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Argument for Convergence: Sustainability Diaspora to Corrective Transdiscipline

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Abstract. Future energy scenarios usually show pathways to green energy futures are possible. However, since the 2015 Paris Agreement, scientific scenarios show human activity is accelerating toward catastrophic failures and loss. A group of transdisciplinary thinkers discussed the history of sustainability and contemplated how a disruptive shift could occur in time for energy decarbonisation and climate stabilisation. How have transitions occurred in the past, particularly those that involved corrective transdisciplines like fire safety, emergency management, food safety, or waste management? After man-made disasters, engineering and operations fundamentally change through duty of care. Corrective shifts in economic, policy and cultural paradigms seem to follow the evolution of engineering practice. Over time, the prevention of harm and loss is manifested in technological enterprise, infrastructures, energies, and behaviour. The only way the whole-system transition changes the trajectory from danger of catastrophic failure to survivable and thrive-able future is that a corrective transdiscipline evolves now. We followed a logic process, framing an argument, developing a supporting theory, and brainstorming the methods involved. The argument is that since 1970 millions of people have gained awareness of future risks, and a sufficient number have focused their working careers on sustainability. The sustainability-active people are not having sufficient impact to cause a corrective transition, because they have become a diaspora. Our reasoning follows that just transition will eventuate when the diaspora converges to a corrective transdiscipline and create training and research programmes which are valued by industry and policy.

Keywords. Corrective transdiscipline, Transdisciplinary engineering, Discipline, Sustainability, Transition engineering, Just Transition

Introduction

When was the last time you had a productive, in-depth discussion with a diverse group of experts? How did the discussion navigate the disciplinary jargon? Did you manage to steer clear of political positions, economic theory, and personal beliefs? Did that discussion get past the problems of the world, the terrifying implications of the 2023/24 run-away temperature increase, ocean acidification, microplastic, receding glaciers, and biodiversity collapse? Did the group agree on a process of inquiry, and did you achieve a coherent and clear vision of *how* the massive transformational changes to stabilize

Earth systems could be achieved? Did the discussion keep going, building on recognition of the science warnings, pulling together every thread of possibility revealed by human experience, constructing an argument for transition, and arriving at an immediately actionable first step and theory change? We didn't think so.

Firstly, we acknowledge the challenge of truly transdisciplinary discourse, and the hopelessness of the mission to pivot business as usual [1]. We all hope that expert transdisciplinary problem solving is underway in governing organisations to formulate the strategic policy interventions, economic incentives, tools and rules that will steer the economy through transition. We hope for green growth, sustainable growth, decoupling energy from GDP, reliable renewable energy, circularity, and degrowth [2]. However, the evidence seems overwhelming that decision-making in the political/enterprise domains is not delivering the problem solving. We are not solving urban housing crises [3], transport and nutrition poverty [4], or education funding. Virtually unlimited energy and resources were the solution to last Century's problems but the profligate use of fossil fuels have created the climate emergency. Now, how will we deal with the corrective changes required to downshift fossil fuel production and material consumption? Economic beliefs have become pervasive throughout our modern culture. Homer-Dixon argues that the increasing complexity of modern systems challenges the ability of leaders to comprehend the problems being created by the march of technology, which in turn hinders the ability to generate the ingenuity needed to diagnose and solve the problems [5]. We might look to new technologies like artificial intelligence to solve our problems through technocratic approaches and optimisation. However, complex systems are emergent, requiring a transition approach more akin to exploration than planning [6].

This paper reports an argument, theory, method, evidence, and conclusion developed by a small transdisciplinary discussion group that met virtually over the course of several months. The participants were mostly in the UK, with one in Israel and one in Australia.

- Professor of Mechanical Engineering, researcher in Transition Engineering
- Electrical Engineer, Medical Physicist, Sustainability Innovation Consultant
- Institute Director, interests in sustainable development, corporate social responsibility, sustainable business, environmental issues
- Psychotharapist with interests in catalysing massive transformational change through learning systems and systems thinking
- Applied Social Scientist, interested in social problems, Diffusion Theory and Strategic Planning
- Computer Scientist, IT and Software Engineer, interested in Transition Engineering
- Mechanical Engineer, Quality Management, Council member for Professional Engineering Body

The aim of the conversation was to develop a compelling transdisciplinary narrative for change, originating from certainty that the concurrent emergencies of climate change, ocean acidification, soil degradation, and biological diversity collapse are sufficient to trigger a new corrective transdiscipline. The discussion used the following definitions:

> *Interdisciplinary* refers to a way of communicating and working that purposefully involves and integrates a wide range of perspectives and specialist knowledge for collaborative problem solving.
> *Narrative for change* refers to a description of events understandable by people from all backgrounds.

