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Futures of TVET Skills: A South African Green Hydrogen Strategic Framework

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Introduction

South Africa is facing numerous grand challenges that intersect. These include unemployment and poverty, food and water insecurity, climate change, dissolution of trust in governance systems and democracy, among others. Vocational training and skills development have long been recognised as a crucial tool of economic development and poverty alleviation – without skills to sell on the labour market, or to make a viable living in subsistence or self-employment activities, individuals are more likely to be in poverty. However, reimagining post-school education and training will require a shift from a narrow focus on 'jobs' towards a more holistic understanding and broader framing of education and skills development for economic wellbeing.

This GHE TVET Skills Transition Framework is oriented at skills for the future green hydrogen in South Africa, towards a vision of a just and inclusive TVET ecosystem for a transversal skills commons that fosters economic wellbeing and ecological resilience by 2050. Various Futures tools are employed throughout this Framework, namely: (1) Three Horizon's framework; (2) 2x2 Scenario Matrix; and (3) Strategy as Landscape model.

The central aim of the research approach is to identify innovations towards a just skills transition, explore desirable future skills scenarios, and develop the overarching goal and actors for implementing a strategic framework utilizing key actions. These actions are critical for facilitating a transformative Just Labour Transition for South Africa that speaks beyond TVET as a means to service the economy and access to jobs for citizens.

Three Horizons Framework

The Three Horizons Framework is a simple and intuitive tool for thinking about the future. It helps groups explore systemic patterns to identify which of the dominant patterns are no longer fit for purpose, how the emerging trends can shape the future, and what visionary action is needed to collectively move us towards a viable future.[1] Using the Three Horizons Framework enables an exploration of the preferred green hydrogen future TVET skills, the current system no longer fit for purpose, and the innovation that will allow the green hydrogen economy to achieve a just labour transition through the TVET college system.

Below are lists of populated information from the Three Horizons exercise, organised according to H1, H2 and H3 (See appendix one for an image of the exercise).

[1] Andrew Curry and Anthony Hodgson. "*Seeing in Multiple Horizons: Connecting Futures to Strategy*." Journal of Futures Studies, August, 13(1): 1 – 20, (2008). https://www.h3uni.org/practices/foresight-three-horizons/

H1 Dominant system:

- Little demand for H2 infrastructure and skills.
- Misalignment between the TVET system and industry needs: poor TVET labour absorption.
- Industrial revolution powered by fossil fuels. In SA: coal mining and coal-fired power, oil refineries, ICE vehicles, dirty industry (steel, cement etc) and jobs to serve these.
- Climate change and tech advances (Industry 4.0) places dominant system under pressure.
- Poor quality assurance: lack of qualified teachers, low resources, and disconnect from industry.
- Lack of coherence on descriptions for future "green" occupations (nature of jobs and skills needed are not defined).
- Limited local-level relations between TVET colleges and industry.
- Predominantly manual engagement with machines.
- Considerable political will (policy certainty and effective action) is present for GH innovation.
- Non-conducive environment for college-industry engagement and overcome trust deficits.
- Little demand for green skills training through SETA's.
- Lack of commitment to TVET nationally – higher education is prioritised.
- Silos within single TVET colleges i.e., DHET funded programmes are separate from occupational programmes. Programmes not speaking to each other.
- No framework and little evidence of green skills development policies.
- TVET system is not gender inclusive.
- High numbers of youth exclusion to economic activity.
- Few opportunities for PSET: Studies show that just over half of TVET graduates are employed within a 3–6-year period, with low level of earnings with limited career guidance.
- Disconnect between vocational skills development (VSD) and economic development strategies.
- Technical skills as most important (but low digital literacy).
- High labour absorption for Artisan graduates, although low completion rates within the standard qualification duration (3 years).
- Selection and location of CoS in radius of weak industry employment opportunities.

- Administrative inefficiencies: complicated registration systems; inefficient grant disbursement and delays in trade testing.
- Triple helix challenges: poverty, youth unemployment and relatively stagnant economic development.
- Persistent funding deficit: Unstable/inconsistent funding streams for occupational training at TVETs (this limits growth).
- Disconnect between fiscus funding through the funding norms for the college component of the apprenticeship and the skills levy funding / tax rebates for the workplace-based learning component.
- Low and declining TVET enrolment rates - colleges not meeting enrolment targets & decline in younger demographic enrolment.
- CoS struggle meeting standards and accountability of workplace-based learning.
- Levels of CoS commitment from SETAs differ (not part of core suite of funding solutions).
- Once-off skills training and not a continual process of upskilling/adapting etc.
- CoS is highly dependent on the buy-in from the college executive.
- Power of TVET for social inclusion not recognised.
- Weak CoS capacities: lack of suitably qualified facilitators; lack of strong project managers/admin teams; financial commitment to CoS' not consistent across SETAs; true costs of CoS' need to be articulated for improved planning.
- CoS not scalable solution for economic inclusion (limited funding).
- Student transport costs are a significant barrier to workplace and/or college learning.
- SMEs can't accommodate administrative burden associated with apprenticeships.
- TVET does not feature in international education policy discourse.

H1 Pockets of the past that we want to keep:

- Retain extensive skills in chemicals, manufacturing, automotive components as they will be in high demand across the renewables sector.
- Work-based learning, apprenticeships, learnerships etc.
- Industrial sector remains (not all service-based or knowledge economy).
- Launch of the Hydrogen Society Roadmap (GHSR) on 17 February 2022 highlighting collaboration with other stakeholders, projects or studies to be implemented to ignite the development of the Hydrogen industry in South Africa.

- Eskom is expected to make an application to facilitate gas-to-power generation at some of the coal power stations, in line with its repower and repurpose of a just energy transition strategy.
- Infrastructure South Africa, together with the Northern Cape and Gauteng provincial governments intend to develop catalytic green hydrogen projects that will underpin provincial green hydrogen strategies, with the Northern Cape being the production hub and Gauteng being the domestic demand hub.

H2 What needs to change:

Funding

- Review of national TVET budget allocation.
- Securing multiple but coordinated funding streams for green H2 programmes at TVET level.
- Constraint: green hydrogen production costs > grey hydrogen.
- Constraint: Not 100% overlap in individuals who stand to gain and lose.
- Change the funding/finance model of TVET education. By way of example, Coursera.

Collaboration

- Creation of 'Network of Change' and co-planning mechanisms
- Increased collaborative planning across the green hydrogen value chain and mapping of South Africa's (green) skills needs.
- CoS = greater alignment of college and workplace provision, creating pathways for TVET students into apprentice training, and building social partnerships to drive these programmes.
- Create a H2 industry body, in the selection of the CoS and mobilisation of employers and the quality assurance of training delivery.
- Establishment of a TVET-Business-Learner Alliance.
- Innovations to emphasize/leverage learner agency.
- Allowance of SME "lead employers" and "host employers" improved workplace training opportunities.

Digitisation

- Better data collection/reporting systems needed for non-formal and informal TVET.

