Sector development plan for the micro-digester sector in South Africa

PATHWAYS TO GROWTH AND SUSTAINABILITY BY 2030

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South African National Energy Development Institute.

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SECTOR DEVELOPMENT PLAN (SDP) AUTHORSHIP

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Foreword

The issue of energy security, especially as it relates to issues of the energy transition, is very much a subject of much discussion. It is no secret that the transition to a sustainable more resilient and resource efficient energy system will have a significant impact on the overall design of said energy system. There are losses that are going to be suffered and this includes the impact that it is expected to have on the Coal mining sector and that entire value chain for energy supply. Bearing this in mind, it is now crucial that to continue to deliberate further on this subject and collaborate in an effort to resolve some of these challenges brought about by the transition.

Globally it is known that largescale bioenergy is still lagging behind other more mature technologies in the form of various scales of wind and solar energy. This phenomenon has also been seen to manifest locally; it is observed in as far as the allocations of the Integrated Resource Plan are concerned (IRP 2019). There is not much energy in the mix expected come from bioenergy sources, because it is known that in order for this to happen there are a number of systems that need to work together to move closer to unlocking the waste to energy sector in South Africa. However, a smaller scale of bioenergy implementation in the form of household scale biodigesters can have a marked impact on waste management and energy supply at this scale.

Against this back drop, the South African National Energy Development Institute (SANEDI) commissioned the University of Johannesburg's Process, Energy and Environmental Technology Station (UJ PEETS) to take stock of the current status of micro-digesters and the wider state of the art in South Africa and globally. UJ PEETS, together with the UJ-TRCTI have conducted this feasibility study and Action Dialogue to develop a Micro-Digester Sector Development Plan (SDP).

The status of the micro-digester industry is unpacked – learning from what is already in existence to inform the charting of the SDP. The goal of this work was to unravel how different factors hinder or promote the micro-digester industry in South Africa. This report includes the existing literature, opinions from different experts and community engagement information were analysed, forming the basis of the current status.

The study revealed an untapped potential for the micro-digester industry, identifying areas that not only are the micro digesters great as a source of alternate Energy and Fuel, but Urban Waste Management and economic opportunities are untapped. However, in order to reap the benefits of this technology, at this scale, it is necessary to understand what the technology requires in order to operate reliably and sustainability.

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Executive summary

Anaerobic digestion of biodegradable organic material has the potential to provide communities with alternative energy sources through the conversion of organic waste material (e.g. cow dung or food waste) into gas, predominately for use in cooking. Micro-digesters are defined by the South African National Biogas Platform's Micro-Digester Working Group as: an anaerobic biogas digester producing less than 0.5 kW of power or less than 2 kW of biogas a day.

Micro-digesters can contribute to reduced carbon emissions, improved waste management and poverty reduction. However, South Africa's uptake of this technology is low compared with other African countries. Reasons include the cost of the technology is not subsidised; operations and maintenance are difficult if there is insufficient training and support; there is competition from other fuels and renewable energy technologies; and there is not a supportive regulatory environment.

This sector development plan (SDP) has been developed to strengthen the micro-digester sector in South Africa. The potential size of the sector is initially estimated to be 21,000 units, followed by a maximum yearly demand potential of 50,400 units. Assuming a continuous market penetration rate of 10%, this equates to 5,040 units a year until 2030. Assuming a daily production of 2kW, the SDP has the potential to create 17,000 jobs while producing around 142.8 MW daily, reducing the reliance on firewood and charcoal and diverting organic waste to landfill.

The plan has been developed in the context of the SANEDI Strategic Plan 2020-2025, the Department of Mineral Resources and Energy's 2019 Integrated Resource Plan (IRP) and the National Development Plan 2030.

It draws on feedback from stakeholder engagement following an in-depth assessment of the sector's status. Based on this assessment and stakeholder feedback, the plan is based on three core pathways for sector change and the following objectives and targets for 2030:

PATHWAY	OBJECTIVE	TARGET BY 2030
Rural energy access	Increase access to clean energy using micro-digesters in rural households	Threefold increase from baseline (n=350).
Urban waste management	Expand the micro-digester industry into urban waste management	Five pilot projects in operation
Business opportunities and employment	Increase the number of people working in the micro-digester sector	Triple the number of people working in the sector from baseline (n=270)

The sector development plan proposes achieving objectives through two pathways of activity that aim to enhance the existing market for micro-digesters in rural areas as a rural energy solution and expand the sector into urban areas using micro-digesters as an organic waste management solution. The third pathway focuses on building up economic opportunities for youth and women's groups and more formal capacitation of new and established small and medium-sized enterprises.

This document outlines the activities that must occur across each of these pathways in relation to technology and knowledge, actors and networks, and institutional change. The activities outlined give direction to the sector, fill gaps, and reduce weaknesses identified during a wide-ranging sector review in 2021. The required activities are proposed together with a recommended activity owner, including but not limited to the South African Biogas Industry Association (SABIA), the South African National Energy Development Institute (SANEDI), universities, and various government departments.

Wits objectives. It also sets out a management strategy to ensure that activity owners maintain momentum and new actors are brought into the sector to continue its expansion.

This plan requires action by sector players as well as engagement in broader debates and activities underway in other areas, notably the South African Waste to Energy Roadmap launching in 2022. The micro-digester sector has significant opportunities to grow if it can strengthen partnerships within the sector and with stakeholders in allied sectors.

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Contents

1 Background and rationale

Anaerobic digesters have the potential to provide communities with alternative energy sources through the conversion of organic waste material (e.g., cow dung or food waste) into methane-rich biogas. This gas can be used for cooking, lighting, heating or generating electricity.[1] These digesters provide opportunities for cleaner cooking, lighting and heating energy where firewood or charcoal, for example, are used. They also contribute to managing waste decomposition, reducing the volume of organic waste sent to landfills and thus reducing methane emissions at landfill sites. In addition to gas, biogas digesters also produce an organic slurry that can be used as fertiliser. As such, anaerobic biogas digesters have been promoted as a viable waste-to-energy vehicle. In several countries (e.g., China, Bangladesh, Brazil, Kenya, and Tanzania), this technology has been taken up – especially at the small- or micro-scale. China has the largest number of installed small-scale biogas digesters (42 million) while India has nearly five million small-scale digesters.[2] In Africa, the numbers are smaller – Kenya has over 14,000, Uganda 11,000 and Ethiopia 10,000.[3] However, in South Africa, the total number of small-scale biogas digesters installed is estimated to be only 350.[4]

This sector development plan (SDP) is focused on 'micro-sized' anaerobic biogas digesters (hereafter referred to as 'micro-digesters'). These are defined by the South African National Energy Development Institute (SANEDI) as "digesters that fall below the minimum licensing and permit requirements from various government departments".[5] There is no standard definition of what size such digesters are in South Africa. Micro-digesters are typically 5 to 15 m3 in volume with a gas output of 0.5 m3 per m3 of digester volume.[6] This output is equivalent to 3.2 kWh of gas per m3 per day. That said, anecdotal evidence collected during this study informed us that many in South Africa see micro-digesters as anything up to 100 m3. Anaerobic micro-digester project guidelines developed with guidance from the National Biogas Platform's Micro-Digester Working Group state that a micro-digester is classified as producing less than 0.5 kW of power or less than 2 kW of biogas a day for household use.[7]
It is this definition that this plan will use.

Images: University of Venda

This SDP has been developed to strengthen the micro-digester sector in South Africa to address this situation in the context of:

- The SANEDI Strategic Plan 2020-2025 which focuses on enhancing energy access
.
- The Department of Mineral Resources and Energy's 2019 Integrated Resource Plan (IRP) which recognises biomass and biogas as energy sources with huge potential to provide electricity and heat for the country, including from small-scale systems. It also recognises the importance of a holistic approach to the role of the energy sector and its potential to support a just transition, including through job creation.

- The National Development Plan 2030 and its recognition of the need to move South Africa towards low-carbon and clean energy sources that can produce sufficient energy to support industry at competitive prices, ensure energy access for poor households, while reducing carbon emissions per unit of power by about one-third.

