NSTF
National Science & Technology Forum

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Energetic behind-the-scenes efforts to resolve South Africa's power problems

The National Science and Technology Forum (NSTF) held its first Discussion Forum for 2024 on 24 and 25 April. The event focused on the energy crisis in South Africa – a topic that features annually on the NSTF's agenda.

Referring to the non-loadshedding-related power outage in Johannesburg on the day of the Discussion Forum, NSTF Executive Director Jansie Niehaus said, "This affects absolutely everything. It is affecting our economy, education, our ability to be competitive in the world, our prospects, and it will affect the elections as well. So it is highly topical and this is also borne out by the great interest in this event for these two days.

"I'm hoping that we will get some perspective on these problems as well as see what kind of developments are happening behind the scenes. People are working very hard at finding solutions and improvement in this situation."

The South African state has a legal obligation to provide energy on a national scale to its citizens, but it has become increasingly clear that the state is unable to do so, universally and consistently. Sources of electricity remain constrained to such an extent that it would take many years to restore and expand the system sufficiently. Yet the government has been addressing the crisis in various ways, and a new Integrated Resource Plan (energy.gov.za) has been published. While the government focuses on national power supply, transmission and distribution, various initiatives address the energy crisis at a more local level.

What follows is a synopsis of the presentations given.

The speakers' biographies, presentations and video recordings are available at https://nstf.org.za/2024/04/25/annual-energy-discussion-forum-24-25-april-2024/.

Skills development in South Africa for a just transition

Ms Tshwanelo Rakaibe, a Senior Researcher at the CSIR's Energy Centre, shared that a few years ago, the CSIR's Energy Centre modelled the direct and indirect jobs that would be lost by the closures of coal-powered power stations as well as the jobs that would be gained through the introduction of renewables, particularly wind and solar.

"While there would be jobs gained through the introduction of renewables, we must ask ourselves whether those jobs will be created in the coal regions – where they are needed – and if not, what interventions are being developed to avoid exacerbating our unemployment, poverty and inequality challenges and all of the social ills that we know result from those," Rakaibe said.

Investing in skills is a strategic response to addressing the electricity crisis and ensuring that the energy transition is just. It also builds capacity for innovation and new technology adoption, enhances operational efficiency and resilience, and addresses policy and regulatory challenges.

She added, "The work done in the renewable energy skills domain focused on science, technology, engineering, and mathematics (STEM)-related occupations, which are critical, but with the ever-changing landscape that includes the unbundling of Eskom, we also need skilled professionals in energy policy, regulation and governance because these shape the environment in which these challenges must be addressed. The evolving market resulting from the amendment of the Electricity Regulation Act as well as persistent loadshedding also led to market reforms, such as more private sector participation in generation projects, further highlighted new skills needed."

One CSIR Energy Centre project, the Co-benefits Project, calculated and quantified the socio-economic benefits of potential renewable and clean energy projects on the re-purposing sites of Eskom coal plants in Mpumalanga – specifically to address the challenge of ensuring that jobs are created where they are required.

"In the report, we highlighted 9 important framework conditions required to maximise some of these benefits that we identified, with the employment effects, skills development and gender needs, as well as industrial opportunities. Some concerned the need to implement policies that enable the development of projects in the province and others focused on interventions that can increase local manufacturing capabilities," Rakaibe continued.

From a skills perspective, the study identified the need to develop skills through the technical and vocational education and training (TVET) colleges to facilitate the graduates' entry into the renewable energy market. Regarding gender inclusivity, the study highlighted practical considerations that prevent women from participating in the sector. For example, these projects are often in far-flung areas, and given that childcare is still primarily done by women, childcare facilities near training centres and even project sites become necessary.

Another project focused on re-skilling and was done in collaboration with Res4Africa. The objective was to determine what skills are required for renewable energy value chains (solar PV and wind), quantify job gains that can be achieved from these technologies, and develop a reskilling framework for coal to renewables.

Again focusing on Mpumalanga, the study identified that the wind value chain required a range of skills in project development, component manufacturing, construction, and operation and maintenance. In the solar PV value chain, skills were identified in system design; project development; and installation, operation and maintenance.

She related, "A spin-off of this work has been a pilot project at Nkangala TVET College in collaboration with the Energy and Water SETA (EWSETA), and Res4Africa. It started with a train-the-trainer programme for about 10 lecturers who have been upskilled to deliver the renewable energy course. The second phase started in April 2023 and will run for 18 months where electrical engineering students will be trained and given practical exposure to renewable energy, followed by six-month internships."

Rakaibe emphasised that these kinds of initiatives must be scaled up and championed by government.

The CSIR Energy Centre recently completed a project on behalf of the Department of Higher Education and Training as part of its Labour Market Intelligence Programme. The researchers again followed a value chain approach in identifying the occupations required for the green hydrogen economy in South Africa.

"The *Identification of Skills Needed for the Hydrogen Economy* is an important study because the energy sector is broader than just electricity and contributes to about 73.2% of global greenhouse gas emissions. It includes

‘hard to abate’ sectors such as heavy-duty transport and industrial sectors like cement, steel, refineries, the chemical sector, agriculture and so on. Their decarbonisation pathways are less straightforward than the electricity sector. Green hydrogen has been identified as an energy source that can assist in the decarbonisation of these sectors,” she said.

The Centre identified 138 occupations and 185 hydrogen-specific capabilities for each of those occupations. It also looked at the qualifications required and the analysis of the relevance of the degrees and the performance that are currently being offered in South African higher education institutions.

In the long term, the study made proposals around curriculum revision in the education system and formalising training of lecturers.

Work outside of the energy sector includes a study under the UK Partnering for Accelerated Climate Transitions programme that looked at a social protection plan for Mpumalanga.

The Just Energy Transition Investment Plan earmarked about R2.4 billion to support the diversification of local economies – something that is key when considering the closing of coal-powered stations and the increasing importance of alternative sectors.

“We evaluated economic diversification options for Mpumalanga. We are already starting to see projects emerge in the mining sector, the energy sector, in agri-voltaics, tourism, and manufacturing, to name a few,” she added.

Small, medium and micro enterprises (SMMEs) contribute 59% of employment in South Africa. As part of the five-year CSIR-EWSETA Energy Industry Support Programme, the CSIR supports SMMEs through a capacity-building programme for SMMEs that want to participate in the sector but are not sure where the opportunities are, and the second component focuses on incubating SMMEs that are already operating in the energy technology space.

Rakaibe concluded, “Policy certainty is queen – the most powerful piece on the chessboard – in enabling investment decision-making as well as skills-planning decisions. Upskilling in higher education is a prerequisite for the transition and we need to have dedicated programmes, tuition, and partnerships with industry in the form of, for example, apprenticeships and on-the-job training.

“Gender inclusivity must be promoted through targeted support programmes. Awareness campaigns are necessary to inform people about career and business opportunities in the energy sector, and re-skilling frameworks must be developed for the different technologies that we are introducing in our energy mix. The more specific we can be about these, the better people will be able to pivot into new sectors and ensure that the transition is just and leaves nobody behind.”

A just transition to renewable energy sources

Mr Steve Nicholls, Head of Climate Mitigation at the Presidential Climate Commission (PCC), framed his presentation against the backdrop of the world being fundamentally unjust, particularly South Africa, and that not responding to climate change will exacerbate this injustice.

