Inclusive Energy

Who's counting?

Exploring whether data pays in biogas carbon projects.

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ABOUT INCLUSIVE ENERGY

Inclusive Energy is a specialist smart metering company working in both solar and biogas. Our smart metering products are in use in 27 countries and are pushing beyond the state-of-the-art, bringing about new opportunities for their customers through digitization. Based in the UK and India, we incorporated in 2018 and launched Smart Biogas in 2021. We have carried out pioneering work in digital monitoring, reporting and verification (D-MRV) in the biogas market for several years; achieving methodological improvements to both CDM and Gold Standard to allow for digital approaches. We have been piloting digital D-MRV with leading stakeholders in Kenya and Uganda since 2022, as this report series details.

Contact us at info@inclusive.energy

ACKNOWLEDGEMENTS

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Who's Counting is the first public publication from the Digesting Data project led by Inclusive Energy, which looks at the opportunities and threats of digitizing the household biogas sector; further publications are planned in due course.

Our thanks go to all of the participants in the Digesting Data project that have made this project possible. This includes the teams at Africa Bioenergy Programs Limited and at Biogas Solutions Uganda Limited. We would also like to thank the 121 families across Kenya and Uganda that are using the biogas digesters from which the project data was derived. Thanks for their generous agreement to participate in the project.

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EXECUTIVE SUMMARY

The clean cooking sector attracts a relatively high value for carbon credits in the voluntary market, third only to forestry and agriculture. The value achieved by clean cooking projects reflects the co-benefits of clean cooking which doesn't just reduce emissions but also improves livelihoods. Yet biogas as a subsector of clean cooking attracts relatively weak carbon value when fully taking into account the dual benefits of clean cooking gas and organic fertilizer output that it provides. This is perhaps due to its relatively small size, when compared to improved cookstoves, and also due to noted concerns about accuracy in measurement of emissions reductions achieved through biogas projects.

SMART BIOGAS

Until recently there was no way of verifying whether accuracy concerns were justified. Smart Biogas, developed by Inclusive Energy, is a smart meter specifically designed for small and medium sized biodigesters. It is intended to be an affordable way to monitor biodigester performance. One use of the product is to track gas production and usage, as well as leakage and venting from the digester – meaning the information required for accurately calculating carbon offsets is now accessible.

DIGITISING DATA

The Digesting Data project is exploring whether the structural constraints and shortcomings in leading international carbon trading instruments can be lessened for the case of household biogas through digitization and remote monitoring. In this paper we looked at costs and revenues: comparing the costs of a non-digital vs a digital approach. Using actual costs for a non-digital approach and anticipated costs for a digital approach, the two options are compared over the course of an example 10-year carbon project. In a forthcoming paper we will go one step further – using the observed data for emission reductions through fuel substitution.

With an increasing focus on the accuracy and quality of carbon credits, this study is a first attempt to quantify the benefits of 'going digital' now and in future.

DOES DIGITAL PAY? COMPARING COSTS

The Gold Standard's 'new' MAMMBUTEG methodology has changed the monitoring and reporting requirement for both digital and non-digital approaches. A new single-survey regime and lower sampling requirements mean that both approaches are cheaper to accomplish. This paper finds that despite more expensive set-up costs, going digital in biogas carbon projects will pay for itself in year 4 of operations and achieve net cost savings thereafter. However, there is currently no way for monitoring approaches to go fully digital and some on the ground surveying is required even when using a digital approach.

A MISSED OPPORTUNITY? COMPARING REVENUE

Usage Rate was found to be a key factor that affected the lifetime payback of a digitally monitored project within this methodology. Digital monitored projects can claim 100% of the monitored Usage Rate against the sample compared to 90% for non-digital projects and this acts as an attractive incentive to go digital.

Leakage Rates, conversely, were found to be a rather blunt instrument where a blanket leakage rate is applied despite the insights offered through digital monitoring. The Digesting Data project has found leakage and venting rates below the default rates that are applied in the new Gold Standard methodology. It would make sense to allow digitally monitored projects to benefit from good performance, when it is shown to be the case.

PUTTING IT ALL TOGETHER

Going digital was found to be beneficial both in terms of costs reductions and revenue gains: In our example project, with metered sample size of 100 biodigesters, the additional costs for going digital are $14,300 and the additional maximum profit over the course of a 10-year project is $69,067, meaning a maximum return on investment of 383%.

Taking both cost saving and revenue gains into account, the potential upside is anticipated to be large enough for most organizations to opt for a digital approach and to attempt to harness a ‘transparency dividend’ in which their actual performance is better than the assumptions made under the non-digital approach.

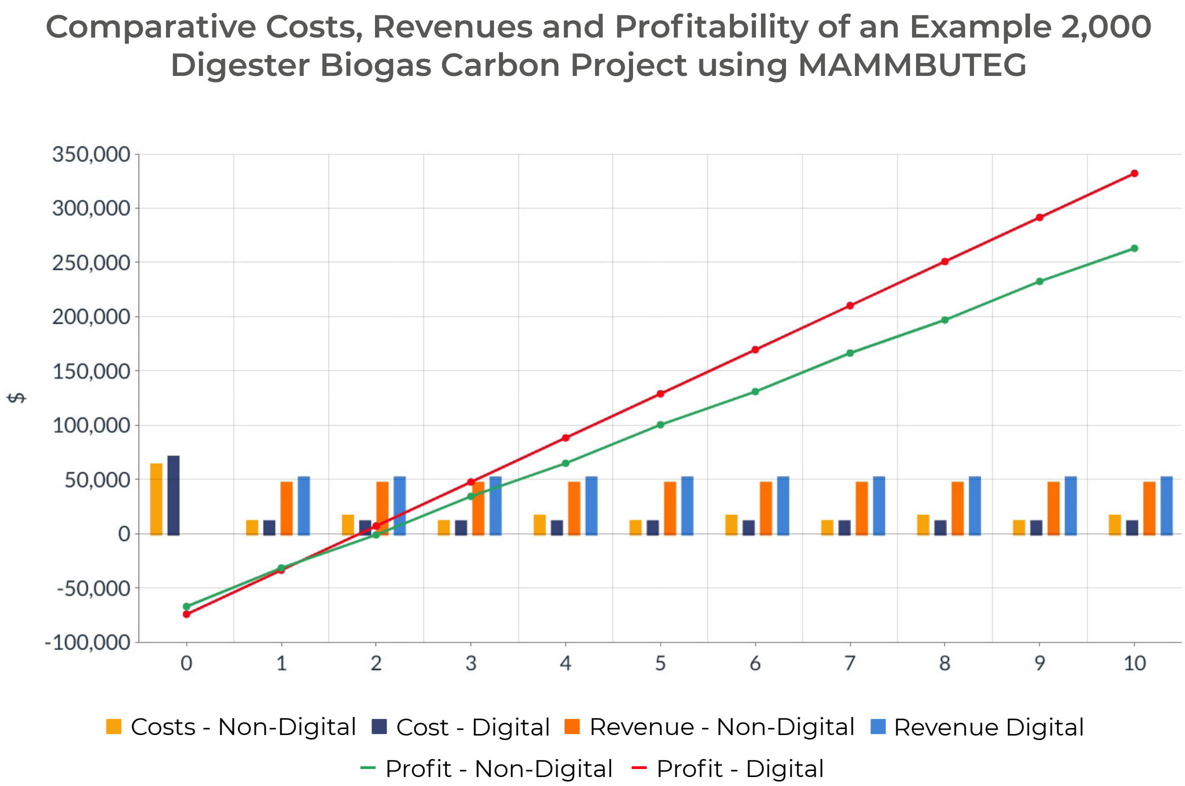

Figure 1 – Comparative business case of digital vs non-digital biogas carbon projects using theoretical maximum usage rates, and anticipated surveying costs over a 10-year project period.

DIGITAL PREMIUM

It is logical that robust digital monitoring can be a force for building confidence in carbon markets and could lead to higher carbon prices.

The ability to digitally link individual households and biodigesters to prospective buyers on voluntary markets is enticing - going beyond minimum sampling requirements towards a digital approach with 100% digital monitoring. This paper found that this model could work financially, offering a payback time of 5 years, if buyers were willing to increase the average price of carbon credits from $5 to $10. Inclusive Energy and partners are in the early stages of exploring whether newfound transparency will translate into buyer-side appetite for premium digitized credits.

INTRODUCTION

The desire and obligation for carbon emissions abatement has created a flow of capital seeking low-cost abatement opportunities, which can be harnessed by projects in low and middle-income countries. This has created a ripe opportunity for clean development – decarbonization coupled with economic, social, and environmental benefits.