Following a review of the status of the sector in 2020 and 2021 (see Section 2) and three stakeholder workshops held in 2021 (see Annexure), efforts have been made to develop an SDP that provides direction for the sector to 2030 with a view to catalyse investment and customer demand. The plan to develop the sector is presented in Section 3, starting with a theory of change to guide the development of three distinct pathways for sector development. The document concludes with management, monitoring and evaluation requirements in Section 4.

[1]Electricity generation typically occurs in larger scale digester plants than those focused on in this sector development plan
[2]https://www.researchandmarkets.com/reports/4997528/biogas-plant-market-growth-trends-covid-19
[3]IEA (2020). Outlook for biogas and biomethane: Prospects for organic growth. World Energy Outlook Special Report. [online] IEA Publications. Available at: https://webstore.iea.org/outlook-for-biogas-and-biomethane.
[4]Muvhiiwa, R., Hildebrandt, D., Chimwani, N., Ngubevana, L. and Matambo, T., (2017)
The impact and challenges of sustainable biogas implementation: moving towards a bio-based economy.
Energy, Sustainability and Society, 7(1), pp.1-11
[5]SANEDI (2017) Moving Biogas Forward. Presentation. [Online] Available at:
http://www.energy.gov.za/files/biogas/2017-Biogas-Conference/day1/Moving-Biogas-Forward-Sanedi.pdf
[6]Mutungwazi, A., Mukumba, P. & Makaka, G., 2018. Biogas digester types installed in South Africa:
A review. Renewable and Sustainable Energy Reviews, 81, pp 172-180
[7]USAID, SANEDI, GIZ (2019) 'Guideline to Plan and Implement Anaerobic Micro-Digester Projects in South Africa'

2 Sector status at end 2021

In 2021 two reports were compiled that reviewed the status of the micro-digester sector in South Africa. The Industry Status Report [8] outlined the industry's status including available technologies and the challenges and barriers to their introduction.
The main findings of this report were summarised in an analysis of the strengths, weaknesses, opportunities and threats for the sector which is reproduced in Table 1.

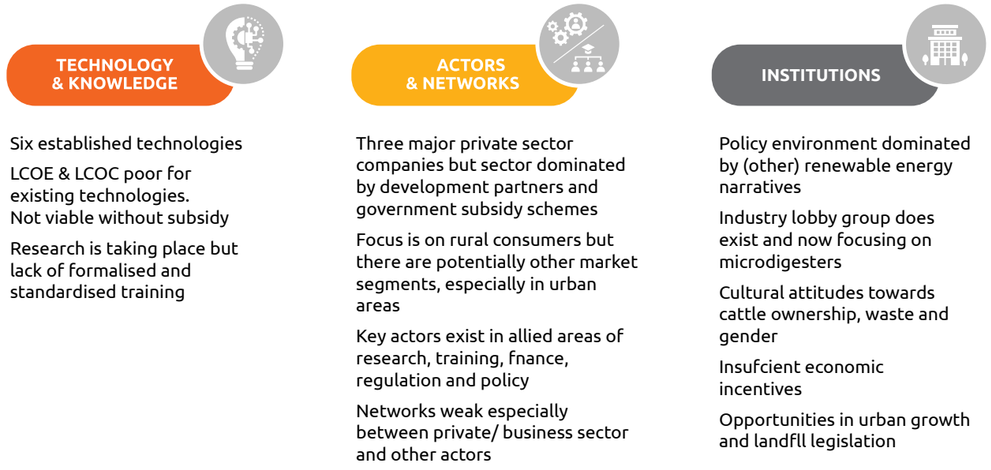
Table 1: SWOT analysis of the South African micro-digester sector in 2021

STRENGTHS	WEAKNESSES
Renewability	High initial investment
Usable byproduct: organic manure	High maintenance cost
Improved hygiene	Lack of skilled labour
Developed and diverse technology	Lack of knowledge and experience
Bio-waste reuse/recycle	Lack of standards and unique policies
Re(use) of landfills	High costs of compiling bid documents
Lower GHG emissions	Low efficiency
Lower environmental impact	Manual operation
Availability of different substrates	
OPPORTUNITIES	**THREATS**
A broad range of applications	Competition from other renewables
High unexploited potential	Exclusion of biogas plants from the air emission licence
Reduction of landfills	Permits and licences required to sell fertiliser
Rural development	Subsidies only for other renewables
Raising environmental awareness	Price volatility due to the volatile economy
Conforms with waste legislation and requirements	National inflation
Job creation	

[8] Rasmeni, Z. (2021) Industry Status Report. Johannesburg: UJ-PEETS

A policy and innovation perspective report[9] analysed the South African micro-digester sectoral innovation system, and made a series of recommendations for sector development.
The findings are outlined in Figure 1.

Figure 1: Status of the South African micro-digester innovation system in 2021



These two reports form the basis for this SDP as they provide a synthesis of all other material available on micro-digesters in South Africa including an extensive desk review of relevant grey and academic literature on micro-digesters in South Africa and around the world. They also draw on fieldwork conducted to review the status of SANEDI-sponsored micro-digester projects in three provinces.[10] This fieldwork also reviewed micro-digesters from other projects in the three provinces. The innovation report includes a dedicated policy analysis, market analysis, political economy analysis and a techno-economic analysis utilising the data from the fieldwork study. Further details of the literature reviewed and methodology used are available in the reports themselves.

When considered together, the two reports provide a good overview of the status of the sector. The key take homes from these two reports are now outlined in brief.

[9] Hanlin, R. et al. (2021) A policy and innovation perspective on micro-digesters in South Africa. Johannesburg: UJ-TRCTI. Available at: https://www.uj.ac.za/faculties/college-of-business-and-economics/trilateral-research-chair-in-transformative-innovation/trcti-publications/
[10] UJ-PEETS (2022). Fieldwork report of micro-digesters in Gauteng, KwaZulu-Natal and Limpopo provinces. Johannesburg: UJ-PEETS.

GOOD TECHNOLOGY BUT A NEED FOR MORE INNOVATION

Approximately known 700 anaerobic digesters of all sizes have been installed in South Africa. Of these, approximately 50% (n=350) are of the micro-digester variety, using the definition outlined above. Of these 350, the majority were subsidised as part of government renewable energy or clean cooking schemes. These have, at times, been funded by international development partners. A review of 100 of these micro-digesters in 2021 found that of the 43 systems that were visited, the majority were not functioning at even 50% capacity, and many were non functional. [11] Reasons for this are listed in Table 2.

Table 2: Technical factors inhibiting use of micro-digesters

TECHNICAL FACTOR	FINDINGS	
FEEDSTOCK AVAILABILITY	Sufficient feedstock must be available to produce biogas.	Certain market segments may not be able to maintain the digester throughout the year. Seasonal feedstocks may reduce biogas production rates.
WATER AVAILABILITY	An adequate supply of water is required for the anaerobic digestion process.	Potential customers need to consider the viability of installing a digester if the water supply is not secure. Consider the cost of water when assessing economic feasibility.
CONSTRUCTION AND INSTALLATION	Skilled staff are required to construct or install prefabricated digesters. Availability of materials.	Construction issues are frequent for built digesters. Training programmes have not always been successful. Material for construction is locally available. Prefabrication leads to standardisation and quality assurance.
OPERATION AND MAINTENANCE	Technical failure due to poor construction and manufacturing. Lack of attention to maintenance. Lagging service management.	Digester longevity needs to be considered. Digesters are not always maintained. Poor performance due to maintenance issues negatively impacts perceptions. Lack of technical knowledge including how to diagnose and troubleshooting by micro-digester operators.

The findings demonstrate that the key barriers do not relate specifically to the technology itself, but to the way micro-digesters are installed, operated and maintained. It is perhaps not surprising then that the industry status and innovation reports of 2021 both emphasised the need to enhance the training of construction, operations and maintenance staff involved in the micro-digester industry. However, they also noted the need for more innovation to make the construction, operations and maintenance more user friendly. This is particularly necessary if the sector is to move into new markets.