- Digitising TVET: SMS and WhatsApp message-based micro courses targeted to improve access to learning (see Ekatra in India).
- Digitising TVET: 3D labs platforms providing near real-life laboratory experience for students without access to physical laboratories (see StanLab in Nigeria).
- Develop improved network and data collection systems for nonformal and informal TVET.
- Digitising TVET? (Alleviating travel and far distances, allowing for scale, streamlining admin etc. see UCT Online High School's approach on "turning physical limitations into digital opportunities").
- Uberisation of education (on-demand education e.g., LinkedIn training courses) - adaptive change.

Policy

- Independent institution involved in rigorous selection and matching of youth to CoS and removal of administration.
- The articulation of green skills needs in national skills policies/strategies.
- Innovation: Industrial policy measures which stimulate the green H2 market in RSA and create demand for infrastructure and technicians/artisans.
- Constraint: Mismatch of timing (e.g., coal declines before PGM booms).
- Leverage the demographic dividend - export human capital to ageing communities.
- Change the perception of TVET Colleges.

Education

- New technical content in curricula needed (incl. electrolysers, fuel cells).
- Shift in college culture towards demand-led delivery.
- Colleges are required to recruit qualified artisans to ensure their training workshops meet industry standards.
- Upskill or reskill for transitional sectors (e.g., PGM and green steel, renewables for coal).
- Preparation for the reskilling of existing hydrogen technicians (already linked to the TVET system) into green hydrogen technicians.
- TVETs to target the higher enrolment of women (program marketing, the design of programs targeted towards women for medium and high skilled occupations).
- Implementation of TVET teacher training programme based in industry.

- The development of novel skills training programmes (including the establishment of a Centre of Specialisation) or content additions to existing programmes.
- Provision of training for workplace mentors.
- Nano/micro credentialing systems for CoS or TVET systems (to enable stacking of credentials) - radical change.
- Jukebox education model (whereby courses can be selected and taken across collaborative institutions (CoS with the same credentialing) - marginal change.

Processes, systems and infrastructure

- OTCs ensure facilitators are adequately trained.
- OTC's mobilise workplace learning opportunities.
- OTCs strengthen partnerships between colleges and industry. 'Business as usual', not sustainable in long-term.
- Timeous procurement and installation of workshop infrastructure and equipment.
- OTCs oversee readiness of the college to deliver.
- Structured rotation process ensures strong integration of institutional and workplace learning.
- TVETs to revise/simplify registration processes to improve access to qualifications and increase enrolment rates.
- TVETs to streamline/simplify administrative processes for SME apprenticeships to incentivise industry/TVET collaboration.
- Improving TVET-learner-industry feedback loops (what works and what doesn't) through networks, learning loops and incentives.
- CoS is viewed by colleges as elevating their status.
- Place industry associations OTCs in the driver's seat.
- Employer participation driven by the Occupational Team Convenors (OTCs).

H3 Seeds of change:

- Bambili pilot training. Extract lessons and scale up with SASOL, Toyota et al. green H2 programmes.
- Installation, Repair and Maintenance (IRM) Initiative: NBI Plumbing Hand / Solar Water Heating programme.

- CoS (or similar) is a means to work with industry on demand-led education via a dual apprenticeship model. Catalytic mechanism to fast-track improvements in TVET content and training approach.
- The coal mining sector has transferable skill sets for PGM mining.

H3 Desired futures:

- Aligned TVET and industry ecosystems (demand-led skills development).
- Socially mobile, expanded and equal opportunity workers which fosters economic wellbeing ecosystems.
- People-centred green hydrogen economy (where relational/soft skills are valued).
- A green skills fund and development with clear and transparent governance.
- Work opportunities translate into well-being outcomes for all segments of the population, including marginalised communities.
- TVET system enables broad post-disciplinary knowledge and application in occupational domains.
- Optimal industry absorption via anticipatory skills governance.
- Effective integration of hydrogen-related technologies in various sectors of the economy/society.
- Gender mainstreamed and inclusive TVET system and dignified labour market.
- Established platforms of TVET-industry collaboration.
- High quality educators.
- No mismatch between graduates and the H2/green economy.
- High demand for professionalised and formalised green H2 skills sectors.
- Strong and significant player in hydrogen export economy continually adding value to the national fiscus.
- A sustainable and growing local market demand.
- Just and including net zero carbon economic growth and societal wellbeing.
- Industry-wide invested and trusted use of hydrogen-related technologies.
- Optimal equitable infrastructure.
- Skills foresight and skills anticipation ecosystem.

- Supportive policy and regulatory environment that incentivizes hydrogen use.
- A secure, clean, affordable, globally competitive and low-cost sustainable energy ecosystem.
- Harmonised and innovative TVET-industry curriculum.

High Impact Key Uncertainties

Six high impact key uncertainties relating to the future green hydrogen economy and TVET skills were distilled from a Three Horizons exercise which mapped three distinct horizons for the future. The exercise explored: the existing dominant system and what elements of this are desired in the future (H1); what needs to change and potential innovations (H2); and desired futures including elements already present (H3).

The six high impact uncertainties were then ranked and rated according to the highest impact and the associated level of uncertainty.

Table 1: Ranking of high impact uncertainties relating to TVET Skills in the South African GHE

Category	Key uncertainties	Impact	Level of uncertainty	Total
Funding	Innovative funding models for TVET colleges	4	2	0
Digitisation	Digital infrastructure and assets to increase accessibility and leverage the 4IR	4	2	6
Policy	Political will (policy certainty and effective action) to change educational outcomes in light of a green economy	4	3	7
Education	Demand-led educational outcomes to ensure economic well-being (the personal and collective ability to mobilise economic, social and material resources to achieve personal and collective wellbeing)	4	3	7
Processes, systems & infrastructure	Open system supported by Total Quality Management (TQF) Framework to enable optimal knowledge production	4	1	5
Collaboration	Ecosystem to support collaboration and alignment across the green hydrogen value chain	2	1	3
		22	12	28

Source: Compiled by the authors

The identified key uncertainties align with the UNESCO International Commission's five thematic provisions of: human and planetary sustainability; knowledge production; access and governance; citizenship and participation; work and economic security.[2]

The two cumulatively highest-ranking uncertainties (highlighted in grey) were then selected for the development of a scenario matrix explored in the next section.

They are:

- The political will, policy certainty and effective political action to change educational outcomes in light of a green hydrogen economy
- Demand-led educational outcomes to ensure economic well-being (the personal and collective ability to mobilise economic, social and material resources to achieve social and collective well-being).