Uncertainty about the way forward causes people to resist change, but, he asserted, the evidence supports the need for rapid change. The world is shifting and South Africa risks being left behind.

“We need to acknowledge that the transition will be extremely difficult and will require a huge collaborative effort. The science, engineering and technology fields are critical solution providers,” Nicholls said.

He explained that the focus of the PCC is that everything that can be done within climate constraints must be done to ensure South Africa's economy is more competitive to create opportunities for every person in the country. In this context, lifting people out of poverty, inequality and unemployment is the PCC's primary goal.

"When we think about these energy transitions and justice transitions in general, there's a lot of uncertainty and conflicting information. There is a lot of misinformation and disinformation out there. So it's very difficult to see the pathway forward, and so we tend to anchor on what we know and we resist change. How do we flip this around?" he asked.

In South Africa, at least 55% of people live in poverty, the country has a 0.63 Gini coefficient – a measure of economic inequality of which South Africa has the highest in the world, meaning it is the most unequal society in the world. Unemployment is greater than 50% with youth unemployment in some parts of the country being as much as 60%. Wealth has distinctly unequal spatial, racial and gendered distributional patterns, and current polluting development patterns have distinct impacts on climate, nature and human health with the poor bearing the biggest impacts and having the fewest resources to recover.

Electricity is critical, both for economic development and for justice. There's some interesting research from the Public Affairs Research Institute looking at how electricity impacts households. It found, among others, that a household with access to a reasonable amount of electricity is more likely to start a business and be entrepreneurial. A strong correlation exists between energy availability and economic development and justice of outcomes.

Nicholls explained, "But when we think about electricity planning, we have to think about this thing called the 'electricity trilemma', which was coined by the World Energy Council. Here we think about energy systems in three axes, environmental sustainability, energy equity, which is about affordability and access, and security, i.e. how can we withstand shocks? Do we have a constant supply?"

The current energy system in South Africa does not provide any of these things. A transition is necessary and studies show that a renewable energy-based system is more environmentally sustainable. It provides more equity, is cheaper, easier to roll out in microgrids.

The PCC released its recommendations on electricity planning in April 2023. It reviewed all of the work done on electricity systems in South Africa. All of those studies showed more or less the same thing: The least-cost pathway is variable renewable energy with peaking support and storage. The peaking support will take care of some of the variability issues. The recommendations were shared far and wide and more input was sought, resulting in the broad recommendations, which were subsequently reinforced by more studies by Bloomberg, the CSIR, Stellenbosch University and the University of Cape Town.

"Studies confirmed that the cheapest way forward, that is adequately secure, and that provides social benefits, is variable renewable energy plus peaking support plus storage. And so our recommendations were to invest in a least-cost pathway, resolve the current energy crisis as quickly as we can, and seek opportunities to accelerate the transition," he added.

The PCC was one of the first to highlight the need to focus on the grid. The grid has now moved much more central to electricity planning and the need to be focused on transmission and distribution.

Nicholls said, "We still worry about the focus on distribution being too small, and we realise that the transmission infrastructure is a major bottleneck to the rolling out of these technologies. But distribution and the business models of municipalities are something that is still not understood well enough, and major work is needed on pricing and market reform in the context of how this impacts the local government business models."

Job creation focuses on green industrial development, specifically around how economies should be transitioned.

For example, unemployment in Mpumalanga is around 40%. “So, even if we made a one-to-one job swap for people who lose their jobs because of the coal transition and gain jobs in the renewable energy sector, you will still have unemployment of 40%.

“This is not just. We need to do more than that. We need to be thinking about the transition of the economy as a whole and economic diversification. Doing industrial development off the back of those energy transitions is something that needs more focus and we need to invest in human resources and skills development.

“We need support for those most impacted by loadshedding, particularly SMEs and indigent households, and we need to enhance social protection measures for those impacted by the coal transition.”

There is agreement that renewable energy is the way forward, but it's complicated with many competing interests.

One of the major objections to high penetrations of renewable energy is the impact that it has on the grid and energy stability. The International Energy Agency has shown that in the first phase of renewable energy penetration, there is no noticeable impact on the system. In the second phase, one sees minor to moderate impacts; in the third phase, one needs to think carefully about how to design the system and system operations. In phase four, the variable renewable energy meets some or all of the demand for a short period, and this is happening all over the world now, for example in the United Kingdom, Spain, Germany, California, and Texas. A couple of countries are in phase five where variable renewables are providing a surplus and that creates some pricing challenges.

There is therefore a clear sense of how these things are happening globally. Many countries are far ahead of South Africa’s level of penetration and are in the process of solving these kinds of problems. The point is that one doesn’t see major challenges to grid stability until the penetration is around 50%.

“All of those other problems have been solved in some or other manner around the world. And so we have a lot of headroom in South Africa to be investing in renewables before we start to hit some of those major challenges and even when we do, those challenges are solvable.”

Physical climate risk is critical to think through. Average global temperatures are rising. The impacts of this are best avoided. For example, South Africa warms at twice the rate of the global average – a critical consideration for things like agriculture and water supply with projected impacts of a further 25% to 75% reduction in agricultural output, depending on crop and scenario, and with just 1.7°C global warming by 2050, 17–40 million people could migrate internally in sub-Saharan Africa, increasing to 56–86 million for 2.5°C.

“No one is saying this is easy. It requires an unprecedented global and local effort at a scale we have never seen. But failure to respond will entrench injustice, globally and locally,” Nicholls asserted.

He added that the opportunity for a just transition is enormous in South Africa. With known investment opportunities, a net-zero economy looks as follows:

- A green manufacturing hub has been established;
- Strengthened its place in global shipping by providing net-zero bunker fuels;
- Is exporting net-zero fertilisers to sub-Saharan Africa;
- Is exporting green iron and steel to the European Union;
- Produces net-zero aviation fuels, also strengthening its tourism;

- Acts as a beneficiation and export hub for minerals mined in Southern Africa;
- Expands its mining capacity as it mines the commodities needed for new economies;
- Expands its cement and steel manufacturing industry as construction booms (for industry, infrastructure and housing);
- Minimises food imports as it builds resilient infrastructure;
- Has reliable, safe public transport;
- Exports electric vehicles and expands the manufacturing and auto-supply industries;
- Localises manufacturing chains;
- Enhances energy security through localised variable renewable energy component production; and
- Has secured access to critical minerals.

The payoffs from these are enormous and include more than 5 million jobs created; more than 1.2 million jobs protected; 30% fewer people living in poverty, with more disposable income; 2 300 deaths and economic costs of R42 billion avoided per year; and a doubled gross domestic product (GDP).

“So what can the science community do? We're so paralysed by the debates and the uncertainty and the misinformation that we're just gonna plough into the barrier in the middle of this fork in the road where we find ourselves. We need a better way to try to build consensus and understand these challenges. We need to shift our mindset from ‘it's impossible’ to the science, engineering and technology community as the community from which the solutions will come.

“It is clear that we can get at least up to 50% penetration of renewables now without causing any major problems to the grid. Let's do that and let's apply our minds to solving those future problems.”