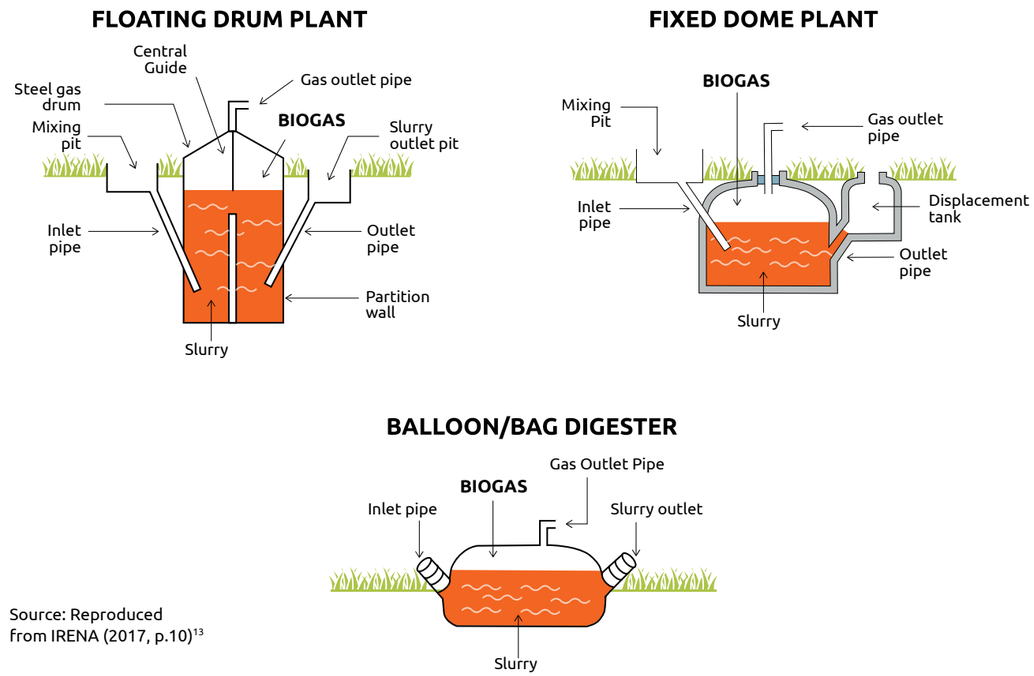
[11] UJ-PEETS (2022). Fieldwork report of micro-digesters in Gauteng, KwaZulu-Natal and Limpopo provinces. Johannesburg: UJ-PEETS.

INTEREST IN MICRO-DIGESTERS BY INDUSTRY PLAYERS

Despite the problems identified above there is a growing interest in the micro-digester industry in South Africa. This is visible through the establishment of the National Biogas Platform, which was set up in 2013 to promote biogas as an energy solution, while a specific Micro-Digester Working Group within the Platform was set in 2015. The National Biogas Platform includes the South African Biogas Industry Association (SABIA), which represents a community of 1,500, predominately private sector, stakeholders in South Africa and lobbies for legislative changes and policy development.

Six main designs are available on the South African market: fixed dome; floating drum; biobag; Puxin; AGET; [12] and plastic rato-moulded. The three most popular designs are the fixed dome, floating drum and balloon or biobag (Figure 2).

Figure 2: Three main micro-digester types



Source: Reproduced from IRENA (2017, p.10)[13]

[12] Designs by African Green Energy Technologies, a Cape Town-based company
[13] IRENA (International Renewable Energy Agency), 2017. Biogas for domestic cooking: Technology brief. [online] Abu Dhabi: International Renewable Energy Agency. Available at: https://www.irena.org/publications/2017/Dec/Biogas-for-domestic-cooking-Technology-brief.

These are manufactured, imported, sold and distributed in South Africa by South African companies (including Agama BiogasPro, AGET, Biogas SA and EnergyWeb). These companies are also actors in the maintenance of micro-digesters alongside a number of community-based organisations. That said, most micro-digesters have been deployed through public sector or international development projects including a programme of work by SANEDI which completed in 2021 and involved Mpfuneko Community NPC, Vatsekeme Community Group, University of Venda, Khanyisa Projects, EnergyWeb, University of KwaZulu-Natal and Gauteng Department of Infrastructure Development.[14]

Most of the components required for assembly (pipes, taps, etc.) can be bought from South African manufacturers, which have established plastics manufacturers and metal fabrication firms certified to international standards. Much of the output equipment (stoves, water heaters etc.), that was found for sale in South Africa during an internet search was imported from China, despite the existence of a number of local manufacturers. [15]

LOW ACTIVE DEMAND YET SIGNIFICANT UNTAPPED MARKET POTENTIAL

As noted, the low use in South Africa can be compared with significantly higher figures in other developing countries. Despite the low active demand for micro-digesters relative to other countries, there is significant untapped market potential in South Africa. Like many African countries, South Africa promotes micro-digesters as an energy source, primarily to provide clean cooking facilities to rural households that traditionally use charcoal or wood to cook food. Nationally, 7.8% of households (n=1.3 million) in South Africa in 2019 used firewood for cooking, the majority in rural areas.[16]

For example, the provinces which use the most firewood as fuel for heating and cooking in South Africa are the predominately rural provinces of Limpopo and Mpumalanga where 31.6% and 16.2% of households, respectively, still use wood for cooking. Assuming a market penetration rate of just 0.05% in the first year nationally, this would equate to over 6,500 micro-digesters (n=6,694). The household growth rate is estimated at 2.4% per annum.[17] This would mean a continual potential total annual market of around 32,000 rural households. Obviously, the rate at which each of these 32,000 households take up the micro-digester will depend on the speed of technology adoption.

This in turn will be determined by household decisions relating to the barriers to adoption Woutlined in Tables 1 and 2 and Figure 3.[18]

[14]These organisations were identified during an in-depth desk review conducted as part of the sector review that informed the SDP. See: Hanlin, R. et al. (2021) A policy and innovation perspective on micro-digesters in South Africa. Johannesburg: UJ-TRCTI. Available at: https://www.uj.ac.za/faculties/college-of-business-and-economics/trilateral-research-chair-in-transformative-innovation/trcti-publications/
[15]See Hanlin, R. et al. (2021) previously cited
[16]StatsSA (2019). General Household Survey. Pretoria: Department of Statistics South Africa.
[17]StatsSA (2019). General Household Survey. Pretoria: Department of Statistics South Africa.
[18]A good study that considers micro-digester adoption factors in South Africa is: Uhunamure, S.E., Nethengwe, N.S. and Tinarwo, D. (2019) Correlating the factors influencing household decisions on adoption and utilisation of biogas technology in South Africa, Renewable and Sustainable Energy Reviews, Vol. 107, Pages 264-273,

If we add rural households that own livestock (a more secure source of feedstock for the micro-digester) then we would be looking at a scenario of nearly 3,000 households (n=2,886) that could be targeted in the first year (if the same penetration rate of 0.05% is used). This is based on the figure that 79% of rural households own livestock.[19] This is comparable to figures by Rasimphi and Tinarwo (2020) that estimated 625,000 rural households with sufficient livestock numbers and resulting organic waste to feed a micro-digester. [20] Again, assuming the same growth in household numbers annually (estimated at 2.4% per annum), the average annual number of micro-digesters needed for rural households with livestock could be as much as 15,000 units a year.

With the majority of the population in urban areas, and cities like Cape Town enacting zero organic waste to landfill targets, there is also untapped market potential for the use of micro-digesters in urban areas. Some pilot schemes have encouraged public facilities in urban areas (e.g., schools and early childhood development centres) to use micro-digesters to eliminate food waste and reduce cooking fuel bills. However, there have been few attempts to encourage micro-digesters in apartment blocks and small housing developments in South Africa, despite the increasing call to reduce organic waste to landfill sites from urban areas. The 2019 General Household Survey identified that just under 2.3% of households (n=394,000) were cluster houses or townhouses houses built as part of a complex, while 6% of households in municipal areas already separate at least some of their waste for recycling. A scenario of just 1% penetration of micro-digesters in existing complex/cluster house developments would be approximately 4,000 micro-digesters. If apartment blocks are added to this, the number rises to 11,500 micro-digesters. A requirement that all newly built apartments, clusters and housing complexes of a specific size must include a micro-digester would create permanent demand from a total of 3,400 housing units, assuming the figures for new housing stock do not change.[21]

In summary, it is estimated that the potential size of the sector initially is 21,000, followed by a maximum yearly demand potential of 50,400. Assuming a continuous market penetration rate of 10%, this equates to 5,040 units a year until 2030.[22]

Assuming a daily production of 2kW, the SDP has the potential to create 17,000 jobs while producing around 142.8 MW daily, reducing the reliance on firewood and charcoal and diverting organic waste to landfill. A joint SABIA and GIZ report estimates biogas potential of less than 10kW per household for 1.55 million agricultural homes.