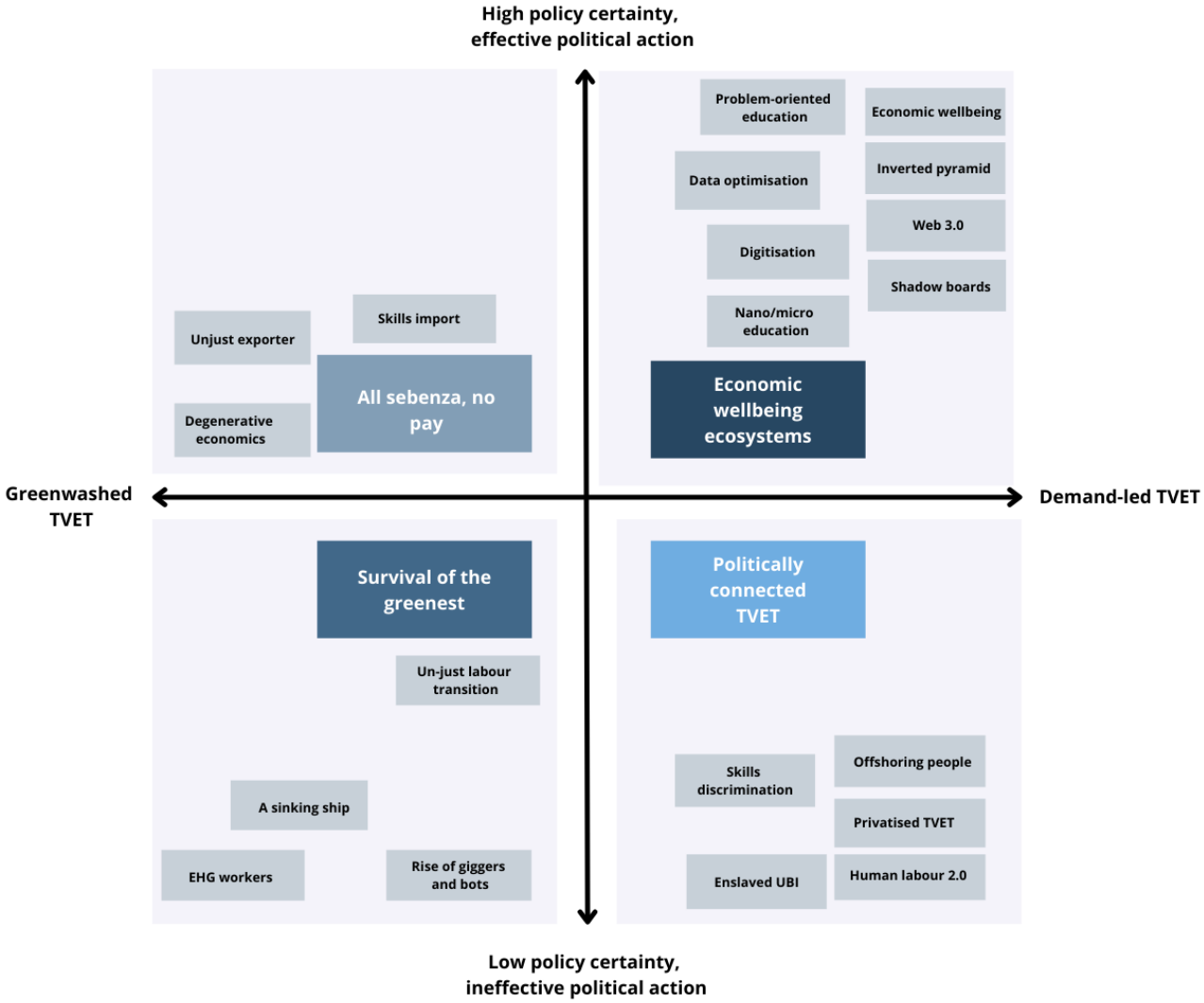
Scenario Planning for GHE TVET Skills Transition

Lessons from macro-historical trends of education outcomes in TVET colleges reveal slow and sometimes stagnant rates of change reflected in the reduced throughput rates over time. In addition, the current educational results portray elements of a closed system ignoring changes in the contextual environment without making inroads in the ever-increasing unemployment rate, especially for the youth. The prevailing global health pandemic, COVID-19, affects livelihoods and creates massive disruptions catalysing radical change as we transition towards a hydrogen green economy.

The scenario analysis below grapples with two variables: policy certainty and effective political action (y-axis) and the suitability and effectiveness of TVET skills (x-axis) redesign. The scenarios (with the timeframe being 2050) highlight a point in our present where we reflect on macro-historical trends and explore possible, plausible and desirable futures within the cone of plausibility. The scenarios are not predictions of the future but open pathways for alternative futures created by actions in our present, each offering lessons as we create foresight by creating resilience as we navigate through the various forces of change.

[2] UNESCO, 'Knowledge Hub: Futures of Education.' https://en.unesco.org/futuresofeducation/background -research

Figure 1: Scenario Matrix for TVET Skills in the South African GHE (2050)



Source: Compiled by the authors

Desirable futures

Economic wellbeing ecosystems

TVET students are empowered to achieve demand-led educational and training outcomes to catapult the green hydrogen economy. Students receive whole-person training to care for their households (the young and the old), to become good citizens that enhance democracy and collective wisdom, and to become socio-ecological beings that see themselves as integrally part of the natural environment and dependent on all the ecosystems services. All of the TVET systems are embedded in social, psychological, economic, and physical infrastructure and investments as provided by the state as facilitator of the wellbeing ecosystems. The education system transcends and increases marginalised persons' collective socio-economic well-being by increasing economic

activity and ultimately leveraging the demographic dividend to achieve a just transition. The economic wellbeing ecosystems opens numerous possibilities by leveraging digital, social, economic, and environmental innovations and scaling to facilitate the whole person education system and the additional benefits of economic wellbeing. The economic wellbeing ecosystem encapsulates high political will (namely policy certainty and effective action and implementation by government) where communities and individuals believe they can create desired futures. Some of these desire futures are imagined below:

Economic wellbeing

Economic wellbeing extends beyond access to jobs and includes the personal and collective ability to mobilise social and material resources to achieve personal and collective wellbeing. The holistic approach to economic wellbeing and security creates four focal points that reinvents economics beyond the formal economy, namely: (1) paid work (forms of employment and exchange), (2) household provisioning (caring for persons that are not in the formal economy (children, preparing food for households and the elderly), (3) provisioning of the commons (access to clean water, air, food, viable ecosystems and trustworthy information sources, and (4) the state (the infrastructural resources creating the conditions for the other three provisions to flourish). Education is, therefore, a societal pillar where the return on investment is noticeable not only in gross domestic product growth rates, but in various forms of holistic wellbeing.[3]

Vocational training and skills development has long been recognised as a crucial tool of economic development and poverty alleviation – without skills to sell on the labour market, or to make a viable living in subsistence or self-employment activities, individuals are more likely to be trapped in the poverty cycle. However, vibrant economies arise not from jobs and the market alone, but from the caring work of households, notions of good citizenship, from the infrastructure and investments of the state and from the collective resources that care for ecosystems services and our natural habitat of the commons. A concern for the long-term functioning of (green) economies, individuals and communities within them, therefore, requires a turn away from a narrow focus on jobs towards a concern for a broader understanding of people-centred economics that embraces economic wellbeing and inclusion.

