. The price ranges from US$7.65/CER to US$11.25/CER.

Table 12. Sensitivity Analysis of Carbon Price Considering Variation of Pellet Price

Variation of pellet price	-20%	-10%	0	10%	20%
DSCR in 2018 without carbon	-0.4	-0.3	-0.1	0.0	0.1
Carbon pricing required to meet DSCR threshold($/tCO2)	11.25	10.35	9.45	8.55	7.65

Besides the BFP price, the carbon price is also heavily driven by the amount of emissions reductions that the project can generate. The base case is based on a weighted average CER of 4.7 CER/household/year. It is assessed that the volume of CER per household could go up to 5.67 CER/year on average, mixing urban and rural households. The change of ER volume will directly impact the cash flow of the project during the business establishment period (2016-2020) and subsequently the solvency of the project. Table 13 below shows the impact on carbon prices based on variations in emissions reductions volume.

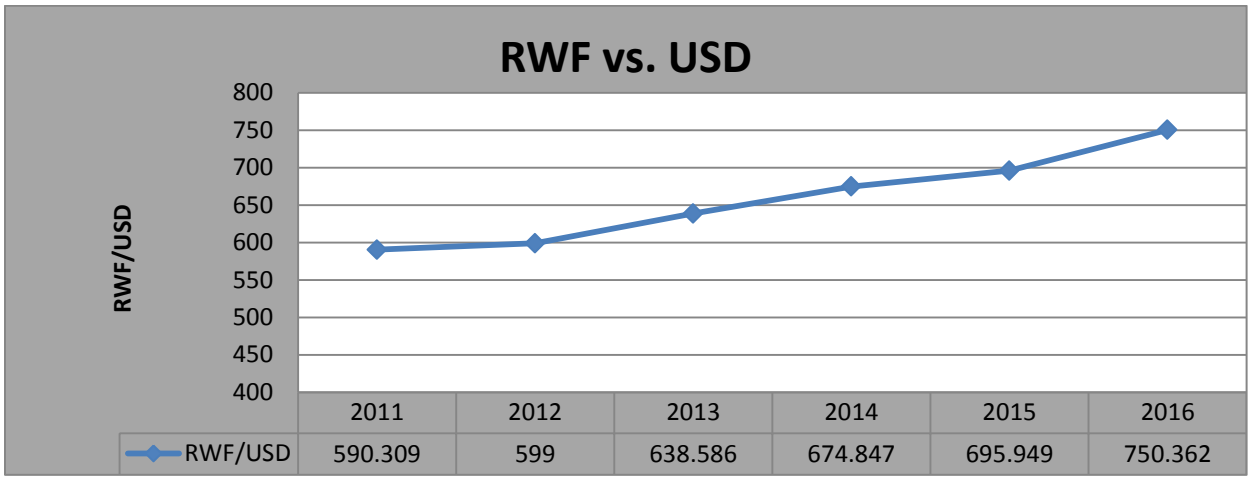
Table 13. Sensitivity Analysis of Carbon Price Considering Variation of Emissions Reductions Volume

Variation of ER generation	-20%	-10%	0	10%	20%
Total ER generation (2016-2020) (million ton)	1.7	2.0	2.2	2.4	2.6
Carbon pricing required to meet DSCR threshold (US$/tCO2)	11.85	10.50	9.45	8.60	7.88

The team also analyzed the likelihood for Inyenyeri to achieve the intended outcome under an adverse scenario. It is estimated that with approximately 25,000 stoves being distributed by 2019 (roughly 25% of their actual target), Inyenyeri could achieve the emission reductions volume required by Ci-Dev by the end of 2022 which is 2 year ahead of the closing of Emission Reduction Purchase Agreement (ERPA). The team thus finds the ER delivery target set for the project is moderate and realistic to be achieved.

- **Currency Risk and Impact on Business Model Viability**

Rwanda has seen depreciation in its currency (Rwanda franc or RWF) in the past few years and the trend continues due to the expectation of a strengthening US$. The following figure[90] presents the dollar appreciation against RWF in the past 5 years. The average dollar appreciation is 5% per year with highest appreciation of 7.8% in 2016.



For both sub-components (DelAgua and Inyenyeri), the majority of revenues will be received in local currency while the investment and financing costs will be paid in US$. Thus, both are subject to currency risk. Given the difference in business models, the currency risk is analyzed separately for each sub-component.

For DelAgua sub-component, the currency risk is more relevant to its retail sales. The risk is likely to be mitigated by (i) likely reduction in cost of stoves and (ii) by increasing the selling price of the stove. It may be noted that DelAgua's business model does not look at short term profits, rather a moderate return (6.67%) over a long term period of 10 years. During this period, cost of the stoves is likely to reduce, given the trend, and could partially offset the impact of any unfavorable exchange rate. The cost of wood and charcoal that form the baseline fuel also shows an increasing trend. The financial savings[91] on fuel costs from the improved thermal efficiency of the stoves is so significant that DelAgua could still be able to increase the price of the stove and still gain traction from potential customers.