GIZ (2016) Biogas Industry in South Africa: An Assessment of the Skills Need and Estimation of the Job Potential. Pretoria: GIZ

[19]Hanlin, R. et al. (2021) A policy and innovation perspective on micro-digesters in South Africa. Johannesburg: UJ-TRCTI. Available at: https://www.uj.ac.za/faculties/college-of-business-and-economics/trilateral-research-chair-in-transformative-innovation/trcti-publications/
[20]Rasimphi, T.E. and Tinarwo, D., 2020. Relevance of biogas technology to Vhembe district of the Limpopo province in South Africa. Biotechnology Reports, 25, p.e00412.
[21]Based on total new housing stock of 56,000 a year of which 6.7% are townhouses in complexes, cluster housing or apartments. New housing stock figures from Centre for Affordable Housing Finance in Africa (20202) South Africa Housing Market. Percentage of houses in complexes, clusters and apartments from the General Household Survey 2019.
[22]These are high-level figures and more detailed analysis is recommended i.e. to take into account the saturation rate of other fuel types and eventual removal of firewood as a cooking fuel source for the vast majority of the population.

Images: istockphoto.com, shutterstock.com

OPPORTUNITIES FOR UNEMPLOYED YOUTH AND WOMEN

Even at meagre penetration rates of less than 1%, a renewed focus on rural areas and a new focus on urban cluster housing complexes would provide a significant opportunity to the micro-digester sector. Techno-economic analysis of current micro-digesters conducted as part of the innovation review in 2021[23] found that a fixed dome brick and mortar design of micro-digester was the most cost-effective and readily available on the market in South Africa.[24] Such designs, because they are built in-situ, coupled with renewed emphasis by the sector on (new) market segments, would create significant opportunities for the employment of unemployed youth as well as income-generating opportunities for women's groups, especially in rural areas.

Taking the market size above and an assumption that all micro-digesters are fixed dome, a total of 2,454 biogas construction engineering firms would be required employing a minimum of 17,000 engineers, masons and/or unskilled labourers each year.[25] The job creation rate is likely to be higher as operations and maintenance are unlikely to be conducted by these same firms.

That said, the industry status report of 2021[26] highlighted the importance of providing business training to these groups to ensure these businesses survive beyond the 3.5 year mark.[27] In addition, the innovation review report highlighted the critical role of conducive policy to ensure sufficient business opportunities (to build, operate and maintain the micro-digesters) are available to these groups (and reduce the reliance on government and international development partner-sponsored programmes).

THE POLICY WINDOW IS OPEN, FOCUSING ON RENEWABLES AND WASTE MANAGEMENT

Policy arenas have aligned and created an opportune moment for the sector to rebound. The sector is benefiting from a renewed interest in efforts by stakeholders to develop a micro-digestor working group including their 2019 "Guideline to Plan and Implement Anaerobic Micro-Digester Projects in South Africa'.[28]

As noted, municipal governments in South Africa are reviewing the volumes of organic waste being taken to a landfill. At the same time, the government is progressing a Waste to Energy Roadmap to be published in 2022. These provide a perfect platform to counter the dominant focus of discussions in this sector on the role of micro-digesters as only a clean energy solution for rural areas. Furthermore, the innovation review report of 2021 highlighted examples of facilitatory policy used in other parts of the continent to encourage their use, including social marketing and financial (including tax) incentives for both suppliers and users of the technology.

Again, taking the market figures above, the sector has the potential to create 142.8 megawatts (MW) of capacity that is converted from less clean and green energy sources including firewood and charcoal.

[23]Hanlin, R. et al. (2021) A policy and innovation perspective on micro-digesters in South Africa. Johannesburg: UJ-TRCTI. Available at: https://www.uj.ac.za/faculties/college-of-business-and-economics/trilateral-research-chair-in-transformative-innovation/trcti-publications/

[24]Cost efficient in this instance does not equate to least-cost technology. A fixed dome brick and mortar micro-digester is one of the most expensive micro-digesters to install in South Africa (costing up to ZAR 60,000 as opposed to ZAR 20,000 for some biobag designs). However, the techno-economic analysis found it significantly more efficient than the biobag type when considered in terms of the levelised cost of electricity and cooking. The results found that assuming the digesters can be operated at 80% of their design output (gas), the levelised cost of energy (LCOE) for the fixed dome digester is USD 72 per MWh, while the levelised cost of cooking (LCOC) is USD 77 per year respectively. The analogous figures for the biobag digester are USD 127 per MWh and USD 136 per year, respectively.

[25]Based on it taking two weeks (10 working days) to build each micro-digester and each firm is made up of one mason/engineer and a further five or six labourers (see: Lee, C.J., Shirley, R. Otieno, M. and Nyambura, H. (2021). Powering jos: the employment footprint of clean cooking solutions in Kenya. Energy, Sustainability and Society. Vol. 11(1)., pp.1-22. Note figures from Kenya are used because the latest job creation figures in South Africa in biogas are focused on projects and not by micro-digester unit).

[26]Rasmeni, Z. (2021) Industry Status Report. Johannesburg: UJ-PEETS

[27]Most small and medium size businesses in South Africa have an average lifespan of 3.5 years. (See: Makhuvha, T. (2017) Financial Inclusion – Best Policy Practices & Guidelines for SMME. Sefa). 40% are expected to not survive the first year (Bushe, B., 2019, 'The causes and impact of business failure among small to micro and medium enterprises in South Africa', Africa's Public Service Delivery and Performance Review 7(1), a210)

[28]USAID, SANEDI, GIZ (2019) 'Guideline to Plan and Implement Anaerobic Micro-Digester Projects in South Africa'

In summary, the sector can be measured using baseline figures (Table 3) at the end of 2021.[29]
The results of a nationwide calculation of anaerobic bio-digesters (including those at the micro-scale) was not complete at the time of this going to press and therefore the figures used are based on the references that were available.

Table 3: Baseline figures

INDICATOR	BASELINE FIGURE	NOTES
Total number of micro-digesters in existence	350	Muvhiiwa, R., Hildebrandt, D., Chimwani, N., Ngubevana, L., and Matambo, T. (2017) The impact and challenges of sustainable biogas implementation: moving towards a bio-based economy. Energy, Sustainability and Society, 7(1), pp.1-11
Installed capacity (in MW/annum)	0.7	Assumes maximum output, 100% efficiency and no downtime for maintenance or lack of feedstock.
Number of micro-digesters installed in rural households	191	26 in the Illembe project in KwaZulu-Natal; 55 in the Mpfuneko Biogas Project in Limpopo; 110 in the Melani Village Biogas Project in the Eastern Cape (see: Rasmeni, Z. (2021) Industry Status Report. Johannesburg: UJ-PEETS)
Number of micro-digesters installed in urban settings	7	4 schools and 3 urban farms visited during sector review fieldwork (see: UJ-PEETS. (2022). Fieldwork report of micro-digesters in Gauteng, KwaZulu-Natal and Limpopo provinces. Johannesburg: UJ-PEETS)
Number of micro-digesters installed in public institutions	12	6 schools; 5 creche/ early learning centres and; 1 old persons home (see: UJ-PEETS. (2022). Fieldwork report of micro-digesters in Gauteng, KwaZulu-Natal and Limpopo provinces. Johannesburg: UJ-PEETS)
Total number of working micro-digesters	60%	A fieldwork study took a population of 100 micro-digesters (29% of the total installed capacity) and purposively sampled 43 of them. Of these, a total of 26 or 60% were at lease semi-operational (see: UJ-PEETS. (2022). Fieldwork report of micro-digesters in Gauteng, KwaZulu-Natal and Limpopo provinces. Johannesburg: UJ-PEETS)[30]
Levelised cost of energy (LCOE) relative to LPG [31]	1.5 – 4 times higher	Taking data from the two highest functioning micro-digesters (one fixed dome and one biobag) visited during the UJ-PEETS fieldwork of 2021, it was extrapolated that both were operating at only 20% of their design capacity, with the result that the LCOE values were between 1.5 (fixed dome) and four times (biobag) the cost of either grid-based electricity or bottled LPG (see Hanlin, R. et al. (2021) A policy and innovation perspective on micro-digesters in South Africa. Johannesburg: UJ-TRCTI)