Without the involvement of the science community providing really good data and really good studies, what is left is a debate around ideology. The science community must fill the gaps with fact-based data.

Nicholls concluded with a sobering review of what a just transition requires. The average monthly spend of a household on food is about R1 027. For a nutritious basket of food, an average household needs R2 900. For a climate-friendly nutritious basket of food, the average household would need R4 300.

Looking at this, most households are lacking in nutrition, which has severe impacts on health and the ability to learn and become contributing citizens helping to build this country.

“So, even without thinking about climate change, we must be thinking about transitioning our economy in a way that quadruples household income without creating inflationary wage pressure. This encapsulates the challenge of the transition and how we are failing at the moment. But we can do better.”

Supporting South African cities to deliver an energy-secure future

Ms Hlengiwe Radebe is the Renewable Energy Technical Adviser at C40 Cities, a network of nearly 100 mayors of the world’s leading cities committed to using a science-based and people-focused approach. In South Africa, Johannesburg, Ekurhuleni, Tshwane, eThekwini and Cape Town have joined the C40 Cities network.

C40 has worked with the cities to develop evidence-based climate action plans to meet emissions reduction targets aligned with the 1.5C goal of the Paris Agreement since 2017.

“The climate action plans provide valuable data on specific electricity demand and consumption patterns and the sector's overall share or contributions to carbon emissions of each city,” she said.

Progress so far includes that four of the five cities have developed and updated greenhouse gas emission inventories with the fifth being in review. Three have developed an urban climate risk assessment, and four have published their climate action plans.

Looking at energy and electricity, Radebe highlighted some of the key targets in each climate action plan. The five cities represent a large share of national energy use and have expressed their ambitions to reduce emissions and increase renewable energy by 10–40% by 2030 and as much as 100% by 2050.

Cape Town, for example, is working towards raising the total share of zero-carbon electricity supply to between 24% and 48% by 2020. Johannesburg and eThekwini aim that 35% and 40%, respectively, of electricity consumed should be from renewable sources by 2030. Ekurhuleni targets a 25% reduction in fossil fuel use in the same period, and Tshwane aims that 10% or 200MW of the City's electricity should be sourced from renewable energy and in 2024, aims to identify 1 000MW of renewable and cleaner energy projects from independent power producers to power the local grid.

"Cities are experiencing ongoing energy security challenges due to generation capacity constraints by the ailing state-owned utility, and recent amendments to national electricity regulations present an opportunity for South African cities to directly address and contribute to energy security concerns and the associated socio-economic and environmental issues. With these amendments, municipalities are enabled to procure new generation capacity from, for example, the independent power producers or building their own," Radebe explained.

A current C40 Cities project aims to accelerate direct sourcing of renewable energy capacity from independent power producers, transform electricity systems in the country, and help municipalities meet their ambitious climate and renewable targets while saving money. The work is funded by the Climateworks Foundation and runs until March 2025.

The cities were supported to put in place comprehensive energy sourcing strategies and roadmaps that align with their climate action plans and to make progress towards procuring from renewable independent power producers.

"We're also looking to support cities to enable regulatory frameworks and policies enhanced to support other private consumers to source renewables, and we focus on cities following a just transition pathway for the energy sector by ensuring that their energy structures help to advance their socio-economic issues," she added.

Assistance comes in the form of facilitating peer-to-peer exchanges, webinars and workshops based on the key challenges arising, such as how a municipality currently not in good standing could also transition; the development of knowledge products; and offering light-touch technical assistance.

The silent revolution – dispelling myths, breaking barriers

Mr Davin Chown, Managing Director of the Genesis Eco-Energy Developments and Genesis Infrastructure and Renewable Energy Group, acknowledged that South Africa is good at debate and policy formulation. However, the nation is not excelling at getting things to a point where they work practically so that implementation can start. Implementation skills, capacity and ability must be ramped up.

Statistics highlighting the South African context, include that from a population of approximately 61 million people, about a third (22 million) receive social security/grants while individual taxpayers total about 7.2 million people, general unemployment stands at 34%, youth unemployment at 51%, and GDP growth is less than 1%. This is against a backdrop of ongoing loadshedding for the past 15 years.

"We often liken our solar policy to that of what's happened in a country like Germany, where you see the kind of rollout that's happened over the years and they've got a fraction of the natural resource that we have. We're

catching up, but ever so slowly. My question is how long will it take us, given our resources and the scale of our country, to get to a position where we are a leading light, where we are taking the latest technologies, where we are developing our own?

“Nobody wanted to use our solar technologies 15 years ago and so they were sold to Germany. From a technology and a science point of view, we have this situation where we excel, we have brilliant minds that develop stuff, but we can't implement it in our own country because our policies and our mindset to adopting new technology tell us that we don't want to take that leap that we need to catapult our economy forward,” Chown said.

“When we design policy, when we look at ambition, when we look at marshalling the funding into new science and technology to solve societal problems and to position our country in a situation where growth is sufficient to deal with our challenges, why do we seem so reluctant? This is a question that we must resolve.”

He made the case that South Africa has the resources and that ample good research exists, including the many international examples of where renewables have been adopted with good lessons learnt.

“At the end of the day, we're looking for a solution where technologies can contribute to fuelling our economy, bearing in mind, behind renewable energy, particularly wind and solar, there is the whole focus on free-fuel renewable energy. We have a conversion cost. We don't have a fuel cost, that fuel cost hedges us against the volatility in the fossil fuel markets, etc. and helps decouple a little bit from that growing risk of the volatility around the world.

“Fossil fuel is something in which South Africa has an abundant resource. So, if we're seeing lower prices, we're seeing free fuel. There is an economic rationale that says we should be doing more of this, not less of it, but we certainly do need to find a way to speed up how we are doing this, how we are implementing.”

Looking at international growth, renewable electricity capacity additions reached an estimated 507GW in 2023, almost 50% higher than in 2022; there is continuous policy support in more than 130 countries, spurring a significant change in the global growth trend. 2023 saw worldwide acceleration driven mainly by year-on-year expansion in China’s booming market for solar PV (+116%) and wind (+66%). Renewable power capacity additions are set to continue to increase in the next five years, with solar PV and wind accounting for a record 96% of it – their generation costs are lower than for both fossil and non-fossil alternatives in most countries.

"People are implementing. We must let the policy catch up with practicality and we must back our innovation and our ideas, our technologies and the people behind them. The question is also what does it mean for jobs? And how do we stimulate it through the proactive and clever use of our energy supply and our indigenous resources, where we can see prices dropping because we've seen the implementation happening around us?

"We should not be questioning every little thing, debating it to the nth degree; we need a fundamental shift away from this perpetual cycle of putting things into the policy 'hamster wheel' to where we get into implementation mode, and particularly using South Africa's indigenous technologies, indigenous thinking, and indigenous resources with the sources of money that exist. Energy and the coming change which is already here and which will accelerate, will create the opportunities to move into the future," Chown concluded.

Institutional skills development in a just energy transition

Mr Devan Pillay, Head of Employment Strategy at the PCC, explained that there are three transitions taking place. “If we look at where we are right now, we have a high vulnerability to climate change; low-productivity and carbon-intensive economy; a weak public sector; limited implementation capacity; extreme levels of unemployment, inequality, and poverty; and a decreasing per capita income. These created a solid foundation for the just transition – an entire societal change.”