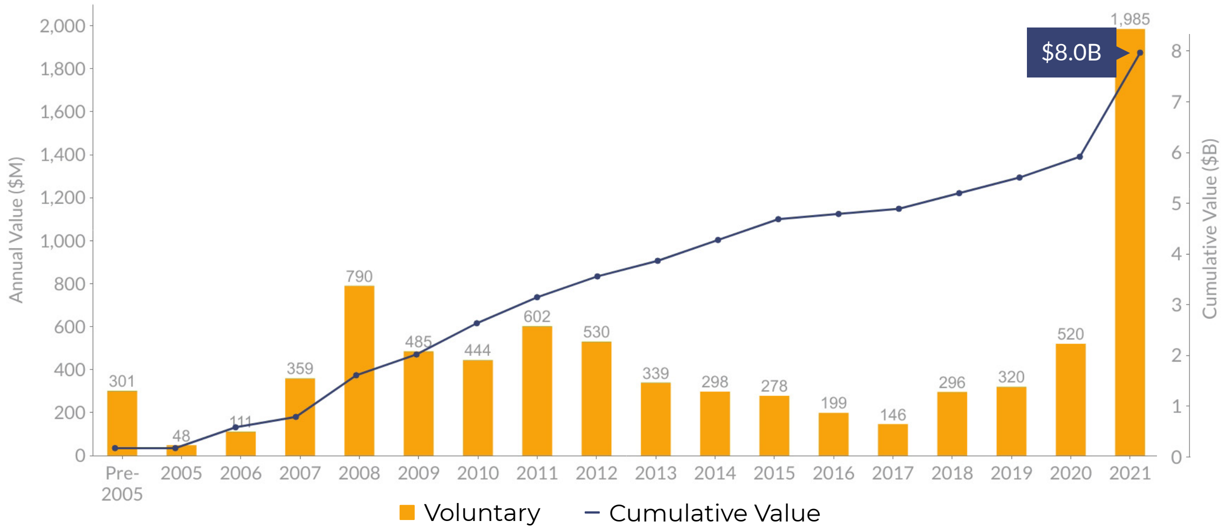

Figure 2 - Voluntary Carbon Market by Value of Traded Carbon Credits, pre-2005 to 2021. Adapted from Ecosystem Marketplace (2022).

After a slow decade after the financial crisis of 2008, the voluntary carbon market has sprung back into life. Total trading value reached almost $2bn in 2021, representing a near four-fold increase on the previous year[1].

Clean Cooking comprises a small fraction of total Voluntary Carbon Market (VCM) transactions, with 8m tons traded at a value of $21.6m in 2021[2]. However, the price achieved in the clean cooking sector is lower only than forestry and agriculture, and far higher than other categories such as commercial scale renewables, transportation, and manufacturing. The relatively high prices achieved by clean cooking projects reflects the co-benefits of clean cooking which doesn't just reduce emissions but also improves livelihoods through myriad factors including reduced indoor air pollution and reduced time spent collecting fuel.

Biogas is uniquely placed among clean cooking technologies as it offers an additional livelihood co-benefit. Biodigesters produce two products; biogas which can be used for energy creation, and bioslurry, a high-quality organic manure and liquid fertilizer which has value to users of biodigesters who can either use it or sell it. Thus, using biodigesters offers an unusually good route to impact through decarbonization. While the co-benefits of different decarbonization options may be 'priced in' to different categories to a small extent, for the most part co-benefits are not reflected directly in carbon prices. It is interesting to consider co-benefits nonetheless, as the Gold Standard have done in their Gold Standard for the Global Goals, a standard which aims to 'design projects for maximum positive impact in climate and development'. Figure 3 shows the value of different carbon

[1]*Forest Trends; Ecosystem Marketplace. 2022. The Art of Integrity: State of Voluntary Carbon Markets, Q3 Insights Briefing. Washington DC: Forest Trends Association.*
[2]*ibid*

reduction options with co-benefits priced in; biogas is the most impactful carbon reduction opportunity available.

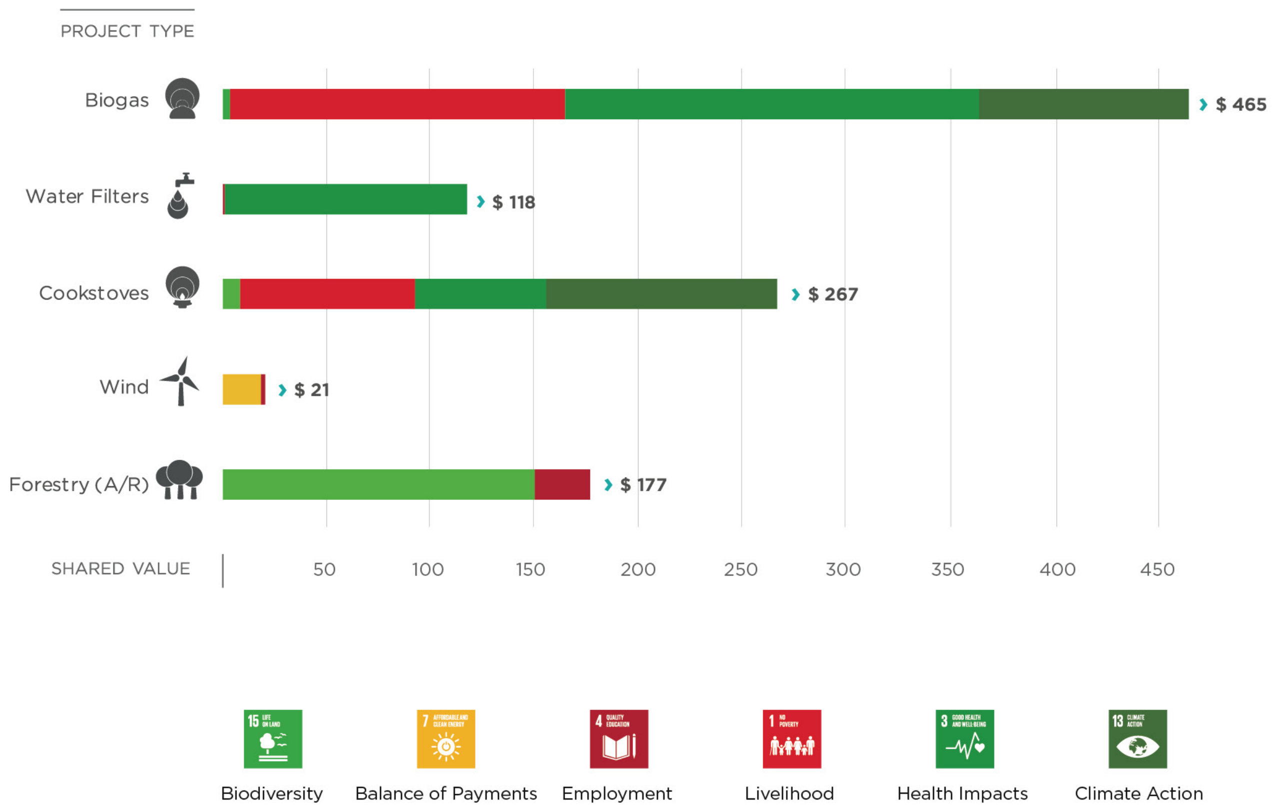

Figure 3 - Monetary value of Gold Standard project impacts. Adapted from Gold Standard.

Currently the market does not offer biodigester projects a significant price uplift versus other carbon abating technologies. In fact, there are notable examples of biodigester projects being offered carbon prices below those of other cooking technologies, and in our experience a carbon price of around $4 - $5/ton is the current norm. There are several reasons for this, firstly biogas is still relatively niche compared to improved cookstoves, for example. Secondly, there are lingering concerns about the accuracy of assumptions made about the mitigation potential of biogas – as unlike other cooking technologies it has both the potential to increase and decrease emissions, and the way a biodigester is managed is crucial[3]. Added to the modest carbon prices achieved, setting up carbon projects for biodigesters is a costly exercise. Given that biogas is a predominantly rural and peri-urban phenomenon, logistics and set up costs are a challenge, while the informational needs for biogas carbon projects are more extensive than other technologies due to the relative complexity of the technology. These revenue and cost challenges result in the need for projects to be large-scale (typically thousands of household scale biodigesters) to be profitable; a substantial barrier to entry exists for most organizations that would benefit from accessing the carbon market.