[29]These baseline figures utilise the figures that are publicly available through a literature search or as a result of fieldwork conducted for the sector review by UJ-PEETS in 2021. There are likely to be other micro-digesters that are in existence or operational, however, it is necessary to utilise figures that have been verified.
[30]It should be noted that in some projects the percentage of working digesters can be higher; where support and guidance are provided to households regularly. For example, a study of 26 micro-digesters installed in KwaZulu-Natal (and a subset within the 100 reviewed by UJ-PEETS) found only six non-operational digesters resulting in 73% operation rate (see Ogwang, J.O. (2020) An investigation into the optimisation of small-scale anaerobic digestion process systems for rural South Africa. University of KwaZulu-Natal MSc thesis).
[31]Levelised cost of energy is a technique that is useful in comparing biogas as a cooking fuel relative to other sources of primary energy used for food preparation. Liquefied petroleum gas (LPG) has increasingly replaced firewood as cooking fuel in South Africa with the General Household Survey of 2019 noting that the percentage of households using gas had increased from 2.2% in 2002 to 4.2% in 2019.

INDICATOR	BASELINE FIGURE	NOTES
Total number of micro-digester designs available in South Africa	9	Nine micro-digester types were identified as being available for sale in South Africa during a wide-ranging desk review conducted in 2021: brick and mortar fixed dome digester; floating drum digester; balloon/ bag digester; AGET underground digester; AGET portable digester; EZ fixed dome digester; The Little Green Monster; AGAMA, Moulded fixed dome, Puxin In-situ cast concrete digester; (see Hanlin, R. et al. (2021) A policy and innovation perspective on micro-digesters in South Africa. Johannesburg: UJ-TRCTI).[32]
Total number of organisations (private firms and community organisations) providing micro-digesters in South Africa	8	Agama BiogasPro, AGET, Biogas SA and, EnergyWeb; Mpfuneko Community NPC; Vatsekeme Community Group; University of Venda; Khanyisa Projects (see Hanlin, R. et al. (2021) A policy and innovation perspective on micro-digesters in South Africa. Johannesburg: UJ-TRCTI) *(see Hanlin, R. et al. (2021) A policy and innovation perspective on micro-digesters in South Africa. Johannesburg: UJ-TRCTI)*[33]
Total number of organisations (private firms and community organisations) in South Africa providing O&M services	No baseline	Mpfuneko Community NPC, Vatsekeme Community Group, University of Venda, Khanyisa Projects, University of KwaZulu- Natal, Gauteng Department of Infrastructure Development + Agama BiogasPro, AGET, Biogas SA and, EnergyWeb (see Hanlin, R. et al. (2021) *A policy and innovation perspective on micro-digesters in South Africa. Johannesburg: UJ-TRCTI)* [34]
Total number of staff employed by the sector	270	This is the lowest figure found during a comprehensive desk reivew in 2021 ((see Hanlin, R. et al. (2021) A policy and innovation perspective on micro-digesters in South Africa. Johannesburg: UJ-TRCTI)
Total number of young people employed by the sector	No baseline	No figures were found during the sector review that informed this SDP. Details of how to measure this in the future are provided in Section 4.
Total number of women employed by the sector	No baseline	No figures were found during the sector review that informed this SDP. Details of how to measure this in the future are provided in Section 4.
Evidence of supportive policy space	No baseline	No data were found during the sector review that informed this SDP. Details of how to measure this in the future are provided in Section 4.
Contribution of micro-digesters to organic waste to landfill targets	No baseline	No figures were found during the sector review that informed this SDP. Details of how to measure this in the future are provided in Section 4.
Contribution of micro-digesters to CO2 reduction targetS	No baseline[35]	No figures were found during the sector review that informed this SDP. Details of how to measure this in the future are provided in Section 4.
Contribution of micro-digesters to poverty reduction	No baseline	No figures were found during the sector review that informed this SDP. Details of how to measure this in the future are provided in Section 4.

NB: where there is no baseline, data collection will be required (see Section 4: Management, monitoring and evaluation)

[32]There are additional designs that have not been included in this baseline e.g. Deenbandhu fixed dome design developed by the University of Venda. This is because the baseline uses the most comprehensive publically available list of micro-digesters at the time of writing.
[33]We are aware that this list is not exhaustive and some organisations will be missing. This is because the baseline used the most comprehensive publicly available list of micro-digesters at the time of writing.
[34]Again, we are aware that this list is not exhaustive. This is because the baseline used the most comprehensive publicly available list of micro-digesters at the time of writing.
[35]No analysis of this has been completed in South Africa as far as could be ascertained but a study in Bangladesh of a 3.2m2 small-scale digester was found that the global warming potential saving across a 20 year life cycle is 217 tonnes of carbon dioxide or 11 tonnes per year (see: Rahman, K.M., Melville, L., Fulford, D. and Huq, S.I., 2017. Green-house gas mitigation capacity of a small scale rural biogas plant calculations for Bangladesh through a general life cycle assessment. Waste Management & Research, 35(10), pp.1023-1033.)

3 | Growth and sustainability by 2030

Based on the status of the sector and a series of stakeholder engagement events held in 2021, three pathways to sector development have been identified. These pathways provide opportunities to

(a) build on the existing capabilities and the momentum that the sector already has in rural energy access,
(b) capitalise on emerging policy windows and urbanisation to develop new urban waste management options and,
(c) build sustainability into the sector through enhanced capability development and employment opportunities.

Through focusing on these three pathways for market development, the sector's actors can work towards the sector development plan's vision and mission.

VISION

To create a vibrant and dynamic micro-digester sector in South Africa

MISSION

To provide micro-digester solutions to a range of market segments and in so doing contribute to South Africa's development plans

To achieve the vision and mission, the sector will work towards three objectives that relate to the three pathways.

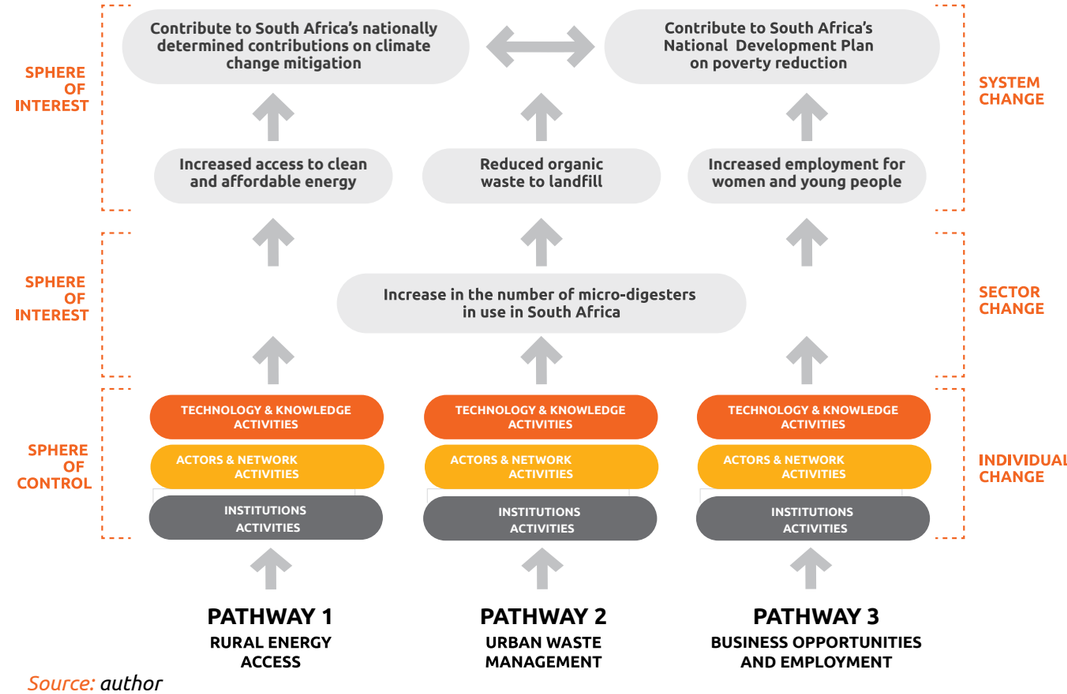
PATHWAY	OBJECTIVE	TARGET BY 2030
Rural energy access	To increase access to clean energy using micro-digesters in rural households	Threefold increase from baseline (n=350).
Urban waste management	To expand the micro-digester industry into urban waste management	Five pilot projects in operation
Business opportunities and employment	To increase the number of people working in the micro-digester sector	Triple the number of people working in the sector from baseline (n=270)