[3] Facer, K. It's not (just) about jobs: Education for economic wellbeing. Education Research and Foresight Working Paper 29. Pa ris, UNESCO, (2021).

Shadow boards

Shadow boards[4] are implemented to facilitate collaboration among various stakeholders, including TVET management, educators, students and industry. This creates interactive and iterative processes for education, by ensuring more inclusive outcomes through business model reinvention, creativity, flexibility and a strong sense of community. Through shadow boards youth are part of the education process redesign and TVET college organisational transformation sustaining inclusive outcomes through transformative action. The shadow boards enable a thriving green hydrogen economy,

Nano/micro education

The fixed three-year curricula transitions to nano and micro educational outcomes made up of smaller modules. This modular approach to skills development enables stacking and building of customisable qualifications beyond fixed categories. This is the era of post-disciplinary education with the major focus on education platform ecosystems building meaningful work around personal experience, giftedness and abilities. Students have the flexibility to build a collection of shorter courses towards a more esteemed qualification which is demand-led by industry, catering to the high-frequency change environment ensuring that students and existing workers access demand-led educational outcomes, increasing employability due to the enhanced diversity and cross-pollinated availability of skills and expertise. By implication, existing workers upskill and or reskill themselves and form part of the emerging green hydrogen economy.

Nano/micro education supports transversal and applied education principles through cross occupational competencies. The green hydrogen economy transitions over time necessitating a phased approach where specific sectors are converted sooner than others. Students benefit from being multiskilled across occupational competencies, further increasing employment opportunities. Employers reap the benefits from a multiskilled workforce due to improved efficiency, competitiveness, improved production outcomes and it creates resilience in organisations by creating the capacity to adapt to changes in market conditions such as increases or changes in demand.

Educators and instructors remain vested in the reskilling process through incentivisation models accommodating the fast-changing environment and market demands. Revised teaching methods include mano/micro educational outcomes catering for short snippets increasing student-centric

[4] "Shadow boards" mimic traditional boards of organisations and institutions, but include younger generations, supporting diverse thinking patterns and approaches ensuring more inclusive outcomes and serves as a catalyst to promote radical innovation thereby steering away from used futures. An emergent quality of shadow boards is that it provides reverse mentoring by creating capacity for collective wisdom.

learning process that is deeper and richer for students, thereby increasing engagement. In addition, continuous learning processes with feedback loops are adopted at TVET colleges for students and educators supporting demand-led educational outcomes.

Digitisation of education

The TVET college system is not limited and contained to brick-and-mortar facilities due to the adoption of digital tools like Augmented Reality (AR) and Virtual Reality (VR) education toolkits that mimics in person learning and doing by hands. These AR-VR TVET toolkits are built on open-source digital infrastructure creating an augmented experiential education system (education metaverse). This Virtual Learning Environment (VLE) enables a new era of distance learning tools with computer-generated simulations integrating the real world (AR) or are entirely self-contained (VR).

Students benefit from setting their pace of learning as they access the metaverse through AR and VR tools, achieving optimal educational outcomes. Geographical location is no longer a barrier because all students access the same digital classroom remotely. AR and VR tools also surpass language barriers where students can learn in their mother-tongue while AR is particularly accessible via mobile phone. In particular, the upstream activities to produce green energy are ideally suited to rural and peri-urban areas, creating the demand for green skills in those areas. Digitisation thereby offers a means to eliminate barriers to entry, decentralise skills (in line with supply/production), offer 'on-demand' education, and attract more students to TVET institutions.

Problem-orientated education

Demand-led and problem-orientated TVET education flipped the curricula by embracing complexity of problems over simple solutions, flexibility in learning, and failing forward principles that enhance social wellbeing. The 'teach by problems' framework enables learners to see interrelationships between problems, by moving beyond traditional static snapshots of things as they are in different parts, but rather seeing the patterns that connect larger wholes and the relationships among the parts and the wholes. This systemic approach to teaching and learning creates open innovation and experimentation ecosystems that allow for failure and learning from mistakes, rather only from successes. The redirection of funding that prioritises demand-led and problem-orientated education enables industry and government organisations such as SETAs to address the most pressing complex problems in society head on, and to imagine alternatives through creating conditions for multiple safe to fail experiments. This scenario is characterised by policy certainty and supportive, effective action from national government. Problem-orientated education creates a new era of highly skilled green artisans that are sought after all over Africa and abroad. SADC member states become global leaders in supplying green energy to international markets due to integrated communities and diverse fit-for-purpose skills sets.

Web 3.0-Ed

Source data supporting educational outcomes are managed centrally by making use of Web 3.0[5] systems enabling optimal decision-making when growing skills pipelines for the green hydrogen economy transition. The skills pipeline 'catches' youth as they transition to higher educational outcomes ensuring that they are equipped with knowledge and skills to be employed, create self-employment opportunities or generate employment for others. Data transparency is a key enabler for TVET colleges strengthening the accountability relationship between the private and public sectors ensuring the optimal balance of supply of knowledge workers with the industry demand, thereby diffusing the narrative of perpetual unemployment.

Inverted pyramid

The overwhelming demand by youth for public and private universities in South Africa is completely flipped on its head like an inverted pyramid. TVET colleges are the educational pathway of choice due to excellence in training for high paying decent jobs and the plurality of direct employment opportunities after graduation. TVET certificates related to the green economy and green hydrogen become sought after by students, leading to the majority of PSET students undergoing TVET learnerships, internships and skills programmes when entering workplace-based learning ecosystems. The registration of students at TVET college systems allows students automatic entry into open-ended high paying flexible careers. The previous extraordinary situation where the highest number of graduates came from universities and made up the majority of students in the education pyramid are completely flipped around. TVET graduates become the largest portion in the hierarchy of graduates in the education pyramid. TVET colleges are well funded and known for excellence and close cooperation with the private sector. In the flipped education pyramid, TVET colleges have overcome perceptions of inferior certificates and low-income potential career pathways. TVET colleges are the primary choice for sourcing top talent by talent hunters/brokers.

Possible Futures

Politically connected TVET

This possible future scenario is characterised by factions and misalignment in the political parties leading to misguided attempts to upskill for the green hydrogen economy. Political will is inwardly focused, where politicians are more interested in personal gain than serving the constituents (i.e., in the form of effective action or favourable and certain policies) who placed them in positions of

[5] Web 3.0, also called the semantic web or the spatial web, is a user-friendly, more secure, more private and better connected internet that utilizes blockchain technology to create true decentralization in a fair metaverse, with digital data ownership through Non-Fungible Tokens (NFTs). All of this is only possible on web 3.0.

power. This environment forces the private sector to invest in demand led TVET skills for profit gain without public policies supporting a more inclusive narrative.