Corrective implies downshifting vulnerability and risks of unacceptable outcomes. *Transdiscipline* refers to common ethos, principles, and strictures that are applied across different fields in different settings, purposefully exploring different perspectives, sharing of methodologies, invigorating creativity and expanding boundaries of possibility.

The narrative was built through dialogue, using argument, and tapping into the collective expertise and knowledge of the group. The group called itself *The Insight Committee*. We sought insight to make the case for rapid corrective socio-technical-corporate change originating from a green swan [7], a purposeful systemic disruption, that would rapidly diffuse through institutions and society. The idea was to discover a green swan disruption that would trigger the corrective changes while managing risks to essential activities and goods. We agreed on immediate bold action being preferrable to waiting for sufficiently catastrophic failures in Nature, by which time the capacity to affect corrective change would be too little, too late.

1. Background Discussions of Transdisciplinary Experts

The Insight Committee agreed quickly on the aim to develop a change narrative. However, with seven senior experts in different fields with different jargons, the first few meetings involved voicing individual knowledge and challenge questions. During the third meeting, agreement was achieved to set out a mission, and to use argument to make the compelling case and develop the narrative, admittedly an unusual aim for engineers.

We provide here the notes of our early discussion, because we think most transdisciplinary engineers will recognise the sentiments from current discourse.

- Engineering doesn't work on its own.
- It's not just about engineering.
- How do we get people to understand that there is a way ahead?
- How do we get Engineering and Society together?
- Are we talking at cross purposes or saying the same thing?
- We have the internal capacity for the trajectory change, it isn't a secret recipe known only to one person, even if they have had a TED talk.
- We need to listen to other voices. But there are a lot of single-issue movements.
- We need to co-create our own narrative, something like change management.
- We need to create permission for taking on corrective projects.
- We need a playbook for best practice before practice can be expected.
- We should use Diffusion Theory.
- We need to just get started.
- We need to figure out how to deal with the greenwashing issue.
- What is the jargon of transition? How do we know it isn't just more growth?
- A playbook is essential, it defines language, has economic power.
- Degrowth? How does that work? We need to define degrowth.
- We need transformation from the inside vs from the top down.
- We need a process to pull together stakeholders.
- We need a philosophy for disruption, and to define wicked problems.
- The roles of players need to be translated into shared vision, a unified journey.

- We all recognise that we are in a great unravelling. The real problem is how do we accept the big changes in systems? Do engineers know their responsibility?
- We need to inspire commitment to turning around.
- What are effective conversation tools, how to have a thoughtful conversation?
- We need a social change movement around systems thinking.
- How to engage people? First coalesce people who care.
- Political decisions aren't making sense, so how do we cause one of those historic moments of shift, or transition?
- Could we turn the table by defining the issues from another perspective - the underlying issue, the systemic nature or the wicked problem?
- Economics is a belief not a science. We need to connect the dots – it's the growth economy that is accelerating the crisis.
- Should we worry about what happens if we rebel?
- Validation and hope – validate that the problem is our system, hope that we can transition in time.
- Integration of the diversity and understanding for shared vision of post-growth.
- Visions and Manifestos define goals, but antidote is caring for people and life.
- We need to use a positive goal, not a negative one.

Collective knowledge of needs and good intentions do not create green swan disruptions or a transition narrative, so we worked through an agreed approach to do so.

2. Approach

The Insight Committee eventually exhausted the discussion circling around the intentions, problems, and questions. It was suggested that we bring everything into focus by defining a mission, some rules for continued engagement, fundamental assumptions, and an agreed process.

Mission: We agreed on the mission of **metanoia** – changing one's mind through a process of breaking down the old patterns and assumptions and subsequent re-building or healing through learning.