In so doing, the sector will work towards a series of outcomes and impacts.

OUTCOMES	IMPACT
Increase access to clean and affordable energy Reduce organic waste to landfill Increase employment of women and young people	Contribute to South Africa's nationally determined contributions on climate change mitigation Contribute to South Africa's National Development Plan on poverty reduction

Taken together, these form a 'theory of change' or a description of how to reach a desired state of change as outlined in Figure 3.

Figure 3: Micro-digester SDP theory of change



Source: author

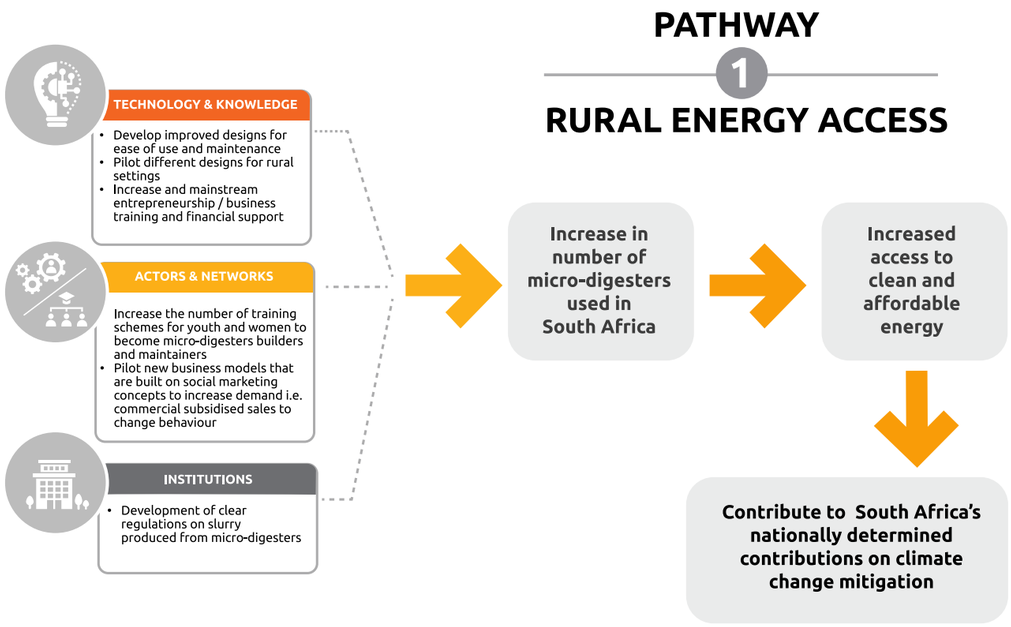
The next section outlines details of the proposed pathways, breaking down the types of activities that are required based on whether they are focused on technological, networking or institutional changes.

Pathway 1 | Rural energy access

The first strategy for developing the sector is to reinvigorate the existing focus on scaling up rural energy access. As noted, this is where the majority of the focus of attention has been, and there is an existing market base. The market is made up of a range of public sector and third sector actors who have predominately funded the provision of subsidised fixed dome micro-digesters for rural communities. To improve, this sector requires several activities across all three technological, networking and institutional areas.

An overview of the sub-theory of change relating to this pathway is presented in Figure 4. The action plan is provided in Table 4.

Figure 4: Rural energy access pathway theory of change



Source: author

Table 4: Rural energy access pathway action plan

ACTIONS NEEDED	DESCRIPTION	PRIMARY ACTION OWNER [36]
Develop improved designs for ease of use and maintenance	Investigate macerators, additives, mixing technologies, direct piping to greenhouses etc. Specifically, investigate willingness to pay and choice modelling of different additions because the technology additions themselves have been shown to work elsewhere.	South African universities
Pilot different designs	Trial new designs developed for rural settings.	SANEDI
Increase training schemes	Provide regular training to women and young people in partnership with existing organisations wherever possible.	Energy and Water Sector Education and Training Authority (EWSETA)
Mainstream entrepreneurship/ business training and financial support	More relevant training, subsidised business advisory support and favourable loans or tax incentives would attract people to the sector.	Department of Small Business Development
Pilot new business models using social marketing	Investigate social marketing models from other countries and develop relevant pilots that support subsidised or grant schemes with a transition to full cost model over time.[37]	SANEDI/ GIZ
Clearer regulations on slurry use	Revise and update regulations on slurry produced from micro-digesters to allow for the easier sale and/ or use of micro-digester byproduct. Allied to this, an advertising campaign to promote the revised regulations.	Department of Water and Sanitation

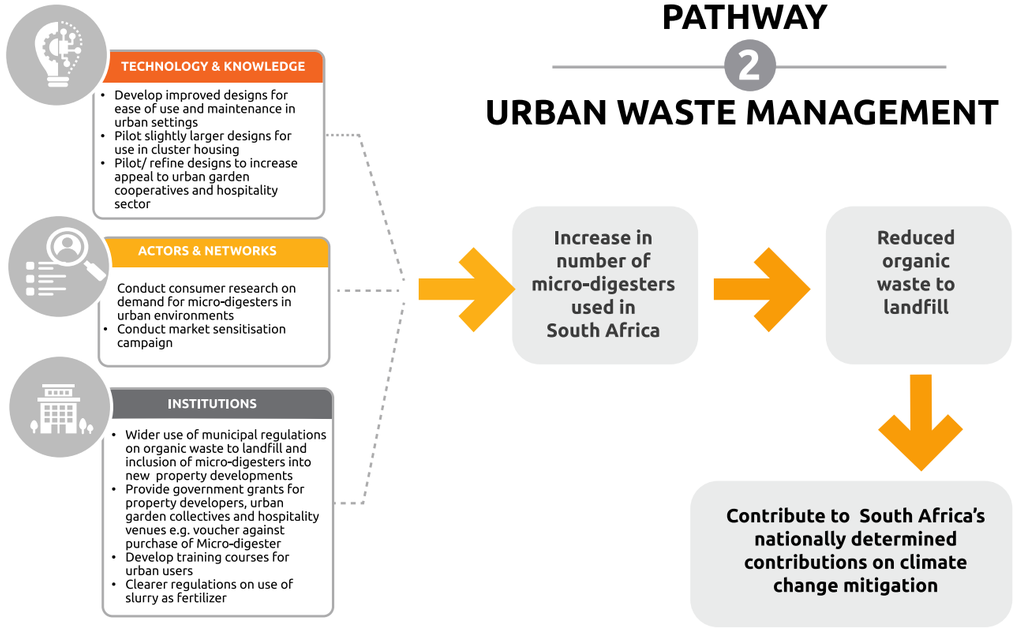
[36]This is the organisation that will take the lead to ensure these activities are conducted. It does not mean that other actors will not be involved in each activity. For example, the increase in training schemes will require not only EWSETA but also the AgriSETA to be involved as well as SANEDI, SABIA and various universities and technical and vocational colleges.
[37]A similar approach was conducted in Cambodia (see: Hyman, J. and Bailis, R., 2018. Assessment of the Cambodian national biodigester program. Energy for Sustainable Development, 46, pp.11-22.).
For social marketing in Africa in environmental technologies see: Kamara, I.T., Sande, H.T. and Niwagaba, C.B., 2008. Social Marketing for Scaling-Up Sanitation for the Urban Poor~ A case of slum communities in Kawempe Division, Kampala City; Maré, M., (2015). Social Marketing Strategies for the Diffusion of Energy-Efficient
Flame-Based Stove Technologies in the South African Market. MPhil dissertation. University of Johannesburg

Pathway 2 | Urban waste management

The second strategy for developing the sector is to break into the urban market for micro-digesters. Very little attention has been focused on this market segment and industry stakeholders are not convinced that it is a viable market segment.[38] However, a review of the policy landscape[39] highlights an open policy window (notably in relation to organic waste but also the water, energy, food nexus) which is potentially conducive to a radical new change in the direction of the sector. To improve this sector requires several activities across all three technological, networking and institutional areas.