Privatised TVET

Actors with the economic means, such as established 'legacy' industries, set up private training institutions and recruit and train well-connected individuals seeking employment at minimum wage. It is a breeding ground for used futures where a wealthy minority forms an integral part of the green hydrogen economy through their networks, and the majority remain marginalised. The narrative of high unemployment and rising inequality perpetuates. Although, added checks and balances curb increasing corruption in public and private institutions, TVET systems are unable to adopt to increased bureaucracy and continue serving vested interests leading to skills development for a small minority. TVET colleges are embroiled in bureaucratic processes where actors in the system are 'stuck' rendering the transition towards a just green economy untenable.

Human 2.0 labour

Rising inequality allows the rich to become the super-rich. The low political will (ineffective political action and policy incoherence) leads to poor public policies, and the super-rich invest their surpluses as they deem fit. Investment is geared towards research in augmented humans (Human 2.0) to support the transition from manual engagement with machines to digital or virtual engagement with devices creating an interaction between the digital and physical worlds. Technology enabled humans unleash their full potential and perform at levels they could not reach without the embedded technology upgrades. In other words, the labour absorption rate decreases due to the increase in demand for 'techno-humans' in production processes. The humans lucky enough to find employment are augmented with modifications, further increasing unemployment and inequality. Due to the reduced tax base, funding for government grants is depleted, necessitating increased borrowing from international markets, rendering South Africa a failed state dependent on debt and aid. The advantages of the demographic dividend have become a distant memory because the unemployed youth focus their energy on the mass uprising, creating violent tensions with law enforcement, creating a hostile economic environment.

Offshoring people

High crime and civil unrest make it impossible for private institutions in the secondary sectors to operate in South Africa and compete globally necessitating offshoring critical production facilities, further exacerbating high unemployment rates. Offshoring enables profit maximisation for private institutions and reduces skills development financing and options in support of TVET colleges by reducing the demand for skills, creating a vicious cycle of unemployment and inequality.

Enslaved UBI

As the unemployment rate increases, Government is under increased pressure to institute a Universal Basic Income (UBI) system to alleviate severe poverty. The UBI is financed by the private sector through increased taxes and Government borrowing from lending institutions becoming more indebted and dependent on global market forces. Increased government debt raises interest obligations and defers investment and innovation in the green energy sector, accompanied by increased unemployment and rising inequality.

Skills discrimination

Low-level skilled jobs are replaced by 4IR technologies, and almost all growth in labour demand occurs in high-wage jobs. In addition, displaced low-wage workers are required to shift occupations (i.e., by means of upskilling) to higher wage brackets, necessitating the demand for TVET skills in the transition towards a green hydrogen economy to ensure employability in all skill levels.

Digital teaching strategies are universal, and students and displaced workers can access international institutions offering digital education to enhance their employability. Again, this benefit only serves the minority who have access to digital infrastructures further entrenching a growing digital divide between those who have access to digital education, tools and infrastructure and those who do not.

Survival of the greenest

The TVET system produces low and ineffective education outcomes. The college system is marked by ineffective political action shifting towards a sustained green economy. The TVET system produces 'greenwashed' education and training paradigms. Here, 'greenwashed' education and training refers to the redesign of skills training that is aimed at supporting green economies but is ultimately ineffective in meeting the demands of emissions reduction, climate adaption, biodiversity loss and fostering resilience towards sustainability transformations. The sustainability requirements of transitioning to a green hydrogen economy and the subsequent skills requirements are unattainable. The emerging qualities of greenwashing educational outcomes becomes evident in the long-term having detrimental impacts on the unemployment and labour absorption rates. Given the ineffective political action and poor skills outcomes a self-interest maximising attitude prevail in the green economy and green skills training. Career entrants and those already skilled in high-carbon sectors are susceptible to unemployment, poor labour mobility, and, ultimately, socio-economic exclusion. Some additional features of the scenario include:

Unjust labour transition

TVET colleges are not regarded as transformative and inclusive institutions despite governments large fiscal investments. Social inequality within South Africa increases given the limited pathways for economic wellbeing. More broadly, an unjust transition exacerbates socio-political tension within the country, especially without the required buy-in from trade unions due to the negative externalities of displaced labourers, limited job opportunities for new entrants, widening social inequality and the rise of an elite, '4IR/digital class.'

The unjust labour transition is due to poor policy coherency and ineffective political action and ineffective education outcomes. It deteriorates South Africa's pre-existing unemployment crisis, notably for low-skilled workers and minority groups such as women and people with disabilities. The domestic coal mining sector will be hard-hit as decarbonisation becomes eminent as we transition towards a hydrogen economy, leaving the currently employed workers excluded from the emerging green economy.

Robust and anticipatory policy planning is critical for the holistic and inclusive development of green hydrogen in South Africa, including the strategic design and implementation of skills training programmes to meet the needs of the future green hydrogen economy. Low political will within this context leads to poor policy coherence at a national level, leading to the continued under-prioritisation of TVET (i.e., in terms of resource allocation compared to universities and other higher education institutions) and a lack of disruptive innovations stifling the emergence of well skilled green hydrogen artisans.

A sinking ship

Despite reforms, turnaround strategies and significant financial support for the TVET system fails to deliver highly skilled and in-demand graduates for the private sector. The supposed transformative role of the TVET system does not materialise, hindering the emergence of a thriving green hydrogen economy. Efforts to transform the TVET college into an adaptive and agile system ultimately fail as the adoption of alternative educational paradigms and models are continuously rejected to keep the sinking ship afloat. South Africa's opportunity to leverage the country's green skills base, to become a significant player in the global hydrogen value chain is missed due to lack of employable and experienced green artisans. As a result, South Africa foregoes the role of a regional and global green hydrogen champion. The political elite and vested interests deny the TVET system its rightful role in job creation The overarching paradigm prevails and the common quip, "it is not due to a lack of stone that the stone age ended," portrays an accurate description of South Africa's missed opportunity to move in sync with the global transitions that require institutions to change quicker than the conditions of change itself.

Giggers and bots

Digital labour platforms are a dominant feature in the world of work. In particular, the gig economy labour model relies on digital crowdwork platforms outsourcing work through an open call to a geographically dispersed crowd, i.e., Amazon Mechanical Turk, Upwork and Uber. While gig work has proved critical in increasing access to labour and bridging unemployment gaps globally, it mostly requires low-level skills, subsequently offering low pay and minimal or no job protection for workers. It is accompanied by the growing prevalence of artificial intelligence bots to supervise the work of giggers. This results in a divestment by both government and industry stakeholders in human-centred training, with a reliance on short-term giggers and intelligent bots to meet the needs of the green hydrogen economy instead. In response, TVET colleges are not able to develop appropriate education and training paradigms for green economies and the rise of giggers and bots threatens the relevance and viability of TVET systems, instead of providing a desirable platform for a symbiotic human-automation relationship.