[3] *Sander Bruun, Lars Stoumann Jensen, Van Thi Khanh Vu, Sven Sommer, Small-scale household biogas digesters: An option for global warming mitigation or a potential climate bomb?, Renewable and Sustainable Energy Reviews, Volume 33, 2014 (Available at: https://www.sciencedirect.com/science/article/pii/S1364032114001543)*

SMART BIOGAS

Until recently there was no way of verifying whether accuracy concerns were justified. Smart Biogas, developed by Inclusive Energy, is a smart meter specifically designed for small and medium sized biodigesters.

It is intended to be an affordable way to monitor biodigester performance. One use of the product is to track gas production and usage, as well as leakage and venting from the digester – meaning the information required for accurately calculating carbon offsets is now in reach. Over the course of 2021 and 2022, with the support of the Clean Cooking Alliance, Inclusive Energy collaborated with both the Gold Standard and the Clean Development Mechanism to formally allow digital monitoring to be used in biogas projects for the first time.

The Digesting Data project is exploring whether the structural constraints and shortcomings in leading international carbon trading instruments can be lessened for the case of household biogas through digitization and remote monitoring. The project is exploring whether digitizing biogas carbon projects offers a benefit to project developers, and if not, what needs to happen to ensure that accuracy is awarded and incentives are aligned. The project used data collected using Smart Biogas from a fleet of biodigesters in Uganda and Kenya, and data from existing carbon projects registered in those two countries.

Two angles of inquiry were taken, firstly in this paper we look at costs and revenues: comparing the costs of a non-digital vs a digital approach. Using actual costs for a non-digital approach and anticipated costs for a digital approach are compared over the course of an example 10-year carbon project. We also discuss some of the prevailing methodological assumptions around the allowable Usage Rates and Leakage Rates. We then present a comparison of the digital vs non-digital business cases for biogas carbon projects and discuss scenarios in which there is an 'Digital Premium' where digital credits are valued more highly due to the accuracy and transparency they offer.

In a forthcoming paper we will go one step further – using the observed data for emission reductions through fuel substitution. In this paper emission reductions for the digital approach are assumed to be in line with non-digital methodology assumptions, to enable ease of comparison between digital and non-digital business cases.

With an increasing focus on the accuracy and quality of carbon credits, this study is a first attempt to quantify the benefits of 'going digital' now and in future.

THE CARBON PROJECT PROCESS

Designing, developing, and implementing a carbon project is a large and specialist undertaking. Companies require in-house expertise or the support of dedicated carbon consultancies to manage the end-to-end process from project design to receiving Certified Emission Reduction certificates ("carbon credits"). Marketing and selling the credits is another task for which many organizations that wish to enter the carbon markets lack requisite expertise.

The general project cycle for a carbon project is shown below in Figure 4.

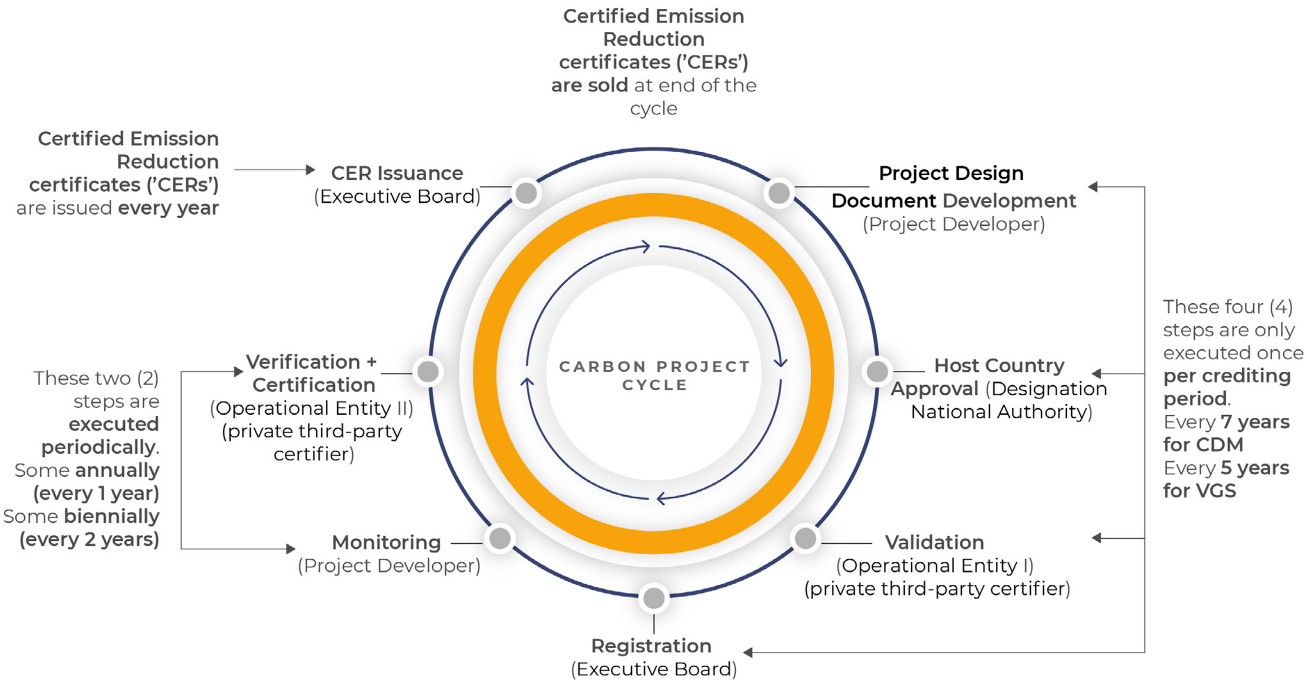

Figure 4: A generalized carbon project cycle adapted from UNFCCC. The lifecycle stages are shown along with the responsible entity for each stage shown in brackets. Monitoring, Verification and Reporting ('MRV') elements are running costs that are the Achilles' Heel of carbon projects.

The costs involved in setting up and managing a carbon project are considerable, in the tens of thousands of dollars. For this reason many organizations require external investment to get a carbon project off the ground. Investors may opt to take a cut of future income from sale of carbon credits as their route to repayment, although more typical debt and equity options are also available in the market.

The level of set-up and operational costs pertaining to carbon projects mean that they have to be undertaken at a certain scale at which the project's revenues are able to outweigh the initial and ongoing costs.

Business models differ from organization to organization. Those that are able to develop projects in-house are likely to have lower set up and operational costs

[3] *Sander Bruun, Lars Stoumann Jensen, Van Thi Khanh Vu, Sven Sommer, Small-scale household biogas digesters: An option for global warming mitigation or a potential climate bomb?, Renewable and Sustainable Energy Reviews, Volume 33, 2014 (Available at: https://www.sciencedirect.com/science/article/pii/S1364032114001543)*

as a result, while they will keep 100% of the project revenues. For this reason, projects that are funded from an organization's own balance sheet are likely to be financially viable at smaller sizes, however, they require the capital to set up the project in the first place.

Organizations that cannot develop projects in-house will lose part of the project revenues to either interest payments, or through sharing project revenues with an investor. However, they will not have an initial capital outlay to worry about. In this case projects typically need to be larger, say 1,000 digesters or more, to ensure financial viability for the implementer and their investors.

Figure 5 shows a sample financial projection for a biogas carbon project in Sub-Saharan Africa. This example assumes a revenue share deal with a carbon project investor, in which 30% of the profits go to the investor while 70% flow to the project owners. 5 metric tons of average CO2-equivalent abatement is assumed per biodigester, with a certificate retail price of US$5 per ton. Pursuant to these assumptions a fleet of around 1,000 biodigesters is required for a carbon project to make meaningful annual profit, while projects are often 2,000 digesters are more in size.

Through digitization we aim to increase profitability by lowering costs and increasing revenues. The result of this would, of course, be more profitable carbon projects and more money within the biogas sector. Beyond this, there is a more subtle outcome at stake – a matter of creating a more even playing field for smaller operators. Increased profitability of carbon projects would reduce the scale barrier to entry, meaning smaller projects and smaller organizations can participate.

The four main determinants of where the break-even point falls are :

- ***(i) Set up and operational costs***
- ***(ii) Number of digesters***
- ***(iii) Carbon credits achieved per biodigester (a function of digester size and usage)***
- ***(iv) The carbon price***

Digitization has potential impacts on several of these levers. In this paper we specifically explore (i) and discuss (iii) and (iv), while the next paper in the series will explore (iii) in more detail.