An overview of the sub-theory of change relating to this pathway is presented in Figure 5.
The action plan is provided in Table 5.

Figure 5: Urban waste management pathway theory of change



Source: author

[38] Views received during stakeholder workshops undertaken during this sector review. See Section 5 Annexure that outlines the stakeholder consultation process.
[39] See Hanlin, R. et al. (2021) A policy and innovation perspective on micro-digesters in South Africa. Johannesburg: UJ-TRCTI. Available at: https://www.uj.ac.za/faculties/college-of-business-and-economics/trilateral.-research-chair-in-transformative-innovation/trcti-publications/

Table 5: Urban waste management pathway action plan

ACTIONS NEEDED	DESCRIPTION	PRIMARY ACTION OWNER [36]
Develop improved designs for ease of use and maintenance	Investigate macerators, additives, mixing technologies, direct piping to greenhouses etc. Specifically, investigate willingness to pay and choice modelling of different additions because the technology additions themselves have been shown to work elsewhere.	South African universities
Pilot slightly larger designs for use in cluster housing	Develop and test a slightly larger design of micro-digester that can be used in communal housing developments. Allied to this, revise the guidelines on micro-digester projects accordingly.	South African universities
Pilot/ refine designs to appeal to urban gardens and hospitality sector	Revise current designs to increase efficiency as a multi-modal solution (organic waste use, resulting in gas and slurry use) for urban gardening cooperatives and hospitality sector (especially restaurants and small hotels).	Private sector firms
Conduct consumer research on urban demand	Undertake surveys to understand the willingness to pay, choice modelling and similar to gauge consumer potential and actual demand for micro-digesters in urban environments, especially communal/ cluster housing developments.	SABIA/ City of Johannesburg and City of Cape Town metropolitan municipalities
Conduct market sensitisation campaign	Develop and roll out a market sensitisation campaign on the benefits and opportunities of micro-digesters in communal/ cluster housing (and apartment) developments to residence associations, property developers and municipal authorities. Conduct the same in the hospitality sector.	SABIA
Widen use of municipal regulations	Roll out reduced or zero organic waste to landfill regulations where they do not exist. Also, mandate the need for all new communal housing/ apartment builds of relevant size to include a micro-digester for organic waste management.	Department of Water and Sanitation City of Johannesburg and City of Cape Town metropolitan municipalities
Introduce grants to encourage uptake	Provide government grants for property developers, hospitality venues and urban garden collectives to encourage them to adhere to new regulations, e.g. vouchers against the purchase of a micro-digester.	City of Johannesburg and Cape Town metropolitan municipalities
Develop training for urban users	Review, revise and develop training for operations and maintenance of urban digesters.	Energy and Water Sector Education and Training Authority (EWSETA)
Clearer regulations on slurry use	Revise and update regulations on slurry produced from micro-digesters to allow for the easier sale and/ or use of micro-digester byproduct. Allied to this, an advertising campaign to promote the revised regulations.	Department of Water and Sanitation

[40] This is the organisation that will take the lead on ensuring these activities are conducted. It does not mean that other actors will not be involved in each activity.

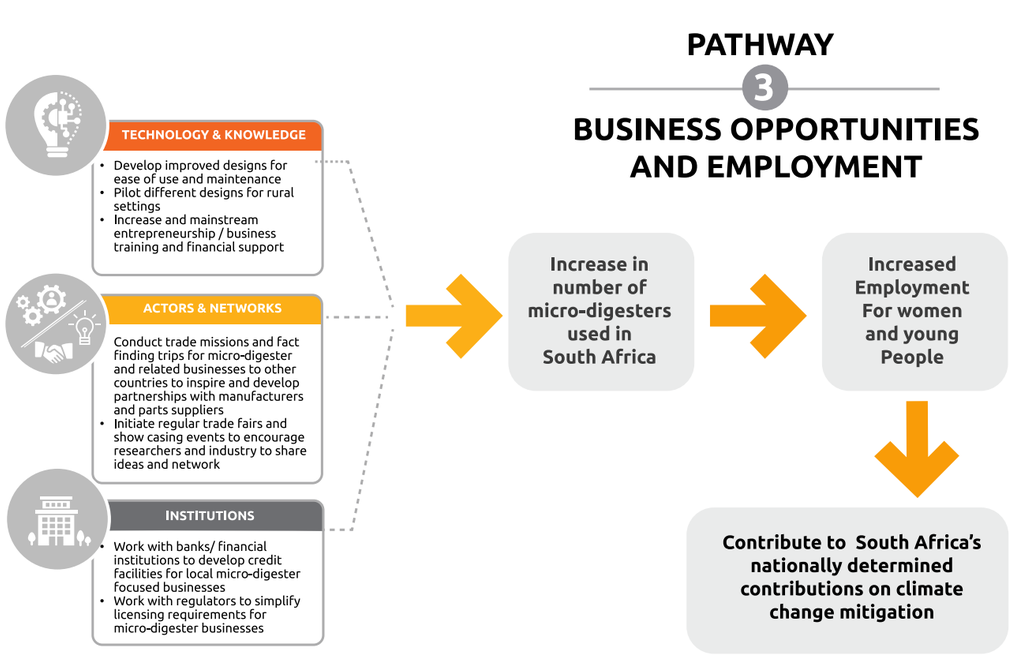
Pathway 3 | Business opportunities and employment

The third area for promotion by the sector is the development of capabilities, specifically for young people and female entrepreneurs to address inequalities in the job market in line with relevant government policies. To develop the sector requires more business involvement. Despite the high cost of building a brick and mortar fixed-dome micro-digester, the level of effort required to build and maintain it provides significant opportunities for community-based organisations and youth groups to generate income through activity in this business sector. There are also opportunities for these groups to become more involved in the operation of these designs. At the same time, small and medium-sized formal businesses will need support to remain active in this sector.

To improve this sector requires several activities across all three technological, networking and institutional areas.

An overview of the sub-theory of change relating to this pathway is presented in Figure 5.
The action plan is provided in Table 6.

Figure 6: Business opportunities and employment pathway theory of change



Source: author

Table 6: Business opportunities and employment pathway action plan

ACTIONS NEEDED	DESCRIPTION	PRIMARY ACTION OWNER [41]
Strengthen training opportunities in education	Enhance training opportunities, including ensuring micro-digester design and manufacturing are included in existing relevant technical and vocational training and engineering courses.	Department of Higher Education and Training
Increase industry training opportunities	Increase the number of training schemes for youth and women to become micro-digester builders and maintainers.	SABIA
Conduct trade missions and develop partnerships	Organise trade missions and fact-finding trips for micro-digester and related businesses to other countries to inspire and develop partnerships with micro-digester manufacturers and parts suppliers.	Department of Trade, Industry and Competition
Initiate trade fairs and showcases	Instigate regular trade fairs and showcasing events (e.g. in conferences and symposiums) to encourage researchers and industry to share ideas and network.	SABIA
Develop credit facilities for local micro-digester businesses	Work with banks/ financial institutions to develop credit facilities for local micro-digester focused businesses.	SABIA
Work to simplify licensing requirements	Work with regulators to simplify licensing requirements for micro-digester manufacturers, distributors and operators.	SABIA

[41] This is the organisation that will take the lead on ensuring these activities are conducted. It does not mean that other actors will not be involved in each activity.