The three transitions are decarbonisation, adaptation and resilience, and a just transition looking at society in terms of capacitation for employment, skills development, and social protection.

The vision for South Africa is that by 2050, the economy and society will be resilient to climate risks; will have a net-zero carbon economy, growing investment to the GDP ratio and a competitive economy, an effective and capable state; dramatically reduced levels of inequality, unemployment, and poverty; and social inclusion.

“When discussions began to gain momentum for the just transition and before the just transition framework, the four most at-risk sectors were identified, namely coal, automotive, agriculture, and tourism,” Pillay continued.

Some 80 000 jobs could be lost in the coal sector, 10 000 at the Eskom coal power stations, and 75% of jobs in Mpumalanga. In the automotive sector, some 450 000 jobs could be lost in manufacturing, mechanics and petrol stations. About 800 000 jobs are at risk in commercial agriculture and more than 600 000 jobs in tourism, specifically catering and accommodation, and small businesses.

To respond to this effectively, the Just Transition Framework speaks to significantly upskilling and re-skilling workers so that they can navigate the transition. Skills development and education are therefore essential for a future labour force in green jobs.

“How do we achieve this? Several initiatives must be in place to impact sectors of the economy. For example, job creation, training capacity, infrastructure planning and roll-out, managing geo- and cultural dislocation, social protection, service delivery and access to infrastructure and markets, economic inclusion and participation, ownership, and ecological restoration. The sectors include petrochemicals and chemicals; power; agriculture, forestry, and other land use; transport; heavy manufacturing; building and construction; and mining, among others. Collectively, this will lead to a more just transition than just a simple energy transition.”

The South African skills formation system depicted in the Just Energy Transition Implementation Plan 2023–2027 features government departments, state entities, the private sector, training service providers, professional bodies, and higher education institutions.

“However, it has been consistently echoed that the skills in the South African economy are insufficient to grow the economy. So, how do we correct this? How do we gear the skills ecosystem for clearly defined occupations? The Just Energy Transition Implementation Plan 2023–2027 addresses this.”

This plan is the outcome of the Just Energy Transition Investment Plan, which had estimated that R2.7 billion is required for scaling for the just energy transition. This amount is over and above the existing funding going into the skills ecosystem, roughly about R20 billion.

Five flagship interventions include the establishment of a three-tier skills ecosystem to coordinate and align just energy transition skills, the establishment of local learning networks, skills needs assessments for core just energy transition value chains, capacity development for government and key government institutions, and support for foundational skills development involving upskilling teachers and integrating energy concepts into school curricula.

Key skilling initiatives include the PCC’s Annual Skills Indaba, a study to understand the future labour market and its skills requirements, a skilling programme for the renewable energy sector (focusing on hydrogen), re-skilling and upskilling existing workers (especially in the auto sector), and coordination of skills activities.

Skills needs, upskilling and youth empowerment in power systems analysis, designs and innovation applications.

Mr Mfundi Songo, Senior Manager of Technology and Engineering at Eskom, explained, “When we look at the projects that we have at Eskom and as a country, we look at them at a high level, i.e. the concept – what needs to be solved, the concept design, execution, maintenance and operations, and obsoletion and discontinuation – the end of the project. Skills need to be matched to each of the tasks.”

He took the audience through the evolution of skills which also incorporates personal development. At graduate level, students are energetic, free-spirited and fairly theoretical. Once experience has been gained at the professional body level, they learn to be more independent with a clearer path and scope definition of their work. They also start to associate with projects, for example, talking about “I designed…”, and participate in presentation forums. At the expert industry leader level, they are working smart and gaining peer recognition. They also start focusing on giving back by coaching or mentoring others.

Just as people gain certain skills across their developmental journey, industry- or project-related skills must be matched to the task along the value chain or implementation of a project.

Following this thinking, the concept phase of projects in the Eskom context is where the ideas, dreams and vision are. It explores the issue or problem to be addressed or solved. It considers the technology and environment as well as the strengths, weaknesses, opportunities and threats; and the cost implications.

Further growth takes place in the design phase where existing and new developments are explored as well as standards and other industry-related drivers. In the execution phase, work gets more intense with consideration of equipment, role differentiation, time, and more clarity regarding cost implications. In the 'maintain and operate' phase, reality really starts setting in. Clusters are honed, own intellectual property is achieved, but it is also the time when 'the community' starts playing more of a role and external issues such as vandalism come into play.

The last stage concerns the discontinuation of projects and infrastructure. Here more complex questions are asked such as what happens to old batteries or panels? What are the environmental actions, especially considering chemicals; are there new businesses to explore or leverage – what is next?

Highlighting some projects, specifically the Battery Energy Storage System (BESS) project which is the biggest project of its kind in Africa, Songo related, “When we started the BESS project, we did not know how BESS designs worked but we had professionals and experts who understood chemicals and the like. We interpreted all of this and developed the construction process. The surface levelling and so on is routine work, but the skills and planning for this, the chemicals that will be spewing out of the batteries, how they will integrate into the network and how the power system will behave, were all worked into the skills and planning.”

The result is the first project to be completed as part of BESS – Hex BESS – that was opened in November 2023 in Worcester in the Western Cape. According to an Eskom media statement, “The BESS project serves as a direct response to meet one of the urgent needs to address South Africa’s long-running electricity crisis by adding more storage capacity to strengthen the grid while diversifying the existing generation energy mix. It uses large-scale utility batteries with a total capacity of 1 440MWh per day and a 60MW PV capacity. The Hex site is specifically designed to store 100MWh of energy, enough to power a town such as Mossel Bay or Howick for about five hours. It forms part of Phase 1 of Eskom’s BESS project which includes the installation of approximately 833MWh additional storage capacity at eight Eskom Distribution substation sites in KwaZulu-Natal, Eastern Cape, Western Cape and Northern Cape.”

The whole project from concept to delivery took 18 months.

“What has transpired in this evolution? We had only theory about how batteries work, we now have a solid foundation, people whom we have skilled in the designs, planning, environmental and construction elements. Now we are learning how to commission and integrate BESS. In two or three years, because of the five-year maintenance plan that we have, we will have experts. And they are all in-house. When you talk about process analysis for microgrids, we'll use this evolution path. We started with no skills and now have a pool of process and analysis engineers and we have experts. These are skills that are upcoming and that is where youngsters should focus on when they enter tertiary education so that we can grow the pool of postgrads,” Songo concluded.

Sustainable energy sector skills development in South Africa

Ms Robyn Vilakazi, Skills Development and Quality Assurance Executive at the Energy and Water Sector Education and Training Authority (EWSETA), explained that the EWSETA works to determine the skills demand of its sector and implements strategies to respond to that skills demand. It attracts young people to the industry, focusing on matric level or even younger. It also has a professional development focus, especially looking at emerging technologies.

“SETAs are mandated to conduct a specific piece of research on an annual basis, leading to a sector skills plan. More than 3 000 employers are registered in this sector and some 19% of employers that pay levies to the SETA participate in the skills planning,” she said.