Example Profit and Loss on an Annual Basis for Biogas Carbon Projects of Varying Sizes

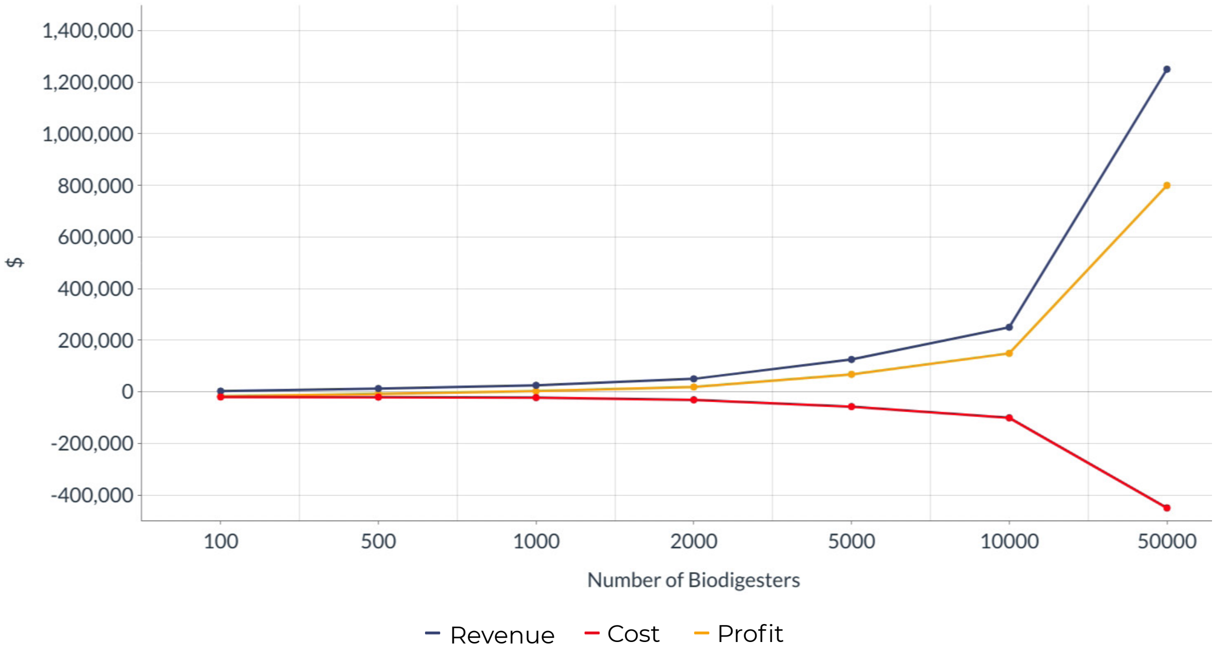

Figure 5 - Sample Revenue, Cost and Profit projection for a biodigester project Sub-Saharan Africa. We assume 5 metric tons of average CO2-equivalent abatement per biodigester, and certificate retail price of US$5 per ton with 30% of profits flowing to a project investor and 70% going to the project developer

COMPARING OPERATIONAL COSTS

In this study the 'status quo' of non-digital approaches to biogas carbon projects is compared with the new digital option. Data for the study comes from a trial set up as part of the Digesting Data project. The trial took place among the households that participated in the Project Performance Field Test (PFT) for carbon monitoring and verification of Gold Standard projects VPA06 in Kenya and VPA03 in Uganda.

Costs for the Smart Biogas digital monitoring method are compared with non-digital costs that come from proposals submitted by survey consultants for the existing VPA06 and VPA03 projects.

Initial costs to achieve a carbon project registration for non-digital and digital approaches are expected to be similar, with the obvious addition of the costs for smart meters for the digital approach. However, it was unknown at the beginning of the trial whether the lower ongoing operational costs for a digital approach would be low enough to offset the initial investment needed for the approach.

All carbon projects also require some data analysis for reporting purposes. Costs related to data analysis are likely similar with and without remote monitoring. Thus, the comparison is based on survey implementation only, while potential increased revenue from digital approaches is factored into our analysis.

COMPARING REVENUE

A sample from each project in Kenya in Uganda was chosen for data collection and 121 Smart Biogas units were installed. While data collection was ongoing the units were not actively monitored, but data was analyzed for the period spanning Mar 2022 through Dec 2022 in early 2023. Of the 121 biodigesters with Smart Biogas monitoring units, 90 saw regular end-user usage, of which 75 had datasets complete enough to merit inclusion in the study.

Of the 90 biodigesters being used, a majority (n = 83) showed venting at some time or other, whilst about a third (n = 44) showed leakage at least once over the course of the study. Looking at this in terms of volume of biogas vented and leaked, when contrasted to consumed, paints a far less dramatic picture, however. We estimate venting and leakage make up less than 4% and 3% respectively of consumption when assessed across the entire sample.

To be able to see a true indication of what is really happening in the field, the digesters with Smart Biogas units in the trial were not actively monitored. I.e. Inclusive Energy, BSUL and KBP teams did not intervene to change user behavior that could have been spotted through the Smart Biogas application. The data collected is used as the basis for the subsequent discussion around how methodologies assume usage and wastage of produced biogas, and what this means for carbon revenues gained and foregone.

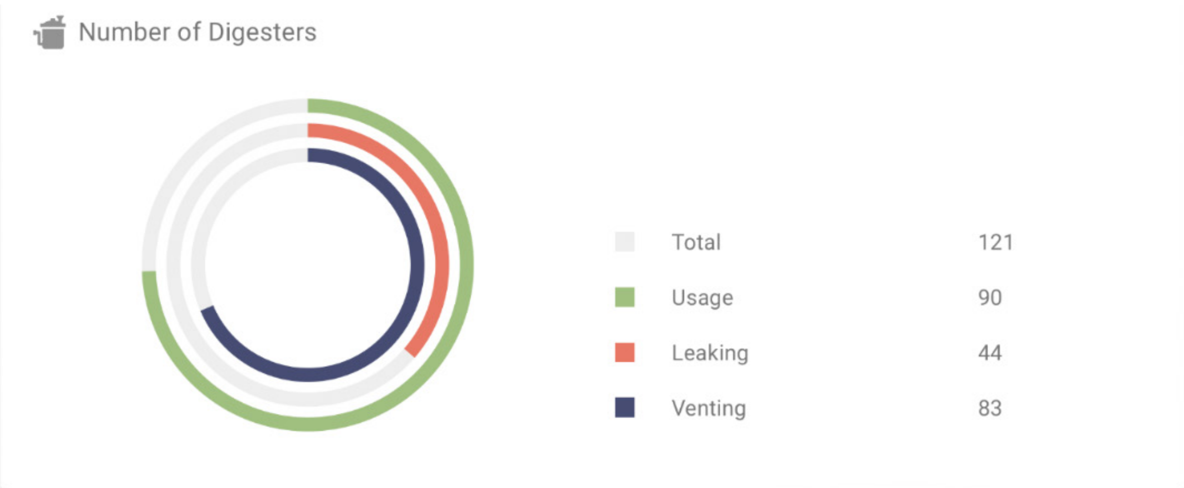

Figure 6 - Summary statistics: biodigester usage, leakage and venting by number of biodigesters.

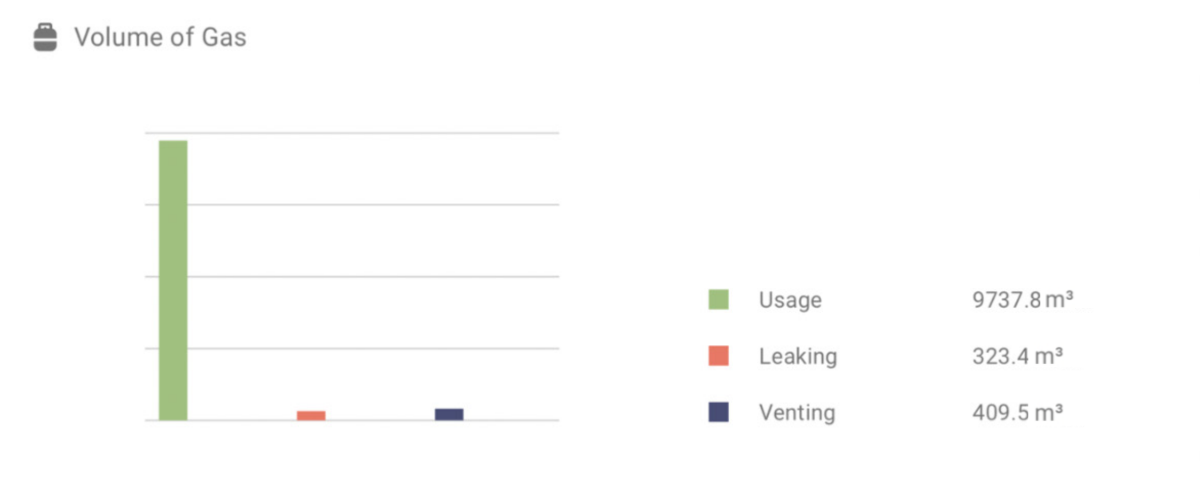

Figure 7 - Summary statistics: biodigester usage, leakage and venting by volume of biogas.