EHG workers

The environment, society and governance (ESG) investment approach fails due to the adoption of the eyewash, hogwash and greenwash approach (EHG) to subvert the just energy transition.[6] Green artisans install, operate and maintain green economy systems, but the green transition has been hijacked by vested interests in the private sector and bought by politicians. The transition to a green economy becomes a 'tick box' exercise with little contribution to the demands of the just transition, due to the private sector's focus on shareholder value rather than real change towards sustainability. For example, national and global oil and gas companies incorporate green technologies but also find ways to subvert and sidestep substantiative change to maintain growth trajectories. Citizens and workers are confronted by a distorted green hydrogen economy, favouring the upwardly mobile elite with trust in democratic governance. There is also divestment in the TVET system as both investors and students are deterred by the poor TVET 'brand,' training quality and capabilities for innovation. For example, all forms of social injustice and climate change effects are multiplied and aggravated, with trust in democratic governance lost.

[6] Eyewashing refers to overt reliance on self-disclosure and self-certification without verification systems thereby allowing exaggerated claims of contributing to the environment by organizations, investment managers and sustainable indices. Hogwashing refers to those that follow the law of the land but not in spirit. An organization may be complying with the applicable laws and regulations on paper but circumventing it through dubious means. Greenwashing refers to false conscious consumerism that aims to leverage the green economy opportunity by claiming they are helping the planet, but are in essence either contributing to climate change or have no significant contribution to halt the crisis. It involves incorrectly conveying to consumers that a given product, service, or the company cares for the environment.

All sebenza, no pay

In this scenario, education and training outcomes are 'greenwashed' and poorly designed to anticipate and meet the needs of South Africa's future green hydrogen economy, despite the existence of effective political action and policy coherency. Instead, efforts (i.e., sebenza which means work in isiZulu) by public and private TVET and green hydrogen value chain stakeholders has 'gone to waste', delivering an unjust labour transition (i.e., the pay) and associated social externalities. Other possible futures in the all sebenza, no pay scenario include:

Skills import

South Africa's green hydrogen-based economy relies on the importation of foreign skills from advanced economies. At the same time, only low-skilled jobs and potentially short-term jobs are offered to locals, which leads to limited socio-economic transformation. While South Africa exports green hydrogen directly to predominantly European markets to attract foreign direct investment, diversify and industrialise its economy and grow its gross domestic product, there are parallel positive externalities. These include the increased domestic consumption of renewable energy sources in line with global decarbonisation ambitions to mitigate the harmful impacts of climate change (i.e., Net Zero 2050 and the Sustainable Development Goals) and the strengthening local value chains through beneficiation processes (i.e. leveraging platinum group metal resources for local green hydrogen fuel cell manufacturing). However, where education and training paradigms (including re and upskilling) do not meet the needs of the green hydrogen economy, a just labour transition (the creation of decent work opportunities for all) is not attained.

Unjust Exporter

South African green hydrogen production is export-oriented only, with little capacity for local beneficiation and the development of regional value chains. The poorly aligned educational outcomes cannot facilitate and sustain a robust local green hydrogen economy. Due to the export orientation, green hydrogen is also not incorporated into South Africa's local energy mix, i.e., negligible green hydrogen Independent Power Producers feeding the national grid. The dominant energy sources remain coal, liquid petroleum gases and wood. Consequently, the country fails to secure a position as a regional and global green energy champion due to a lack of appropriate skills and the inability to lower carbon emissions to mitigate the impacts of climate change despite existing political impetus.

Degenerative Economics

Gross Domestic Product (GDP) growth remains the only metric to record economic prosperity and by settling for growth, the incentives to develop robust economic wellbeing through a domestic green hydrogen economy are ignored. TVET system outcomes are viewed in a narrow lens focused

on implementing marginal time changes, which ultimately are decisive in the degenerative effects and collapse of South Africa biosphere and ecosystems services. Big business supports the greenwashing of educational outcomes, where the international TVET systems adopted regenerative cultures into curriculums that foster sustainability transitions. The opportunity to equip the domestic skills base and a whole generation of graduates with the skills and capabilities of regenerative future remains elusive and reinforces the transgression of South African and regional planetary boundaries

TVET Skills Transition Strategic Framework

The Skills Transition Framework made use of the Strategy as Landscape model[7] to distil critical strategic actions towards a 'vision' for TVET skills in the green hydrogen economy.

The Strategy as a Landscape model is a useful, intuitive, and visual means to think about strategy and action plans in terms of an actor's 'journey across a landscape towards a preferred future.'

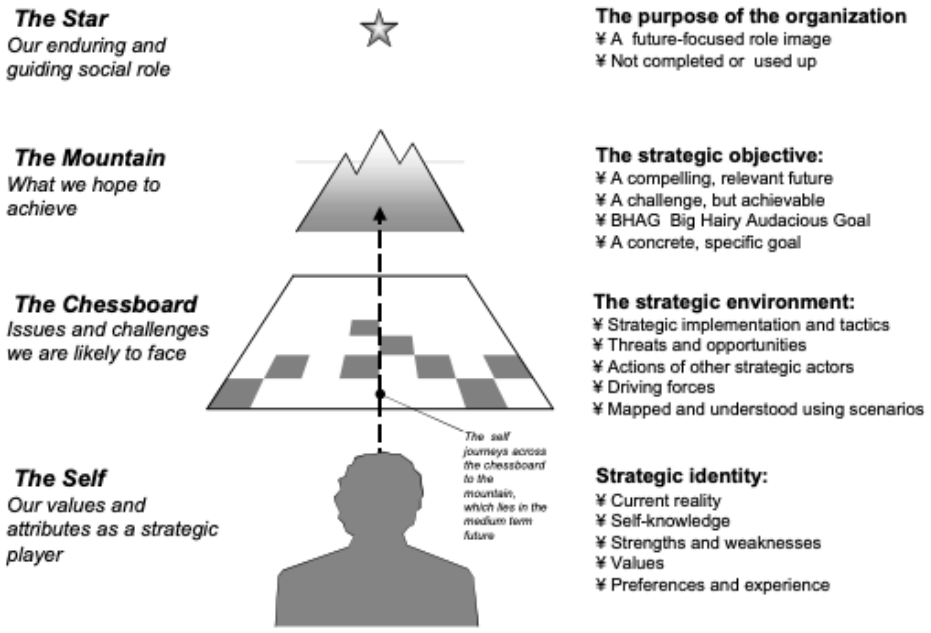
> *"The literature of strategic planning contains a profusion of strategic concepts, many of which deal with only one aspect of what is involved in strategy setting. The advantage of the strategic landscape is that by means of a deceptively simple pictorial s pace the essence of many individual strategic concepts and entire strategic frameworks can be brought together." – Hardin Tibbs*

The Strategy as a Landscape model constitutes four dimensions:

1. The self – our values and attributes as a strategic player
2. The chessboard – issues and challenges that we are likely to face
3. The mountain – what we hope to achieve
4. The star – our enduring and guiding role

[7] Developed by Hardin Tibbs http://www.psicopolis.com/futurdrome/archivio/futures.pdf According to Tibbs: "*Seeing the future as a psychological landscape clarifies the elements of strategy, provides insights into key areas of strategic thinking, and helps develop the strategic conviction essential for visionary leadership.* "

Figure 2: The Strategy as Landscape Model



Source: Compiled by the authors

Using this framework, an action plan and strategic actions are the 'journey across the chessboard' to the mountain, while actions are the things that link 'aspiration' to 'anticipation.' Using the Strategy as Landscape model, strategic goals as well as draft strategic activities were distilled as they correspond to identified actors and goals, and more broadly, to the 'star' and. This output and the populated template are contained in the sections below.