To address the challenges regarding the quality and quantity of input received, the EWSETA does its own research on specific trends, sectors and sub-sectors. “We also leverage a lot of external research and we are spoilt in the energy sector with regards to the volume of research coming out around skills needs. To just mention two of the most recent skills analysis reports that we use almost daily to inform our planning: the Identification of Skills Needed for the Hydrogen Economy and the Energy Skills Roadmap 2023.”

Vilakazi shared the SETA’s strategic response to what the research is telling it about skills needs in the energy sector.

The SETA locates its energy skills development focus within the global and national context. It has a robust partnership model that enables a good big-picture view of what is happening and needed. The context for the energy skills development focus includes renewable energy, decarbonisation, and restoring energy security.

“We focus a lot on the TVET sector and have several responsibilities in the vocational space. We look at how we can enable the community education and training (CET) colleges and build a CET and TVET system that can produce the relevant skills for our economy sustainably,” she added.

From an energy perspective, the EWSETA identified leadership and ethical leadership as important skills areas for an energy sector to function optimally – that then also becomes a driver for economic development. Gender parity issues in leadership are also a focus.

Developing technical skills goes without saying, and SETAs also have a mandate for innovation and technology and understanding that these are important elements of a capable workforce to drive the development of new markets and new technologies.

“We also have a major mandate in the area of policymaking as it pertains to skills development and a capable workforce. For example, the EWSETA was instrumental in the recent Renewable Energy Independent Power Producers Procurement Programme (REIPPPP) bid windows for informing the development scorecard that ensures that some of the skills needed are funded through the REIPP projects.”

The EWSETA identifies what qualifications are required and occupational qualifications are developed in a public process. Vilakazi listed qualification development foci in the energy space – also aligned to the Integrated Resource Plan:

- Hydrogen Fuel Systems Technologist
- Battery Energy Storage
- Wind turbine Operator
- Solar PV Design Assistant
- Solar PV Installation Tester
- Solar Photovoltaic Installer
- Solar Photovoltaic Manufacture
- Biogas Process Assistant
- Concentrated Solar Power Plant Process Operator
- Energy Management System Specialist
- Power Plant Electrical Network Controller
- Waste Electrical and Electronic Equipment Small Business Operator
- Waste Electrical and Electronic Equipment Collector and Sorter
- Waste Electrical and Electronic Equipment Manual Dismantler
- Auxiliary Fossil Power Plant Operator
- Energy Efficiency Technician (Energy Audit Technician)
- Hydro Power Plant Operator.

The SETA has teacher capacity programmes as well as learning capacitation programmes. "We focus specifically on rural areas where we capacitate learners and their teachers about careers within our sector and we run several STEM initiatives to attract learners into the sectors."

Vilakazi mentioned that the EWSETA has a portfolio of more than 200 projects. One of which is with the CSIR's Energy Industry Support Programme where 15 SMMEs received incubation or capacity-building assistance to encourage innovation, promote the development of intellectual property, and support South Africa's industrialisation goals. The target is to empower 75 SMMEs in five years.

Other projects are:

- An executive development programme for women in the oil and gas industry in partnership with the WITS Business School.
- The Kanana Renewable Energy Programme where the independent power producer in the rural area is capacitated through training and linked to the local TVET college.
- The 4IR Aquatech Hackathon of which one participant, Faith Mokgalaka, has gone on to start an agri-fintech company revolutionising agriculture. She was also the Top Women in Tech in 2023 and received a National Rising Star Award, among other accolades.

"Our work echoes a quote from President Cyril Ramaphosa of a few years ago: 'It's a call to action to make South Africa a learning and skilled nation, a nation that has highly skilled people in all facets of life,'" Vilakazi concluded.

Energy in eco-industrial parks

Mr Bernd Oellerman from the National Cleaner Production Centre South Africa (NCPC-SA) at the CSIR, spoke about the work of the NCPC-SA and energy in industrial spaces in South Africa.

Oellerman said that everyone has a role to play in addressing energy, but not everyone can necessarily get involved in the grid for energy provision or the like. Many people work in peripheral areas such as industrial spaces that have a crucial role to play in realising South Africa's green economy objectives.

"Planet Earth is a limited resource in terms of the amount of minerals that is being mined. The known deposits will end in the next 10 or 20 years. What do we do then? This is without considering things like climate change, biodiversity loss, the current geopolitical landscape and so on. All of this has an impact on the economy, value chains, supply chains, and logistic flows. We are on the cusp of a massive systems change in terms of how humanity functions," he said.

South Africa has an estimated 400 industrial parks that include 15 special economic zones. These parks and zones are key Department of Trade, Industry and Competition focus areas as well as being catalysts for socio-economic growth.

"It's important to understand that we are part of a system. When you talk about energy, industrial spaces form part of a system, not just to provide energy, but also in terms of energy consumption and then also housing industries that can play a role in the national energy landscape. Industry, of course, is a key contributor to economic strength even though South Africa's industry has been shrinking. Any country without a good manufacturing industry will struggle in terms of its growth plans," Oellerman explained.

The drivers at the national and provincial levels include industrial spaces, specifically considering the priority of a green economy or the circular economy.

The current focus areas regarding activities in industrial spaces and energy include various roleplayers who are working together to address current grid and electricity constraints – quality, security, and availability of supply. Discussions and interventions also focus on countering cable theft and other crime-related aspects. Other focus areas include supporting continued business operation and retention of jobs; addressing emissions reduction, carbon tax and carbon-related aspects, for example, the Carbon Border Adjustment Mechanism; supporting and improving competitiveness; facilitating collaboration between industry, municipalities and other entities; and supporting industry's transition to the circular economy and contribute to sustainability, including the Sustainable Development Goals (SDGs) and the Nationally Determined Contributions (NDCs) of South Africa.

"If we talk about the just transition, this is where one of the touch points is with industry. Industry is generally focused on turnover, production, order books, cash flow, and so on. Many often do not participate in the conversation about the just transition because of time commitments – this is a challenge globally. However, industry must be a core player in the just transition and specifically in our context, the just energy transition. While South Africa has done some great preparatory work, we seem to be struggling a bit in implementing at industry level," he added.

Using technologies to realise part of the just transitions looks at new solutions such as smart metering, small-scale embedded generation (SSEG), storage smart grids, microgrids and the like.

The NCPC-SA has done energy planning for several industrial spaces, especially from the eco-industrial park perspective. These include the East London Industrial Development Zone (ELIDZ), Phuthaditjhaba in the Free State, Ekandustria and Rosslyn in Gauteng.

It has also assisted ELIDZ with implementing renewable energy solutions, and it has assisted Babelegi in the North West and Wadeville in Gauteng with a zonal approach that included energy. Most of its work is done in collaboration with others, including energy-efficiency assessments and implementation support or facilitating access to solutions with the South African National Energy Development Institute (SANEDI) and the Global

Eco-Industrial Parks Programme. As part of a toolbox for eco-industrial parks which includes water stewardship and resilience, the NCPC-SA has provided several guides.

The next step for industrial spaces is to scale up the impact of existing energy activities but also other green activities, for example, water and resource use.

The fourth industrial revolution technologies are increasingly relevant to industry as is providing research, development, and innovation support. Regulatory and reporting requirements must be addressed, for example, carbon tax; carbon footprints; extended producer responsibility; energy performance certificates; the NDCs; the SDGs; and environmental, social, and governance aspects.