MONITORING ELEMENTS

The projects from the trial in Kenya and Uganda apply the Gold Standard's 'old' TPDDTEC V3.1 methodology, which has recently been replaced with the 'new' MAMMBUTEG 1.0 methodology. In accordance with TPDDTEC V3.1 the following surveys were required:

Survey	Purpose	Frequency	Sample Size	Scope for Digitisation	
				In TPDDTEC 3.1	In MAMMBUTEG 1.0
User Survey	SDG monitoring, AWMS, fuels used prior to installing a biodigester, bio-slurry management	Annual	At least 100	No	No
User Survey	Usage rate of biodigesters	Annual	At least 100 or 30 per age-group with more than 4 age-groups	Yes	Yes
Project Performance Field Test ('PFT')	Measurement of fuel use in addition to biogas for cooking	Biennial (every two years)	30, provided the level of precision is within the 30% interval of the 90% confidence level	No	Yes

Table 1 - Summary of surveys under TPDDTEC3.1, and prospects for digitization of each under both 'old' (TPDDTEC3.1) and 'new' (MAMMBUTEG) methodologies.

In the following sections the non-digital and digital costs for different survey components are compared. Thereafter, the overall costs of non-digital and digital approaches are considered, factoring in the advantages that the digital approach can offer.

SURVEY COSTS

The specific requirements for each of the TPDDTEC3.1 and MAMMBUTEG 1.0 Usage Surveys are detailed in Technical Appendix 1. The annual Usage Survey and biennial PFT costs received from credible consultants are tabulated below.

Country	Usage Survey Cost	Sample Size	Cost Per Sample
Uganda	$7,652	264	$28.99
Kenya	$6,251	210	$29.77

Table 2 - Summary of on-site Usage Survey costs under TPDDTEC3.1.

Country	PFT Cost	Sample Size	Cost Per Sample
Uganda	$5,790	60	$96.00
Kenya	$7,155	60	$107.40

Table 3 - Summary of on-site PFT survey costs under TPDDTEC3.1.

REMOTE MONITORING COSTS

The Smart Biogas digital monitoring costs consist of smart meters, travel, and data charges. The costs for setting up a remote monitoring campaign are shown below.

This example shows the minimum costs in which the smallest possible monitoring sample is used, and data is collected only for the minimum time period required. While this lean set-up offers a like for like comparison with the status quo surveying methods, it is also the case that organizations that opt for digital monitoring may wish to monitor all their assets rather than just monitoring the minimal sample for the sake of carbon projects.

It is assumed that smart meters are installed on a new digester sample every year, and a budget of $20 per installation is included on an ongoing basis. An additional $5 is included for running repairs of smart meters on an annual basis, this is in case of the need for replacement components such as solar panels and flow and pressure sensors.

Cost Item	Kenya	Uganda
Smart Meters Including Shipping	$110.00	$110.00
Travel, Installation and Repair & Maintenance (Annual)	$25 / unit	$25 / unit
Data Charges @ $0.60/month, for 2-Months Annually	$1.20	$1.20
Under 'Old' Methodology		
Number of Smart Biogas Meters Needed	264 + 10% contingency = 291	210 + 10% contingency = 231
Total Set-up Costs	$37,830	$30,030
Ongoing Annual Costs	$7,275	$5,775
Under 'New' Methodology		
Number of Smart Biogas Meters Needed	100 + 10% contingency = 110	210 + 10% contingency = 231
Total Set-up Costs	$14,300	$14,300
Ongoing Annual Costs	$2,750	$2,750

Table 4 - Summary of metered survey costs under 'old' and 'new' methodologies.

DOES DIGITAL PAY? COMPARING COSTS

'OLD' GOLD STANDARD METHODOLOGY

The proposition for using remote monitoring as a substitute to qualitative physical site visits is strongest where separate physical PFT and Usage Surveys are being replaced with Smart Biogas. However, the 'old' (TPDDTEC3.1) Gold Standard methodology does not allow remote monitoring as a substitute for PFT. As it stands, a Smart Biogas metering approach would only displace the Usage Survey. In this case the set-up costs of a digital approach are substantially higher than the non-digital approach, while the ongoing costs would be lower – as shown in Figure 8 below.

Clearly the benefits of a digital approach manifest over time when considering the benefits of swapping out the Usage Survey only in TPDDTEC3.1. However, there is little to choose between the two approaches over a 10-year project lifetime when considering the cost side only, and digital is expected to be slightly more expensive over a 10-year period given the assumptions made in Table 4.

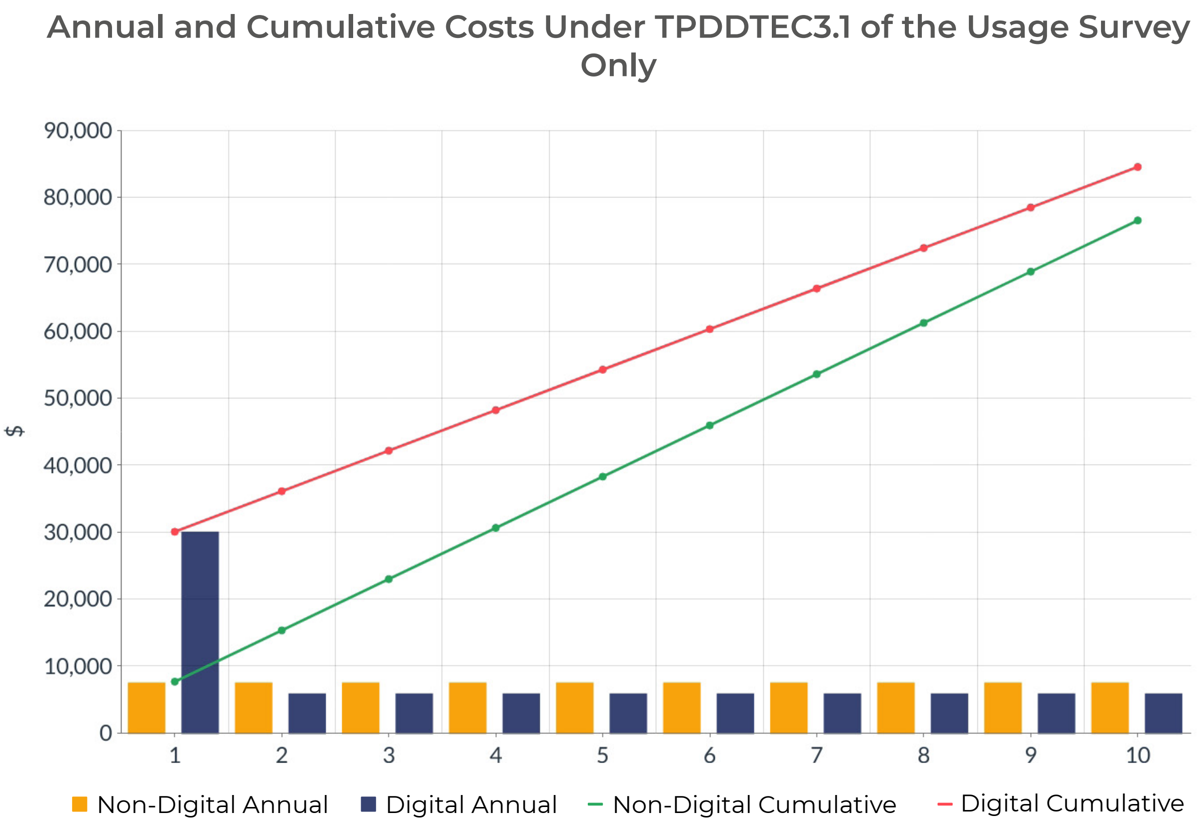

Figure 8 - Comparative costs of digital and non-digital approaches over a 10-year project lifetime for the Usage Survey, the only part surveying element that can be digitized under TPDDTEC3.1. In this case the size of the annual sample is 210 biodigesters.