4 | Management, monitoring and evaluation

MANAGEMENT OF THE SDP

A management committee should be established and meet annually to review the progress of the SDP against the monitoring and evaluation plan outlined below. The management committee should be comprise of a range of stakeholders from across the public, private and third sectors. In the first years of implementation of the SDP, the SABIA Micro-Digester Working Group could be tasked with managing this. A terms of reference document should be developed as the first order of business.

MONITORING AND EVALUATION OF THE SDP

Routine monitoring and evaluation are recommended for the SDP as per the following tables (Tables 7, 8 and 9). The baseline indicators provided in this report should be used to measure progress towards the SDP objectives. These can be augmented with additional inputs as needed, e.g. in-depth interviews or focus group discussions to take account of changing stakeholder attitudes, changes in the policy environment etc.

Table 7: Indicators to measure progress toward rural energy access

Pathway 1: RURAL ENERGY ACCESS

OBJECTIVE:	**To increase access to clean energy using micro-digesters by threefold in rural households by 2030**
TARGET:	**Threefold increase from baseline = 1,050 micro-digesters deployed**
Total number of micro-digesters in existence	
Installed capacity (in MW)	
Number of micro-digesters installed in rural households	
Total number of working micro-digesters	
Levelised cost of energy relative to LPG	
Contribution of micro-digesters to CO2 reduction targets	
Contribution of micro-digesters to poverty reduction	

Table 8: Rural energy access

Pathway 2: URBAN WASTE MANAGEMENT

OBJECTIVE: **To increase access to clean energy using micro-digesters by threefold in rural households by 2030**
TARGET: **Threefold increase from baseline = 1,050 micro-digesters deployed**
Total number of micro-digesters in existence
Installed capacity (in MW)
Number of micro-digesters installed in rural households
Total number of working micro-digesters
Levelised cost of energy relative to LPG
Contribution of micro-digesters to CO2 reduction targets
Contribution of micro-digesters to poverty reduction

Table 9: Indicators to measure progress in economic opportunities created

Pathway 3: BUSINESS OPPORTUNITIES AND EMPLOYMENT

OBJECTIVE: **To triple the number of people working in the micro-digester sector by 2030**
TARGET: **Triple the number of people working in the sector from baseline = 810 employed in the sector.**
Total number of micro-digester designs available in South Africa
Percentage of micro-digester designs made in South Africa
Total number of private firms registered in South Africa selling micro-digesters
Total number of firms registered in South Africa providing O&M services
Total number of staff employed by the sector
Total number of young people employed by the sector
Total number of women employed by the sector
Contribution of micro-digesters to poverty reduction

The baseline indicators in Table 10 do not map onto the pathways but are useful to review regularly to gauge government commitment to the sector.

Table 10: Indicators to measure public sector commitment to micro-digester sector development

Number of micro-digesters installed in public institutions
Evidence of supportive policy

BASELINE DATA COLLECTION

To effectively measure progress across these indicators, each requires a baseline. Unfortunately, at the time of SDP development, there was no baseline data available for eight of the indicators. Proposed methods to collect this baseline data are provided in Table 11. The details of survey data collection are provided in the monitoring and evaluation schedule. It is recommended that these are collected as soon as possible after implementation of the SDP. For example, at the time that this plan was going to press, a nationwide review of the number of anaerobic bio-digesters (including those at micro-scale) was on-going.

Table 11: Data collection for missing baseline indicators

BASELINE INDICATOR	COLLECTION METHOD
Total number of organisations (private firms and community organisations) in South Africa providing O&M services	Survey data
Total number of staff employed by the sector	Survey data
Total number of young people employed by the sector	Survey data
Total number of women employed by the sector	Survey data
Evidence of supportive policy space	Desk review
Contribution of micro-digesters to meeting organic waste to landfill targets	Statistical calculation using survey data
Contribution of micro-digesters to CO2 reduction targets	Statistical calculation using survey data
Contribution of micro-digesters to poverty reduction	Statistical calculation using survey data

MONITORING AND EVALUATION SCHEDULE

The following monitoring and evaluation schedule is recommended:

a. Annual monitoring of progress through a survey of all organisations involved in the sector. This will collect data against each of the relevant indicators outlined in Tables 7, 8, 9 and 10.
b. A formative evaluation in 2026 to review progress and revise the SDP as required.
c. A summative evaluation in 2030 to assess the ability of the SDP to meet its targets and inform the development of a sector plan for the period post-2030.
   The two evaluations should be conducted with stakeholder involvement and public consultation. The evaluations should also take into account changes in technology as well as environmental, political, social and legal conditions. In 2030, if not before, this should include scans at the global, regional as well as the national level.
   Progress data and the two evaluation reports should be presented to the SDP management committee at their annual meeting,

CORRECTIVE ACTION

Collecting annual progress data as well as the formative evaluation will provide an opportunity for the management committee to review progress and revise sector actions and this plan as required.

5 | Annexure: Methodology

The sector development plan was developed using a stakeholder-led approach.
The report is the culmination of the following activities:

SECTOR REVIEW

UJ-PEETS and UJ-TRCTI were engaged in 2020 to conduct a review of the micro-digester industry in

a) A thorough desk review of materials relating to the biogas industry in South Africa and sub-Saharan Africa more generally.
b) A workshop in July 2020 and subsequent write up of an action dialogue report.
c) The commissioning of a series of reports that looked at the status of the innovation system in South Africa and specifically the policy landscape, political economy analysis, market analysis and the techno-economic efficiency of micro-digesters in South Africa.
d) Fieldwork to review the status of micro-digesters in use in Gauteng, Limpopo and KwaZulu-Natal.
e) A small theory of change workshop in February 2021 with academic stakeholders and SANEDI representatives. The total number of participants attending from outside UJ-TRCTI was 10.
f) A stakeholder and innovation system mapping exercise conducted with a limited number of academic stakeholders and SANEDI representatives in March 2021. The total number of participants attending from outside UJ-TRCTI was six.
g) Three formal discursive multi-stakeholder meetings with various SANEDI staff and project managers involved in SANEDI-funded projects in Gauteng and Limpopo between February and March 2021. These meetings focused on the experiences of the project activities to date, challenges and windows of opportunity encountered, and general reflections on attitudes to, barriers, and enablers for micro-digesters in South Africa. The number of external participants engaged across all three meetings was 18.

Based on the findings of the above review, draft sector development plans were developed. The findings of these reviews (Rasmeni, 2021 and Hanlin et al., 2021) are publicly available.[42]

STAKEHOLDER CONSULTATION PROCESS

These were then shared with stakeholders in late 2021. Over 80 stakeholders attended each of the workshops. The technical audit meeting was attended by 15 participants.

a) 19 October 2021 – A first workshop presented the sector review results and initiated a dialogue on the future of the sector by introducing a 'theory of change' approach for sector development and mapping potential future market pathways for the sector.
b) 12 November 2021 – A technical audit meeting assessed the current status of micro-digester technology in South Africa.
c) 26 November 2021 – A second workshop narrowed down the pathways through a presentation of the final theory of change.

The final sector development plan was also reviewed by a small number of industry stakeholders in February 2022 and subjected to stakeholder validation during a workshop in March 2022.

[42]Rasmeni, Z. (2021) Industry Status Report. Johannesburg: UJ-PEETS and Hanlin, R. et al. (2021) A policy and innovation perspective on micro-digesters in South Africa. Johannesburg: UJ-TRCTI. Available at: https://www.uj.ac.za/faculties/college-of-business-and-economics/trilateral-research-chair-in-transformative-innovation/trcti-publications/


sanedi
South African National Energy Development Institute.
SABIA
SOUTHERN AFRICAN BIOGAS INDUSTRY ASSOCIATION
UNIVERSITY OF JOHANNESBURG
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