Awareness raising and education as well as capacity building remain critical as does coordinating planning and interventions, and the implementation of projects.

Oellerman concluded, "Many things impact industry – global and local drivers, complexity, new technologies and solutions, systems and processes. Industry can make a difference. With all of these considerations, we can no longer do the same things or think in the same way. If we do this wrong, we will end up with an industry that can't…"

Dealing with loadshedding-accelerated business disruption

Mr Adrian Stone, Manager of Data Management and Integration Platforms, Sustainable Energy Markets, in the City of Cape Town Energy Directorate, said that, with the pressure brought about by loadshedding, he has seen senior colleagues go from one extreme to the next in their views of how loadshedding should be responded to and what risks should be taken.

"When loadshedding is bad, it seems we're prepared to take a lot of risks and when it clears up, like currently, then all of a sudden we're very aware of the risk and things move more slowly. So, it's a very difficult problem to deal with because our perception of it is constantly changing, no matter how experienced you are and how much we know about the industry," he said.

Municipal revenues from electricity sales are key to the concept of an event horizon – the point of no return.

Electricity sales have for many years been the golden goose of municipalities. But the goose seems to be ailing at the moment. Some of the reasons why demand will increase again include decarbonisation and the drivers of increasing electricity demand other than the reducing factor of small-scale generation.

"But for the last 10 to 15 years, we have seen a solid decline in sales and we see a decline in the electricity intensity of the economy. The amount of electricity going into units of GDP has dropped. Last year loadshedding took away 15% of sales. Cape Town has some generation assets, namely a pump storage station, and we have been able to achieve significant green shares," Stone said.

Despite this, the City is still severely impacted by loadshedding.

Stone related that Cape Town has strong political commitments in addressing this challenge. The Mayor's priority programme, Energy Security for Economic Growth, has four aspects.

The Energy Strategy is a long-term, wide-reaching strategy to ensure a cost-effective and cohesive approach to the energy transition. Loadshedding Mitigation is a programme of specific demand- and supply-side interventions to limit the impact of loadshedding within City supply areas. Power Utility Reform is a programme to transform the utility business model for a future-fit and financially resilient power utility. Fourthly, SSEG Streamlining is an efficient system for registering SSEG to promote local embedded generation.

The City's Energy Strategy has as its vision realising energy security for Cape Town based on the principles of affordability, reliability, and carbon neutrality, which all lead to better resilience. Commitments include harnessing new energy supply, alleviating energy poverty, and optimising energy use. Two main enablers are to operate a future-fit utility business and participation by residents, businesses and partners.

Stone shared the City's various expansion planning studies regarding loadshedding mitigation and said that the complexities of obtaining regulatory approval for recovering supply costs that represent a premium in a novel structure mean that loadshedding mitigation is not just a planning and procurement problem but also a regulatory problem.

Despite this, a strong regulatory argument for recovering costs through the tariff emerged from the studies, showing that the benchmark cost of loadshedding mitigation is not Eskom Megaflex. By definition, Eskom cannot supply and thus shouldn't be the benchmark. It is rather the cost of diesel-fuelled backup for the average customer, considering that internal combustion engine efficiency varies with size.

The reserved capacity invested for loadshedding mitigation effectively provides backup for customers who cannot capitalise on their own backup. It also brings to bear economies of scale and higher capacity factors that reduce the system cost of emergency backup despite distribution system losses.

The capital portion of a utility loadshedding mitigation asset should also be benchmarked against the capital cost per kW of a typical customer backup generator and this cost recovered from customer fixed costs.

"If we are running backup at a much higher capacity factor, that's a lot cheaper. It reduces their levelised cost by about 30% in severe load shedding, and that overcomes the difference in losses. I think there's a strong regulatory argument, but we don't know whether it would be heard," Stone said.

The scientific and research community's assistance is needed in the form of methodologies for electricity system planning at a local and regional level. "We've learnt a lot. We know that we need to start with the hosting capacity of the major nodes on our network. And we know that network planning and extension planning need to be very integrated."

The scientific community's assistance is also needed to identify the legal, regulatory and technical measures to ensure system-wide electricity resilience as well as at the critical load centres.

Independent technical and legal studies that support the regulator in key decisions could look at whether it is economically supportable for a municipal utility to mitigate loadshedding with an expensive peaking plant and pass the costs in the tariff. Further questions are to what degree, and how much should electricity (including self-supply) and electricity from the grid cost in South Africa and how much should be recovered from fixed costs to ensure the sustainability of the system?

"Both technical and legal studies are needed to support the regulator. It is very much on its own, and I sympathise with its vulnerable position in making these different difficult tariff decisions," Stone concluded.

Supplying energy to urban informal communities using a blend of old and new technology

Mr Paul Vermeulen, Chief Engineer of Renewable Energy at City Power Johannesburg, suggested looking at a few disruptive technologies and putting these together in a new way to possibly solve some of the energy poverty problems around Johannesburg.

"The City expects us to provide energy services for people living in informal settlements, and is trying to put together a policy, but it's been quite a challenge. The policy thus far focuses on supporting alternative energy

solutions that would include lighting, cooking and heating to informal settlements as interim measures," he said.

These energy services are only an interim provision until a permanent solution – relocation or in situ upgrading of the settlements – is accomplished as per the Housing Act. These interim energy solutions will be rolled out on a 'needs' basis, with the most deprived settlements supported first.

The scale of the challenge is immense. Johannesburg has about 312 informal settlements comprising more than 180 000 structures which are not connected to the grid. The City has programmes in place to upgrade and electrify informal settlements, but it can only do that where it is legally permitted in terms of, among other criteria, land ownership.

The process for normalising an informal settlement starts by putting roads and access ways in and also assigning the plots within the area. Once it has been formalised, the normal 3 kVa AC service connection can take place.

"If we were to do that for all 312 informal settlements, we would need another 600MW worth of bulk infrastructure. In other words, substations and input, substations from Eskom and the infrastructure supporting those substations to feed these areas. Some of these vulnerable communities are 20 years old already," Vermeulen added.

The need for a relocatable and reusable household energy delivery system as a pre-cursor or permanent solution to formal electrification is great.

Other challenges include a multitude of illegal – and unsafe – service connections that overload the surrounding areas and cause outages, community tension, and electrocutions. What is needed is a safe energy solution that can out-compete the illegal "mafiosi-style" operators.

What do we currently have? Vermeulen said that we take the AC distribution grid for granted. The interconnectedness of the existing grid is a high-value enabler. As one connects many different types of load, the system benefits from demand diversity, so one changes the shape of the total load, and one ends up having to design for the cheaper option.

The same grid is open to supplier diversity where many distributed energy resources can be connected to the networks.

In addition, when one couples energy storage with the grid, one also enables the temporal demand and supply side. Now one can start shaping the load profile.

This grid, at least within urban areas, surrounds most of the informal settlements already and communities get electricity, albeit illegally. If those energy flows could be properly controlled, the grid would also be the cheapest form of backup energy for any clean energy solution.

Thinking about the grid as a connector means that any large rooftop such as a warehouse or a factory building that's already connected to the grid, enables access to cheap clean PV power with virtually no capital expense.