'NEW' GOLD STANDARD METHODOLOGY

Under the Gold Standard's 'new' MAMMBUTEG 1.0 methodology, all surveys (User, Usage, and PFT), can now be combined under a single comprehensive survey. Of these, the latter two can be completed digitally. The sample size requirements are also lower, making the set-up costs of a digital approach less burdensome (See Technical Appendix 1 for details).

A consequence of the new single-survey regime is that the non-digital approach of qualitative physical site visits to cover monitoring requirements has also become cheaper.

The standard is still too new for there to be any hard numbers for us to compare with. However, it is reasonable to assume that the cost of a comprehensive annual User plus Usage survey will be conservatively about US$12k in East Africa and will be required annually, with an additional PFT every two years (we estimate the full survey including the PFT to be around $17k). Whether or not a project has digital monitoring or not, the User Survey must be done in person. Therefore, the benefit from going digital is the cost difference between the combined surveys and the User survey alone, which we estimate to be around $3k (for the years) without the PFT and $8k (for the alternate years where the PFT is also required). Figure 9 shows our best estimate for the costs of all completing all surveying under the 'New' Gold Standard methodology.

While the initial set up costs for a digital approach are still more than a non-digital approach, the lesser digital monitoring requirements in this new methodology significantly reduces the initial outlay. Under the assumptions laid out above, there is a cost advantage to going digital under the new methodology, with payback achieved in year 4 and cost savings thereafter.

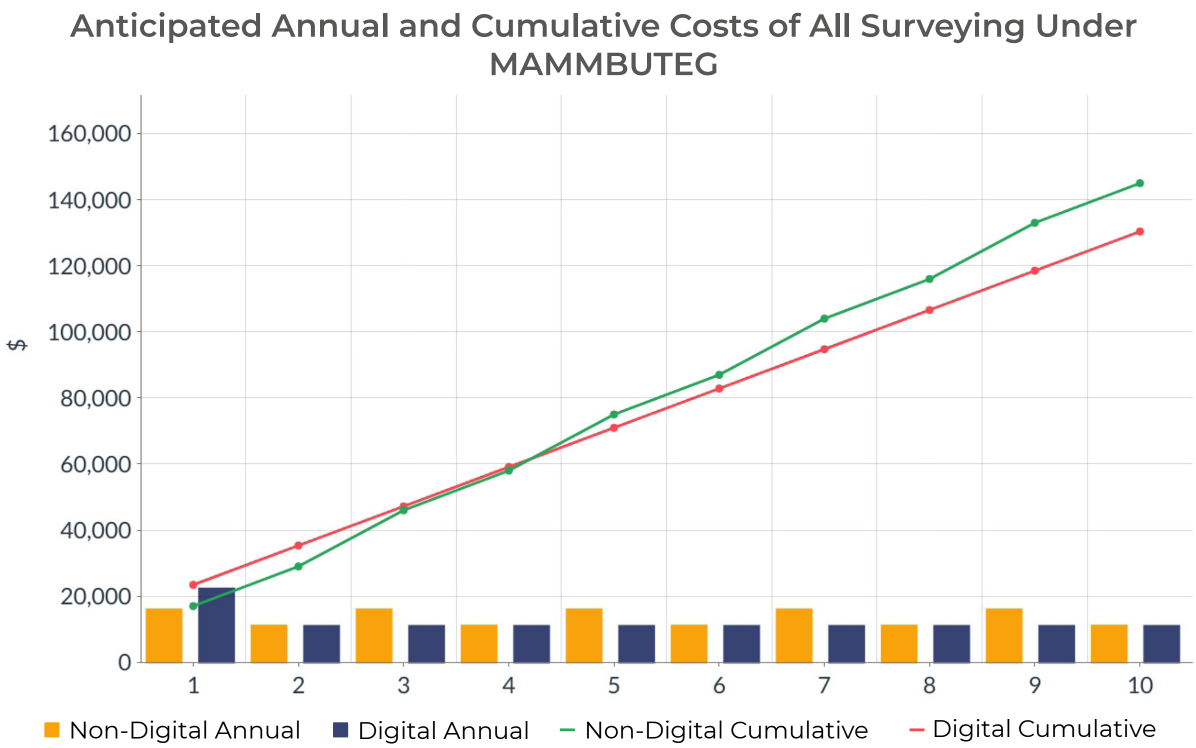

Figure 9 - Comparative costs of digital and non-digital approaches over a 10-year project lifetime for all surveying elements under MAMMBUTEG. In this case the size of the annual sample is 100 biodigesters.

MONITORING AS A SERVICE

We have shown that with our best estimates a digital monitoring approach can save carbon project owners money. However, it is also the case that organizations may not wish to take on the perceived added risk and complexity of a digital approach. At least to begin with, there would be some additional costs – in terms of training of technicians to work with smart meters, and some additional complexity – for example annual installation and uninstallation of smart meters at customers' properties.

For this reason, it may be more enticing to project owners to outsource this work to their carbon consultant or their digital services provider, e.g. Inclusive Energy, and receive a 'Monitoring as a Service' (MaaS) package. As explained in Table 1, there are digital and non-digital surveying elements even in the new Gold Standard methodology. Therefore, even with a digital approach 'classic' surveying methods are needed and there will be boots on the ground on an annual basis.

MaaS would outsource risk and complexity from the project owner to a service provider. It would cost more than the solution outlined in Table 4 and Figure 9 in which digital monitoring is done in-house. Inclusive Energy is in the early stages of exploring this business model option, and we believe it will be possible to offer a cost comparable solution for digital MaaS versus the status quo surveying costs, and we invite organizations to contact us to study this possibility.

A MISSED OPPORTUNITY? COMPARING REVENUE

USAGE RATES

Non-digital carbon projects contain built in assumptions. To reduce the risk of overstating impact it is prudent for methodologies to make reasonable, cautious assumptions that stand up to scrutiny.

One such assumption is around the Usage Rate that non-digital methodologies presume. This is explored in detail in Technical Appendix 1. In short, non-digital projects can claim a theoretical maximum Usage Rate of 90%, compared to 100% for digital projects. While a Usage Rate of 90% is high, certainly higher than currently observed in our Trial (this will be reported on in the next paper from the Digesting Data series), it should be noted that the projects used in the Trial have been ongoing for many years and Usage Rates are likely to reduce over time.

The increased maximum Usage Rate of 100% should serve as a significant driver to owners of digitized carbon projects to ensure upkeep and use of digesters.

Using a theoretical project with 2,000 biodigesters, each producing 5 carbon credits per year with a carbon price of $5/year, the ‘upside’ potential of a higher usage rate is plain to see. This upside can be harnessed by carbon project owners right away.

Assuming a fleet of 2,000 digesters, each creating 5 carbon credits per year at a carbon price of $5/ton	**Usage Rate**	**Annual Upside Potential**
	90%	-
	95%	$2,500
	100%	$5,000

Table 5 - Potential increases in revenue under different Usage Rate scenarios.

LEAKING AND VENTING

Methodologies requiring non-digital monitoring must also assume how much biogas that is produced is lost to the atmosphere rather than used. Currently methodologies assume 10% to be lost. However, we found in our trial that the recorded number was 7% (as shown in Figure 7 above) and believe that for newly installed and well monitored projects this number could easily be in the region of 0 - 5%. Similarly, to the Usage Rate, reduced leakage represents a significant revenue growth opportunity.

However, there is no allowance for digital measurement of leakage in Gold Standard methodologies and thus this gain is theoretical only for the time being.

It is also important to note that the current Smart Biogas technology calculates leakage upstream of a digester only; while leaks from the digester itself are not detected. Venting is from the digester is already measured by the current Smart Biogas technology. This is, therefore, something to work towards, both methodologically and technically.

Assuming a fleet of 2,000 digesters, each creating 5 carbon credits per year at a carbon price of $5/ton	**Leakage Rate**	**Annual Theoretical Upside Potential**
	10%	-
	7%	$1,500
	5%	$2,500
	3%	$3,500
	0%	$5,000

Table 6 – Theoretical increases in revenue under different leakage rate scenarios.

CALCULATING THE UPSIDE

The maximum Usage Rate upside that can be achieved through good biodigester performance for an example 2,000 digester project, with a monitored sample of 100 units, is $5,000 per year. With a set-up of cost of around $15,000 – a digital approach can be expected to pay itself back in our example though 'assumption busting' in a minimum of 3 years.

Lowering the assumption around leakage rates is, for the time being, out of reach. We aim to work with key stakeholders to investigate possibilities of including leakage monitoring within methodologies.