Fact of Common Observance: We considered that historical observance of corrective transdisciplines could provide the basis for the change narrative.

Rules of Engagement: In the spirit of metanoia, we agreed to break with established narratives by banning certain words from further dialogue. The words "we need", "we must" or "we should" are comfortable for experts, but useless for achieving a mission. We instituted a rule that the word "solution" can only be used at the end of a fulsome, quantitative options analysis with a clear problem statement.

Assumptions: We agreed to not assume that economic theories are facts, and we set aside beliefs that government policy or end user behaviour will bring about the whole system transitions required by science in time. We agreed that assumptions would be validated through evidence resulting from rigorous science. We agreed further that the emergent system behaviour that has created the current situation defines the most likely future system behaviour. In other words, we agreed to stop wishing that our Western capitalist and democratic systems would solve the global warming, ocean acidification, and biodiversity collapse problems. We aim to generate ingenuity to invent transition

mechanisms that do not exist in our current systems but that have successfully created transitions in the past.

Method: We decided to break with familiar scenario modelling and foresight approaches, and instead to construct an *argument* for the existence of a future where democratic countries with enterprising economies, based on value exchange between members of society, and between Humankind and Nature, are thriving and do not face risks arising from unsustainable technical enterprise and consumption.

3. Historical Observance of Corrective Transdiscipline

Background research provided insight into the corrective change dynamics. New technology underpins profitable technological enterprises which grow quickly, creating disastrous failures, casualties, and loss. Early in the 19th Century, high pressure steam boilers created a new era for shipping, rail transport and industry, but catastrophic explosions were common. James Watt, inventor of the steam engine, warned that increasing power and efficiency of high-pressure steam engines also increased the risk of explosion. But designers, manufacturers, and users were reticent to slow down adoption of this extremely useful but increasingly dangerous technology and revert to Watt's safe low pressure steam engine [8]. Watt's campaign for safety, and counter arguments for economic progress raged from 1800 through the 1850's even as the scale and frequency of explosions increased, accompanied by rising public alarm. During this time, governments were reluctant to limit uses of high-pressure boilers, companies fought against regulations, operators were blamed for the failures, and boiler designers brought forward new safety technologies that did not actually reduce casualties. Clearly, a disruptive transition mechanism did occur, because today, steam boilers use much higher pressures, but explosions are nearly unheard of. In 1824 one research group, the Franklin Institute, was founded in Philadelphia, and received the first engineering science research grant by the US government for an experimental laboratory to study the science of steam production and boiler systems engineering. Their first reports exposed myths and errors in popular theories about what was causing the explosions. Their work set out the fundamentals of Mechanical Engineering needed to understand and apply engineering science to system design and operation. Finally, they recommended that Congress should enact regulatory legislation that included training, experience, and character standards for engineers who design and operate boilers. This foundation was essential but not sufficient. There was a belief that the enlightened self-interest of entrepreneurs would provide for public safety, and it would be too hard to establish training and qualifications for engineers and operators. In 1852 Congress passed a law requiring standards for steamboat boilers, which was the first successful regulatory legislation in the USA [9]. The first Boiler and Pressure Vessel Code published in 1915, was research-based design, manufacture and operator standards [9].

The metanoia dynamics are a fact of common observance in the emergence and impact of *corrective transdisciplines* in the case of boilers, and across all sectors (See Figure 1). The unacceptability of the disasters does not cause changes in the technological enterprise, although it does spawn solution mythologies. Governments cannot require regulations that are not yet conceived, but they can fund a research effort to identify the underlying problems, expose the false solutions, and establish the discipline. Discipline and practice are integral to academic research. Discipline delivers safe design and operation of the technological enterprise.

Today industrial societies are faced with climate emergency, ocean acidification and biodiversity collapse because of successful technological enterprises fuelled by growing supplies of oil, coal, and gas. The economic growth of the fossil fuel era is driving the most colossal potential man-made disaster outside of all-out nuclear war [10]. The capitalist economic system drives the industrial growth, government policy enables high consumption by providing infrastructures and policies supporting growth, and marketing pushes up consumer demand. The engineering capabilities across all sectors underpin growth in buildings, transport, manufacturing, and industrial agriculture that have greatly outpaced any purported sustainability solutions. Following the historical pattern, we would expect a research effort to emerge that provides corrective transdiscipline, based on science, consisting of a standard duty-of-care practice and guidelines that can be taught to all trainee and practicing professionals. Then government regulation can require the standards be followed, and the changes in concept, design, manufacturing, operation, and end of life will deliver the downshift of fossil fuel demand.