In the high case where US$ appreciates by 10% annually, by 2020, the local price for the stove would reach approximately 93,000 RWF compared to the current sales price of 63,800, representing a 46% price increase. Based on the current sales price, the consumer could pay back the installments for the stoves in 2.6 years while obtaining 2,823 RWF savings per month compared to the status quo. Even in the high case, the consumer of DelAgua would be able to save 3,026 RWF per month despite of an extended pay-pack period of 4.2 years. With excessive savings, the consumer could always choose to pay back the loan. While there are many factors

[90] Annual average exchange rates are used. For 2016, the value is based on the data up to October 16,2016

[91] A household spends around RWF 5,000 - 10,000 (7,500 on average) per month to buy wood for cooking. The fuel costs savings could reach 70% by adopting the high efficient gasifier cookstoves. This results in 3,500 – 7,000 (5,250 on average) RWF savings per month.

which impacts the consumer's decision on a cookstoves product, the above analysis demonstrates the cost savings resulted from the using high efficient cookstoves will attract potential consumers even in a highly volatile currency environment provided that DelAgua could raise the customer awareness efficiently and extensively.

For Inyenyeri, the project has already built-in a 5% dollar appreciation in their base case financials.
With all other conditions remain unchanged, the annual 10% appreciation scenario is also examined. According to the table below, the total revenue and cost for both scenarios are presented. It is clearly indicated that US$ appreciation against RWF will cause the reductions in both revenues and costs. Provided that the amounts reduced in revenues are larger than in costs, the profits in US$ will shrink.

Table 14. Revenues and Costs given different exchange rate (2016-2020)

		2016	2017	2018	2019	2020
Total Revenues (US$)	Scenario 1 - 5% Annual Appreciation US$ (Base Case)	1,902,944	4,282,157	9,781,870	19,314,673	35,488,064
	Scenario 2 - 10% Annual Appreciation for US$	1,866,978	4,020,498	8,805,175	16,789,920	29,813,053
	Increase in Revenues	(35,966)	(261,660)	(976,695)	(2,524,753)	(5,675,011)
Total Costs (US$)	Scenario 1 - 5% Annual Appreciation US$ (Base Case)	1,880,165	4,118,308	7,121,836	11,396,628	18,273,893
	Scenario 2 - 10% Annual Appreciation for US$	1,813,710	3,796,246	6,365,246	9,876,071	15,380,917
	Increase in Costs	(66,455)	(322,061)	(756,590)	(1,520,557)	(2,892,975)

From the table above, the further dollar appreciation (from 5% to 10%) will reduce the profits denominated in US$ and thus deteriorate Inyenyeri's solvency. In order to mitigate the risk, a possible measure for Inyenyeri is to increase the pellet price. Base on the analysis, a mark-up of BFP by 9% will ensure Inyenyeri sufficient cash flow to meet its debt service obligation (i.e. the average DSCR to reach 1). In the base case scenario, the annual cost savings for the using by switching charcoal to BFPs is about 20%. Hence, the BFPs will remain attractive to the local customers even after a price increase of 9%.

Annex 6: IWA Tier Standard on Emissions, Efficiency, Indoor Emissions and Safety[92]

Tiers Associated With The Vita Water Boiling Test 4.1.2

EMISSIONS

	High Power CO (g/MJd)	Low Power CO (g/min/L)
Tier 0	>16	>0.20
Tier 1	≤16	≤0.20
Tier 2	≤11	≤0.13
Tier 3	≤9	≤0.10
Tier 4	≤8	≤0.09

	High Power PM (mg/MJd)	Low Power PM (mg/min/L)
Tier 0	>979	>8
Tier 1	≤979	≤8
Tier 2	≤386	≤4
Tier 3	≤168	≤2
Tier 4	≤41	≤1

EFFICIENCY / FUEL USE

	High Power	Low Power
	Thermal Efficiency (%)	Specific Consumption (MJ/min/L)
Tier 0	<15	>0.050
Tier 1	>15	<0.050
Tier 2	>25	<0.039
Tier 3	>35	<0.028
Tier 4	>45	<0.017

INDOOR EMISSIONS

	Indoor Emissions CO (g/min)	Indoor Emissions PM (mg/min)
Tier 0	>0.97	>40
Tier 1	≤0.97	≤40
Tier 2	≤0.62	≤17
Tier 3	≤0.49	≤8
Tier 4	≤0.42	≤2

[92] International Workshop Agreement developed by The International Workshop on Cookstoves under ISO (the International Organization for Standardization)

Tiers Associated With The Biomass Stove Safety Protocol Developed At Iowa State University

SAFETY	Score
Tier 0	<45
Tier 1	≥45
Tier 2	≥75
Tier 3	≥88
Tier 4	≥95