Looking at new technologies, Vermeulen referred to several technology options, including the following:

- Modern DC distribution technologies have overcome the problems of switching, fault arcing and safety problems of DC distribution.
- Extra low voltage DC distribution is less than 120 volts DC and carries a lower electrocution risk.
- The conventional AC grid could also be the energy source or an embedded DC distribution system.

- Power line carrier technology enables things like customer communication and alarming, simple vending control, and tamper detection.
- Lithium-ion battery technology has overtaken lead acid battery technology; it has 5 000 cycles at a depth of discharge of 80%, making it more usable over a longer lifetime.
- Soon, sodium battery technology may overtake lithium-based technologies for stationary applications, and super-capacitor technology is developing fast and the cost will decrease with mass manufacturing.

"We get to the point where we have to ask the question, what would be a useful amount of energy? In the energy budget, we would list things like an outside light, inside lights, cell phone, TV recorder, TV screen, Internet (tablet), and an induction-based hotplate for boiled water. You'd come to an amount of around 3kWh that you'd need to make a useful difference. Part of the challenge is to convince the community that might use this that this is worth having. It's not the full grid connection, but it can provide the higher value utilities," he said.

The proposed solution is to adapt micro-grid concepts for a system embedded within the conventional grid. The concept is to develop a rugged appliance or 'Energy Box' that will be registered and issued to each dwelling and kept as assigned property within the dwelling.

Each energy box will contain a 3kWh energy storage system that is charged via a constant supply of 130W of non-lethal DC electricity through a safe, 'informal' wiring network. The DC grid will receive energy from the conventional AC supply grid from adjacent reticulated areas through AC to DC converter and distribution control units that provide a managed supply of energy to charge the Energy Box in each dwelling.

The proposed solution includes renewable energy by using any suitable warehouse-type rooftops within the local conventional AC grid system's geography. The PV system is sized to offset the full cost of the energy provided to the informal settlement. This enables the use of larger, economically viable and secure rooftop PV systems to provide a portion of the energy required from clean sources.

City Power has done its homework regarding financing and sustainability and has also surveyed an informal settlement within its supply area with positive results. The project now seeks venture capital and a technology and manufacturing partner.

Loadshedding and the state of South Africa's electricity supply industry

Mr Chris Yelland, Managing Director of EE Business Intelligence (Pty) Ltd, stated that 2023 overtook 2022 as the most intensive loadshedding year yet with more than twice the amount of loadshedding and Stage 6 increasing six times.

"As a result of the general downward trend [of Eskom's performance] and massively increasing loadshedding, the President, after a lot of consultation, developed a plan to end loadshedding," Yelland said.

The five main points of the plan are:

- Fixing Eskom's coal-fired power stations and improving the availability of existing supply.
- Enabling and accelerating private investment in generation capacity.
- Accelerating procurement of new capacity from renewables, gas and battery storage.
- Unleashing businesses and households to invest in rooftop solar.
- Fundamentally transforming the electricity sector to achieve long-term energy security.

In trying to distinguish between the hype and the real situation, he said that while there has been a significant reduction in the intensity and frequency of loadshedding, it's not just one party that can take the credit.

The first thing to look at is what is happening to unplanned breakdowns compared to last year. Last year, unplanned breakdowns totalled about 35% of the fleet. This year totalled 30% – a significant reduction when one turns this into megawatts.

Planned maintenance has increased during this year compared to last year because more money has been set aside for the purpose and there has been more time for it because of the decrease in unplanned outages.

Looking at the amount of generation capacity that is available to meet demand, the overall net available generation capacity was about the same, except for a dip between weeks 12 and 16, but overall, the energy availability has been higher than last year.

"The reliability factor, which has improved significantly compared to last year, is still unacceptably low – South Africa should not have 30% of its fleet out of service. It should be closer to 10% due to unplanned breakdowns. So even though the energy availability factor has significantly improved, it still has not reached 60% yet," Yelland said.

Why are we experiencing less loadshedding? While Eskom is fixing its plants, other things have been happening.

Eskom data from July 2022 to March 2024 show that rooftop solar PV has increased month by month. Currently, there is around 5 400MW of rooftop solar PV and battery energy storage in the residential, commercial and agricultural sectors. This has been helping to reduce the burden on Eskom's fleet.

Non-rooftop renewable energy in South Africa from the public procurement processes, i.e. the Risk Mitigation Independent Power Producers Procurement Programme (RMIPPPP) and the Renewable Energy IPP Programme, totals more than 6 400MW.

"Adding the two – rooftop and non-rooftop solar PV – gives nearly 12 000MW of renewable energy. This is making a big difference. Even though renewable energy is not a constant output, when you add 12 000MW of peak capacity to the grid, it makes a big difference in the day and at night because wind, for example, blows more in the night than in the day. The uptake of renewable energy is thus making a significant impact by reducing the burden on the Eskom fleet," he explained.

One also has to look at what is happening with electricity demand in the country. Since 2011, the amount of energy produced by Eskom has decreased every year. In 2023, we reached a 20-year low. Whatever the reason, the burden on Eskom is being removed and this does not mean that the country is using less electricity, it means that the Eskom share of electricity produced is declining.

Because of the weak economy, GDP growth is flat and therefore electricity demand follows suit. At the same time, the energy intensity of the South African industry has been decreasing: The amount of electricity the country uses to produce a unit of GDP has been declining as the move is away from an energy-intensive industry towards more services and light manufacturing. Heavy energy-intensive industries are under pressure, part of which is due to dramatic increases in electricity prices year on year causing businesses to tighten their belts and use electricity more efficiently. The latter is also true across the economy, including residential and other sectors.

Yelland listed several reasons for the current cessation of loadshedding:

- The results of the President's plan to end loadshedding, and the work by the Minister of Electricity and Eskom are beginning to show.
- The weak South African economy, and the resulting generally flat overall demand for electricity.

- The rapidly rising price of Eskom and municipal electricity two to three times the inflation rate for many years, is dampening demand for Eskom-generated electricity.
- Loadshedding and low reliability of Eskom and municipal grid electricity, particularly for the last four years, have been negatively impacting electricity supply.
- Electricity customers are responding by moving to self-generation and alternative energy sources, including rooftop solar PV, battery energy storage, gas for cooking, solar hot water geysers, energy efficiency, and a general reduction in demand for grid electricity.
- The pipeline of big renewable energy and battery energy storage plants is now coming to the grid, and this trend is accelerating.

Concerning the future outlook for new capacity, a three-year view shows not much coming from Eskom – 800MW coming from Medupi and the same coming from Kusile. By 2026, the overall estimated total additional capacity coming online amounts to about 31GW from sources such as public procurement programmes, imports, municipalities, private power purchase agreements, and the domestic and commercial sectors.

Yelland concluded, "Loadshedding, while not over, its intensity and frequency will continue to decline. It will become more intermittent. All these things, including the work done by the respective roleplayers and also the restructuring of Eskom that is happening as we speak augur well for the future.

"We must move from only doing crisis management to dealing with the longer-term issues. That means proper planning from non-negotiable policy positions of government, for example, decarbonisation. We also need an Integrated Energy Plan. South Africa, since 2008, has never published an Integrated Energy Plan. Fortunately, it was gazetted late last year that government has to produce an Integrated Energy Plan by the 31st of March 2025. Then, of course, we need sector plans and one of the sector plans is the Integrated Resource Plan for Electricity, the IRP, which was published in 2023 for public comment. IRPs should be done every year – the last one was done in 2019. And we need regulations that are aligned with these plans."