It is worth remembering that the monitored results for usage rates and leaking from a digital metering campaign could be worse than the assumptions taken in the non-digital methodologies. Inclusive Energy's experience with customers to date suggests that this is not the case. Our experience shows that once a culture of proactive digital monitoring is in place within an organization, the numbers of digesters leaking, venting and becoming mothballed can be reduced. It is also the case that projects that opt for digital monitoring from the outset have correctly aligned incentives, i.e. they will be rewarded for actualizing reductions in greenhouse gas emissions beyond the expectations of the methodology.

Digital vs Non-Digital Annual Revenue Potential Using Gold Standard Methodology

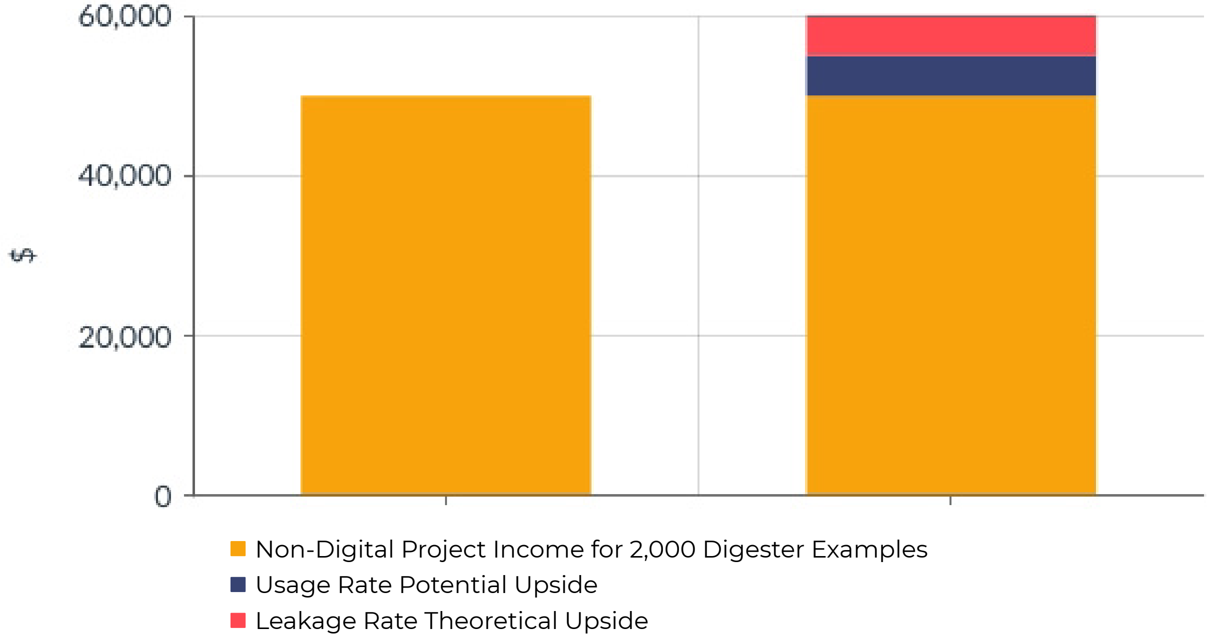

Figure 10 – Current and future revenue streams from digital and non-digital carbon projects, using an example of a 2,000-digester project with a carbon price of $5/ton and 5 CERs per digester per year.

PUTTING IT ALL TOGETHER

This paper has looked at the potential for digital metering in terms of reducing costs and increasing revenues from biogas carbon projects. Both have been shown to be potentially beneficial, although it is noted that the actual results achieved in a digital biogas project are not guaranteed, as is the case for the non-digital equivalent.

In Figure 11, the comparative surveying costs from Figure 9 are combined with the revenue potential outlined in Table 5 to show how the lifetime financials of a digital biogas carbon project compares with a non-digital equivalent. For this example, the usage rates for both digital and non-digital options are assumed to be at their theoretical maximum, i.e. 90% for the non-digital project and 100% for the digital project.

There are cost reduction and revenue increase benefits to be had by digitizing the biogas carbon project process. In the example two-thousand digester project modeled, the additional costs for going digital is $14,300 for which the additional maximum profit over the course of a 10-year project is $69,067, meaning a maximum return on investment of 383%.

It is the case that if the Usage Rate is below 90% then the potential Usage Rate benefit will not be realized. However, taking both cost saving and revenue gains into account, the potential upside is anticipated to be large enough for most organizations to opt for a digital approach and to attempt to harness a ‘transparency dividend’ in which their actual performance is better than the assumptions made under the non-digital approach.

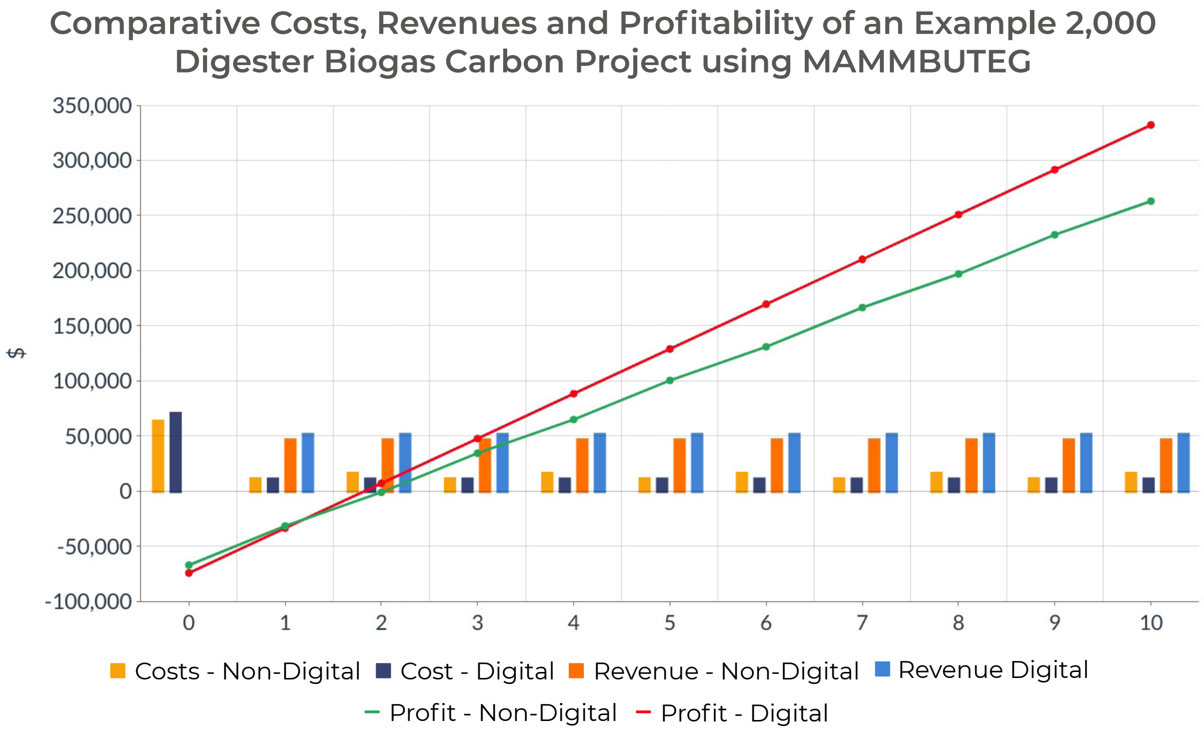

Figure 11 – Comparative business case of digital vs non-digital biogas carbon projects using theoretical maximum usage rates, and anticipated surveying costs over a 10-year project period.

DIGITAL PREMIUM

While it isn't strictly needed to make the digital business case stack up, another interesting idea in the market now is whether digital carbon projects might enjoy a premium carbon price. The ability to digitally link individual households and biodigesters to prospective buyers on voluntary markets is enticing. Inclusive Energy and partners are in the early stages of exploring the market appetite for seeing whether this 'transparency dividend' will translate into buyer-side appetite for premium digitized credits.

It may be the case, however, that buyers will be willing to pay premium prices only if digesters are continuously and individually monitored. This differs from the monitoring campaigns costed in this paper, which are temporary and cover a sample of digesters only. Complete monitoring will cost a lot more to achieve, but buyers will be able to buy carbon credits with a full understanding of the actual emissions reductions achieved by specific digesters. This is likely to differ from the best estimates which the sampling methodologies naturally offer, and we will go further into that topic in the next paper in this series.