The self:

The TVET ecosystem

Star/Vision for a Just Labour Transition:

A just and inclusive GH2 TVET ecosystem for a transversal skills commons which fosters economic wellbeing and ecological resilience by 2050.

The seven identified 'mountain' goals are:

- Excellent physical and technological infrastructure
- Adequate and sustained financing
- Institutionalised anticipatory governance

- Effective partnerships
- Inclusive, economic wellbeing
- Transformative, quality and relevant training and education systems for enhanced mobility
- Reduced GHG emissions and foster ecological resilience

The identified stakeholders for strategic activities are:

- TVET management/educators
- TVET students
- SETAs/EWSETAs
- DSI
- DHET
- DTIC
- The presidency
- Private industry
- Academia
- Think-tanks, NGOs, CSOs
- Trade unions and trade union federations

Sustained and disruptive innovations

A range of strategic activities were distilled through the Strategy as Landscape model, relating to the seven identified goals. The goals were further categorised as 'sustained' or 'disruptive,' in terms of how they support the ultimate vision.

Sustained innovations produce current successes and with continued focus and marginal adjustments it is expected to be part of alternative futures. Disruptive innovations are not part of the present environment, but if implemented will create disruptions to the current environment towards alternative futures, and it does not possess qualities of used futures.

Table 2: Horizon 2 - Sustained Innovations

Sustained innovations
Establish, optimise and scale Centres of Specialisation (CoS) for greater alignment of college supply and workplace demand, creating pathways for apprentice training
Enable collaborative planning (i.e., through a working group) across the green hydrogen value chain to map South Africa's (green) skills supply in relation to the current and future demand
TVET Colleges to optimise process efficiencies across the value chain
Revise national TVET budget allocation to achieve the expected outcomes
Integrate the CoS programme into college funding norms
Implement skills governance, skills foresight and skills governance approaches and tools that are futures-informed
Create a H2 industry body to regulate quality standards of the CoS and ensure apprenticeship placements through rigorous selection and matching processes
Implement regulation and internal controls to manage educational outcomes of OTCs
Develop a communication plan to promote awareness and readiness of H2 energy skills development sources across all sectors
Provide support to SME's to become "lead employers" and "host employers" to optimise workplace training opportunities
Occupational Team Convenors (OTCs) to promote employer participation by redefining the partnerships to increase TVET-industry alignment and employment absorption rate
Articulate green skills needs in national skills policies through a Green Skills Master Plan
Establish an overarching body to coordinate relevant stakeholders in the quadruple helix around the H2 economy ensuring a smooth and just transition
Utilise CoS to elevate the TVET College status and perception thereby making it an attractive option for higher education for new entrants and working adults
Target the higher enrollment of women (program marketing, the design of programs targetted towards women for medium and high skilled occupations)
Leverage the demographic dividend by establishing international partnerships to scale up training required for H2 export economy
Develop and implement novel skills training programmes on digital, soft, STEM, climate change and GH2 skills
Design and implement jukebox education model (whereby courses can be selected and taken across collaborative institutions (CoS') with the same credentialing)
Collaborate with technical experts to develop training content aimed at a green energy transition

Source: Compiled by the authors

Table 3: Horizon 2 - Disruptive Innovations

Disruptive innovations
Investigate feasibility and implementation of available digitisation tools (i.e. 3D labs) to enable increased access and mitigate physical limitations
Implement formal and informal innovations platforms to leverage learner agency
Adjust the CoS model for increased flexibility allowing qualifying TVET colleges and interested industry partners to partner on selected green hydrogen-related specialisations in specific locations
Innovate funding model of TVET education to secure multiple, transparent and adequate funding streams
Shift college culture and manage skills supply towards anticipatory and demand-led delivery ecosystem
Improve TVET-learner-industry feedback loops (what works and what doesn't) through networks, learning loops and incentives
Design and implement industrial policy measures stimulating the green H2 market in RSA and create demand for infrastructure and technicians/artisans
Grow industry green H2 skills demand and increase job absorption rate in line with national transition plan
Articulate and brand the college as central to a Just Transition in South Africa
Develop a framework for reskilling and upskilling to preserve jobs in sectors affected by the energy transition
Design and implement nano/micro credentialing systems for CoS or TVET systems (to enable stacking of credentials)
Adapt the Organising Framework for Occupations (OFO) to include green skills
Implement TVET teacher training programmes based in industry and workplace training for mentors to ensure fit-for-purpose training
Implement selection criteria for TVET colleges to participate in green specialisations programmes

Source: Compiled by the authors

Conclusion

A just and inclusive green hydrogen TVET ecosystem enabling transversal skills that foster economic wellbeing and ecological resilience by 2050 is achievable.

The current juncture requires the region to re-envision knowledge and reimagine the purposes of education and the organisation of learning, particularly for the provision of quality post-school education and training which remains unrealised. It also presents opportunities for embracing digitally enhanced sustainable development, within the core functions of the post-schooling institutions themselves, as well as in relation to building societal capacity for transformative change.