A strategic approach to skills development for a just energy transition and the energy crisis

Ms Aradhna Pandarum, Head of the Just Energy Transition Department at The Impact Catalyst, said, "Many people think about the just transition as just being about renewables, but it's so much more than that. Once we realise that, we can start planning better in terms of the landscape or the ecosystem," she said.

Aspects to consider are the technical aspects, modelling and feasibilities; environmental considerations; social considerations and protection; economic considerations and diversification; enabling policy and infrastructure; and innovation.

She added, "For the economic consideration, for example, there is understanding in terms of the call to renewables. But renewables will never be able to replenish the number of jobs that will be lost from the coal sector. We must come to that realisation and aim to understand what needs to be done; this is where economic diversification is required in terms of different sectors, in terms of unpacking what the different linkages are and where there could be opportunities like manufacturing, the circular economy, agriculture and so on."

Strategic targets should respond to the objectives of poverty alleviation, job creation and economic development, equality, reduction of financial investment risks, decarbonised and diversified economies, and a reduction of financial investment risks – all while also considering and aligning with the SDGs.

"With that in mind, what should be the strategic approach? Skills development is more than TVETs and course or curriculum development from the university. We must think wider to include what needs to go into these different elements of skills development and what can we realistically do to successfully achieve skills development for the transition and going forward," Pandarum elaborated.

Step one is understanding the current system – electricity but also energy and other value chains such as coal mining as well as understanding the skills status quo and identifying how skills can be developed to close the skills gap, looking at the entire education system. Understanding the governance, funding, implementation and necessary support landscape is also key.

Step two determines what changes are required. It includes holistic modelling – looking at the socio-economic, environmental, technical and financial aspects. For example, looking at a pathway for technology, solar and wind might be identified, but how can these be optimised to deliver the best social economic benefits? This incorporates a theory of change and a systems thinking approach.

“Once we have this view – this crystal ball showing the holistic picture – we can identify what type of technology pathways we will have and how we're moving forward in different sub-sectors. Here we can also identify what the skills for those different pathways going forward would be as well as the gaps – this is step three. And from there we follow a value chain perspective looking at the core ecosystem,” she explained.

Soft and hard skills are required. Soft skills include those needed for strategy development, financial abilities, and so on, and these and other related skills must be incorporated into value chain approaches. For example, in windfarm development, understanding bird patterns is very important, it is not just about the technology. Homing in on the skills gap and skills required looks at the entire education system, especially how to promote STEM subjects.

Step five focuses on monitoring and evaluation, and getting to a culture of continuous learning, flexibility, adaptability, change, being resilient and developing cross-cutting skills that would be easily moved to another profession or another technology development value chain. “But if we don't know what indicators we are monitoring or making progress on, we would not know how to improve the process and get to a point where we are more resilient,” Pandarum said.

In terms of a future electricity system, there is talk of a distribution system operator, a market operator and the creation of aggregators and different markets. There are a lot of opportunities and value chains that would be created and these must also feed into skills and ensure that the right skills are developed. The same is true when considering grid development, energy storage, and energy efficiency.

Concluding, Pandarum emphasised that collaboration and alignment from all government entities and a common vision are key. The modelling and strategy must be cross-sectoral involving technical, socio-economic, environmental, and government and financial players. A theory of change is needed that will enable systems thinking, and immediate activities needed for the energy crisis can be incorporated into the bigger plan. Other aspects and technologies that are complementary and conform to the just element of transition must be considered, for example, the circular economy; the water, energy, and food nexus; and social ownership, among others. Finance and funding must be redesigned with the incorporation of blended finance and de-risking mechanisms. Partnerships need to be forged especially for infrastructure development, and capacity building for decision-makers and key role players is a must.

“Everyone must be brought along on this journey. There is no point discussing this at a national level, but then at a local level, people don't understand what is happening and they are the ones responsible for implementation.”

Decentralised renewable energy to combat South Africa’s electricity crisis in marginalised areas

Mr Kendy Madisha, Spokesperson for ActionSA on Energy & Mineral Resources, said South Africa’s challenges cannot be solved without solving them in the townships and rural areas, and this is also true for the

electricity crisis. He highlighted the importance of communities and their representative organisations being involved in the discussion.

“South Africans are feeling the pain. Whatever solutions we propose as we fix Eskom must not leave communities behind,” he said. “How do we come up with an inclusive solution that does not leave a segment of our South African citizens behind? With unbundling now happening, we’re on the right track to introduce some competition running right along with Eskom.”

The Energy Resource Plan offers several good suggestions, one exciting development being considering microgrids as a way to solve some of the problems.

He showed how communities are connected, especially the danger of illegal connections, particularly to children playing among these electric lines. “Access to electricity is a human rights issue. So many things in the 21st century that otherwise wouldn't be possible rely on electricity, for example, online education and job opportunities, to mention a few,” he added.

Solar PV is a solution for every township house and should be placed on every household rooftop, connected to a microgrid and using smart metering. Madisha reiterated that South Africa is one of the best places to exploit solar energy.

Some of the technical solutions that must be considered in putting up microgrids to serve marginalised communities include that the current technology on some of the solar panels is still low (15%–20%). Other considerations are the average daily irradiation of 220W/m^2, the need for high DC voltages (~600V), and the fact that low voltages of up to 48V are workable if no shared storage is used.

A typical household profile includes a fridge, deep freezer, plugs for television and charging devices, lights, and a microwave. This can be complemented by gas stoves and solar geysers, although communities are still wary of using gas.

The setup has many considerations. It could be a hybrid setup so that if there's a need, connection can happen through the grid to supplement some of the electricity. An upgraded system could also include backup batteries and other alternatives.

Typically, one would have a 5KW inverter with six panels to cover one household. If that is turned into a microgrid, the inverter would be slightly different. Costs vary – could be up to R150 000 – but when one puts it into a microgrid, economies of scale come into play and the cost per house should come down.

Besides easy deployment, relative to other sources of energy, solar is easy to maintain and it presents opportunities for job creation, even creating an industry in its own right, he said. However, solar has a high capital cost and interventions are needed to resolve this. Another consideration is that while it has no limits in the energy coming through, it has limits in terms of the space through which the energy is coming.

A few examples exist of microgrids in Midstream, Gauteng, and an estate in the Free State. Their systems include six batteries of 1MW (2.5MWh) lithium iron phosphate; using Eskom’s grid but also diesel generators; fibre lines to facilitate the Internet of Things where houses can speak; and 98% efficiency of recovery for storage.

“Concerning the investments that are required, we're looking at about 50 houses with a capital investment of R3 million to about R5 million. This figure still needs to be recalculated because we don't quite have the technical details tied down, but it is a big ask,” he said.

“Going forward, we need to have further assessments of the costs. We also need to resolve some of the technical teething challenges and create community and political awareness so that people know this is a feasible solution. Alignment with the regulations framework is necessary so that we don’t have policy uncertainty, and we need to further strengthen the business case for microgrids,” Madisha concluded.