Table 7 shows the cost assumptions for a fully digitized 2,000 digester project. Table 8 then shows the theoretical opportunities that lay ahead through 100% digital monitoring, again, taking the example of a 2,000-digester project with each digester creating 5 carbon credits per year. In this example we assume that the 'Digital Premium' would enable increased carbon prices.

Cost Item	
Smart Meters Including Shipping (Reduced Bulk Price)	$90
Travel & Installation (One-Off)	$20
Data charges @ $0.60/month (Annual)	$7.20
Number of Smart Biogas Meters Needed	2,000 + 10% contingency = 2,200
Total Set-Up Costs	$242,000
Ongoing Annual Costs	$14,400

Table 7 - Cost assumptions for a 2,000-digester project in which every digester is digitally metered.

	Carbon Price	**Usage Rate**	**Carbon Credits per year**	**Annual Revenue**	**Approximate Break-Even vs Non-Digital Example**
Non-Digital Project Example	$5	90%	10,000	$50,000	NA
Digital Project Example with $10 Carbon Price	$10	Up to 100%	Up to 11,111	Up to $111,111	5 years
Digital Project Example with $15 Carbon Price	$15	Up to 100%	Up to 11,111	Up to $166,665	< 2.5 years

Table 8 - Forecasting the potential payback of biogas carbon projects in which 100% of digesters are digitally metered, with various carbon prices and usage rates.

While only a thought experiment at this stage. This example shows that if buyers were willing to pay a premium for digitized credits, there is large scope to increase revenues to make this project model stack up. An increased carbon price from $5 to $10 would mean a 100% digital project could break-even in 5 years. However, at this stage it remains to be seen whether there is buyer appetite for such an approach, and there would also be financial challenges in funding the creation of fully digitized projects with the much higher set-up costs that they would entail. We hope to be able to say more on this topic later in the Digesting Data series.

CONCLUSION

The ‘new’ Gold Standard methodology, MAMMBUTEG, has led to changes in projects’ annual and biennial surveying requirements. The methodology allows for the use of digital smart metering to be used in lieu of some surveying needs, but other physical survey needs remain. The methodology contains assumptions and theoretical maximums around Usage Rates and leakage rates which may or may not be to the advantage of a project owner.

This paper, the first in a series from the Digesting Data project, has used a trial undertaken by Inclusive Energy and its partners in Kenya and Uganda to understand whether there are opportunities to benefit from the new methodology when it comes to utilizing a digital monitoring approach.

It was found that while there are additional set up costs when opting for a digital approach, the surveying costs reductions over a project’s lifetime make going digital worth the investment alone. Once revenue increases over a project’s lifetime are factored in, the benefits of using smart meters is potentially large. We found that going digital offers a maximum return on investment of 383% (3.83X) over a 10-year period, although the actual returns will depend on project performance.

While this paper concentrated on a like for like comparison within the Gold Standard methodologies, it is acknowledged that these methodologies are not ideal for all biogas companies. The requisite size of a biodigester portfolio plays against the smaller biogas company, who by their nature generally have less access to capital and smaller portfolios. Larger biogas companies can more easily utilise the Gold Standard, further improving their competitive position in the biogas market.

The paper demonstrates there is a clear opportunity to increase carbon revenues through digital methodologies, while also demonstrating that there is further to go in reducing the barrier to entry to carbon markets for smaller scale biogas players. The Digesting Data project is investigating options for a new type of biogas carbon project in which every biogas asset is monitored, and carbon credits are sold at a ‘digital premium’. While unfulfilled to date, this ambition may be the key with which to lower barriers to entry in the future.

TECHNICAL APPENDIX : USAGE SURVEY REQUIREMENTS

'OLD' GOLD STANDARD TPDDTEC

Usage Guidelines 2.0[4] came into force for biogas projects applying TPDDTEC from 27 Oct 2020. The guidelines distinguish 3 levels of survey rigor: (1) 'mandatory requirements'; (2) 'good practice'; and (3) 'best practice'.

The mandatory requirements are applicable to all project activities, irrespective of their claimable usage rates. The project developer can claim up to a maximum 75% Usage Rate by meeting the mandatory monitoring requirements. An exception is provided for household biogas digester projects, which can claim up to 90% when following the mandatory monitoring requirements. These projects can claim up to 100% the best practice requirements are applied.

1. Mandatory requirements

The main changes, compared to the situation prior to the introduction of the Usage Guideline 2.0, are:
• 100% physical visit requirement instead of minimum 50% household visits, and the remainder could be contacted by telephone.
• Collection of additional data such as, taking pictures, kitchen observation, interview with the main cooking, GPS coordinates assess seasonality, 5-10% verification by Project Developers.
• The sample size remained the same: at a minimum 100 households, with at least 30 samples for project technologies of each age being credited (i.e., if there are 4 age groups, the minimum sample size is 4 x 30 = 120)
• The maximum Usage Rate, at age-group level, is capped at 90% for household biodigesters.

2. Good Practice requirements

Usage Rate is capped at 90% under Good Practice guidelines, which carried the following addition requirements:
a. Training of field teams and supervision of field teams collecting data.
b. End-user training and follow up visits.
c. Awareness campaigns on the benefits of continuous use of the project technology and key product attributes.

3. Best Practice requirements

Household biogas projects can claim age-group usage rate of up to 100% by applying both the mandatory and good practice requirements and a number of additional requirements for best practices. Two options are:
Option (i): Usage data is collected monthly, with information about downtime and maintenance records provided.
Option (ii): Monitoring technologies such as gas meters to monitor continuous

[4] *Available at: https://globalgoals.goldstandard.org/standards/407G_V2.0_EE_ICS_TPDDTEC_Usage-guidelines.pdf*

use of biogas stoves among at least 100 households for 90 days, with at least 30 samples for project technologies of each age being credited. (i.e., if there are 4 age groups, the minimum sample size is 4 x 30 = 120)

Many household biogas projects have installed thousands of digesters spanning a large geographical area. Meeting the requirements of Option (i), which effectively means collecting the digester status of 100% of the digesters, will thus often be challenging due to the distances involved. Although monthly reporting by the end-user is allowed, and perhaps this could be organized through a monthly SMS or by filling in a digital form, it will be difficult to meet the reporting requirements in terms of frequency (monthly) and the reporting requirements (100% of all digesters). That is not only because of the infrastructure necessary (telephone coverage), but also in terms of maintaining an up-to-date telephone number register etc. In addition, maintenance records are to be provided, which will be another challenge.

Option (ii) will in that case be more attractive, especially because this can be organized among a sample of the population. Best Practice guidelines making use of this option are used as the basis for comparison in this report.

NEW GOLD STANDARD MAMMBUTEG USAGE SURVEY REQUIREMENTS

The Gold Standard's new 'Methodology for Animal Manure Management and Biogas Use for Thermal Energy Generation' ('MAMMBUTEG 1.0') came into force on 25 January 2023, and is now mandatory for all new carbon projects, as well as projects undergoing crediting period renewal.

Monitoring of operationality of the biogas systems, including the operationality of both the biogas digester and biogas cookstove, shall be conducted using one of the following methods:

1. Census of users or survey of the users at randomly selected sample sites.
2. Based on on-going rental/lease payments or a recurring maintenance fee by users.
3. Measurement campaigns using biogas flow meters.

For cases where sampling is applied, the CDM Standard for sampling and surveys for CDM project activities and program of activities shall be used for determining the sample size to achieve 90/10 (for annual monitoring). The minimum sampling requirement however depends on the group size, which is 30 with a group size of less than 300, 10% of the group size between 300 and 1000 and over 1000, it is 100. In practice, for most biogas projects, the minimum sample size will therefore be 100.

The usage rate is capped at 90% for option (1). For Option (2) and (3) up to 100% Usage Rate claim is possible.

Option (3), where biogas flow meters are used, has additional requirements:

For the case of measurement campaigns using biogas flow meters, it may be undertaken at randomly selected sample sites. The selected samples should account for possible stratification of the population according to the capacity, biogas digester types and region where the digesters are installed (e.g., 6 cubic meter or 8 cubic meter capacity, fixed dome or floating dome type, regions where seasons influence average ambient temperature). The stratification of the population could be exempted in cases the project demonstrates that the approach applied for measuring the used biogas, results in conservative values for biogas used. The continuous use monitoring campaign shall be conducted for a minimum of 100 households for at least 30 days. The operational rate of each system is determined by dividing the number of days in operation by the length of the campaign. An operational day is a day in which biogas is consumed.


SMART BIOGAS
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