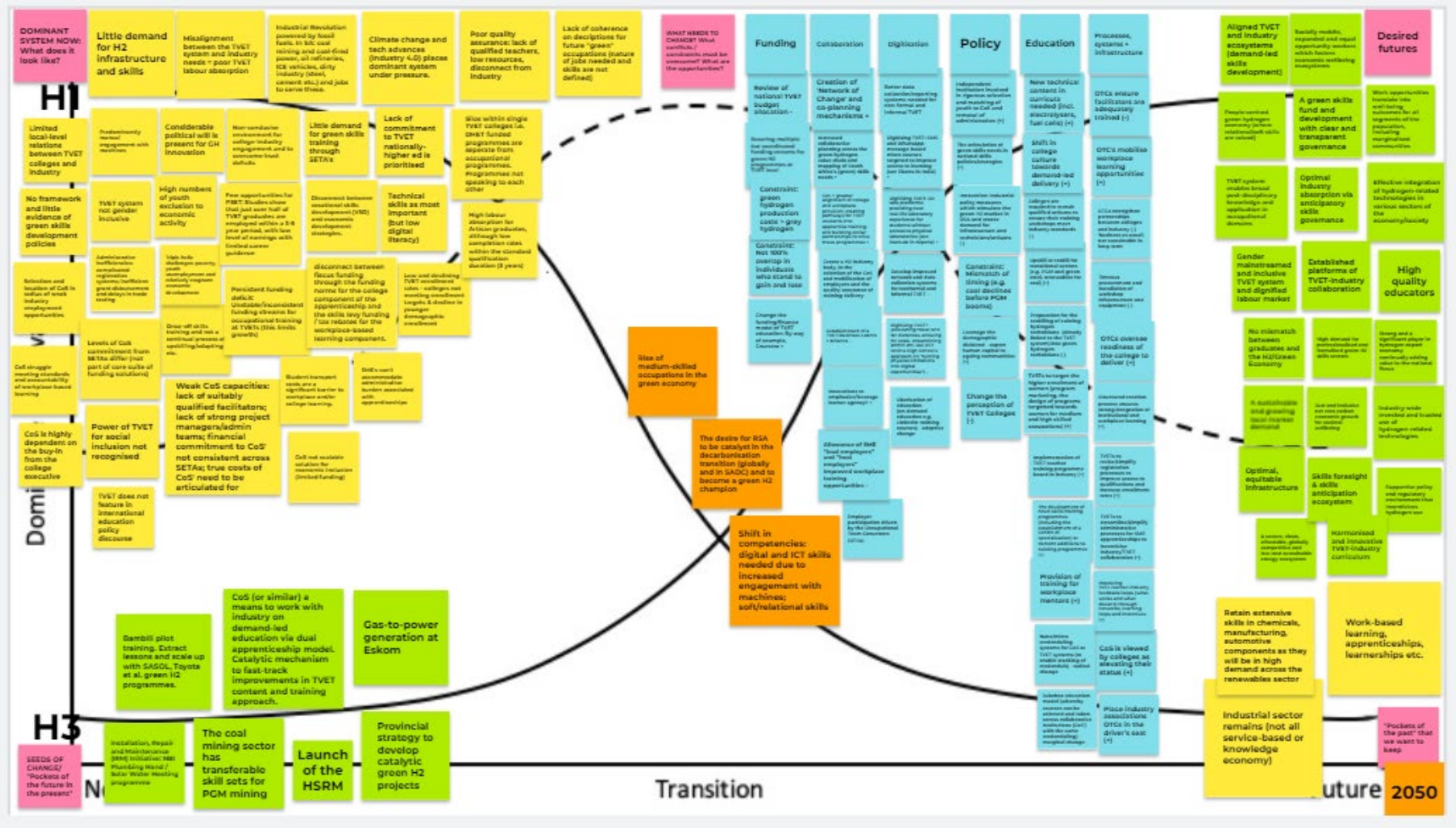
The ultimate goal is for society to have the autonomy, capacity, resources and skills to become architects of their own destinies; where individual wellbeing is recognized and influences collective

responsibility on each other; empowering agents of change to make a difference towards enhanced planetary, human and economic outcomes.

Education and skills development institutions are ideally suited to do the required social knitting to create stronger and more resilient communities by providing support and mitigating and removing barriers that prevent individuals from living active and connected lives.

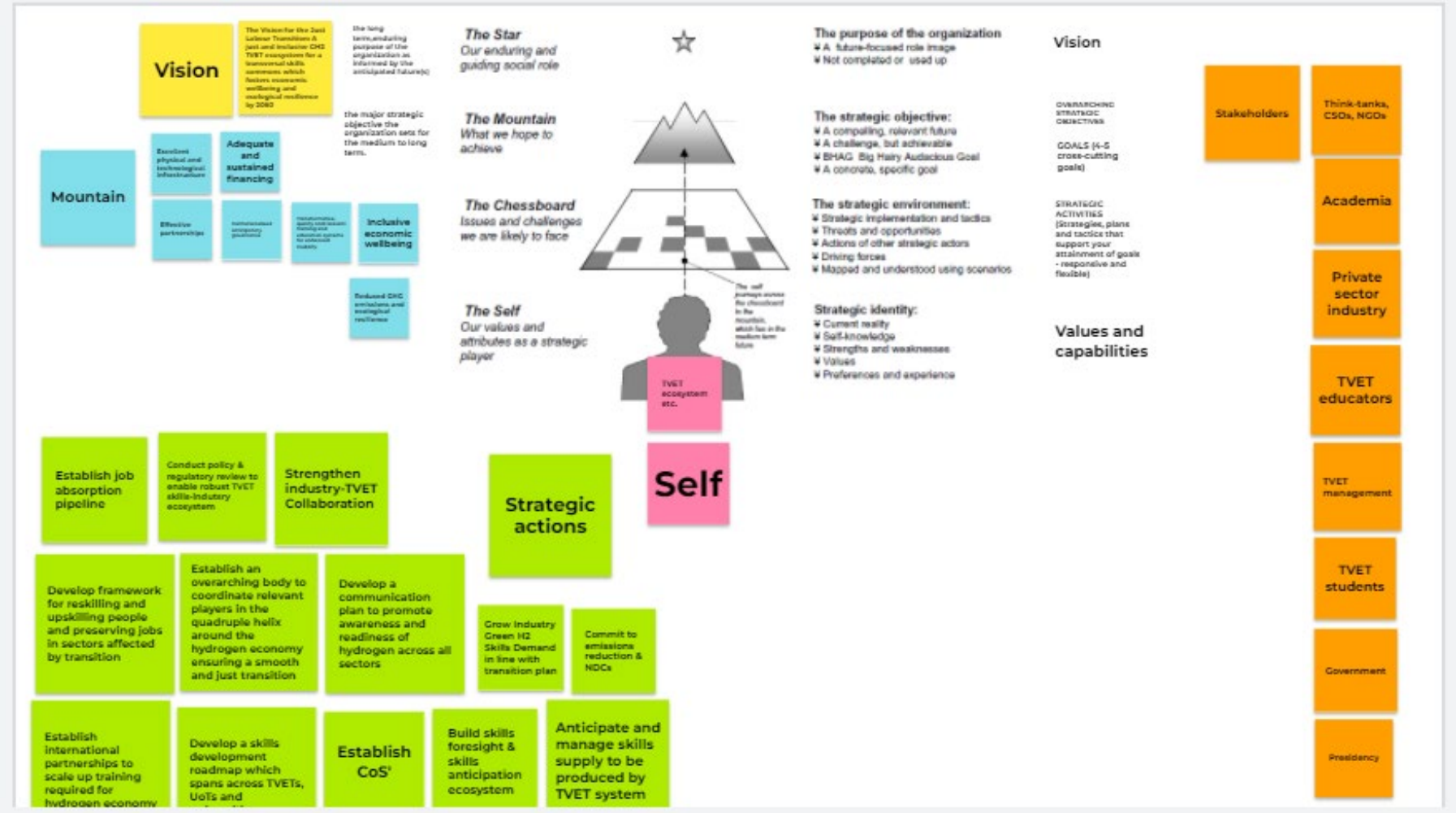
Appendix 1: Populated Three Horizons Framework

Figure 3: Populated Three Horizons Framework



Appendix 2: Populated Strategy as Landscape Model

Figure 4: Populated Strategy as a Landscape Model



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