Figure 1. Technology generates economic benefits (technological enterprise), but unintended consequences grow, causing tensions and paradoxes, until one research institute, funded by government and partnering with industry, builds transition engineering knowledge through applied sciences, creates a disruption and builds the discipline that changes the future**.**

4. The Argument

We undertook a logic argument to gain insights and arrive at a change narrative. We saw metanoia in the historical patterns of corrective transdisciplines emerging when technology deployment outpaces safety standards. However, the challenge for the argument is monumental. The current expectations are that decarbonisation will be achieved by building more wind and solar, EVs, hydrogen and CCS. Metanoia requires breaking down these expectations, then creating a narrative of rapid downshift of fossil fuel production and building a fruitful low energy economy.

4.1. Metanoia: breaking down and rebuilding the sustainability norms

No further climate science is required. The Earth Systems Research Laboratories have been monitoring global CO_2 concentration since 1959, when the measurement was established due to concern about rising atmospheric concentration. If the rate of increase in the 1960's had continued, then the safety limit of 350ppm could be reached by 2025, and even the earliest models showed that the resulting global warming would cause climate changes [11]. By the 1980's it was clear that fossil carbon was the problem, and that coal, oil and gas production had to decline to future-safe levels [12]. The first sustainability norm to break down is that more scientific observation of the catastrophes is needed or that some level of understanding of the magnitude of the catastrophes will bring about corrective action. Environmental science is not the discipline that will deliver sustainability. Sustainability science is not a corrective transdiscipline. Sustainability professionals, measuring carbon footprints and ESG are enabling the catastrophe.

The science observations and models of the disastrous impacts of anthropogenic energy activities have generated widespread public concern [13] and should have triggered the first research initiative to study the root causes of fossil fuel production increase, exposing the mythologies and false claims, and setting out the fundamental science and engineering of fossil energy downshift/decline. Instead, many university research groups have been set up around "*Promoting energy innovation and advancing systemic solutions for a sustainable energy future"* as in the ICL Energy Futures Lab [14]. The sustainability norm seeks marginally sustainable technology innovations without tackling the inherently unsustainable incumbent complex systems.

We argue, by fact of common observance, that current sustainability norms, from the Brundtland Commission definition of sustainability to the Sustainable Development Goals, ESG reporting, carbon footprint, saving energy, recycling and sustainability standards, are now part of business-as-usual. Technological enterprises have embraced corporate responsibility, created a sustainability manager position, hired a sustainability consulting firm, added a sustainability page to the corporation website, developed a sustainability strategy, and continued with unsustainable growth as the business plan. Thus, the business-as-usual sustainability initiatives and programmes are not the corrective transdiscipline to deliver downshift of unsustainability. Hydrogen, carbon capture and storage, sustainable fuels, and other valorous research themes are heroic to us mainly because we have been taught to find them heroic. Metanoia, breaking down the normal way of pursuing sustainability, requires getting beyond myths and recognising the problem is *unsustainability* of incumbent technological enterprise.

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4.2. Metanoia: rebuilding through convergence around downshifting unsustainabilty

Fundamentally, survival requires identification and downshift of unsustainable activities through social-ecological systems that negotiate self-organisation for survival [15]. Today's manufacturing, construction, land use, architecture, vehicles, etc., are only normal in a world of unlimited low-cost unabated fossil fuel energy. The investors, engineers, and operators of fossil energy producing and consuming technological enterprises have responsibility to avert the climate and biodiversity catastrophes the same way that boilermakers and operators had responsibility for worker and passenger lives. Our argument concludes, by fact of common observance, that corrective transdisciplines have emerged in the past, supported by research and university programmes, and have created professional codes of practice, standards, and certifications that delivered to the social responsibility. In a relatively short timeframe, professionals learn a new corrective transdiscipline, direct their perspective to downshifting unsustainable attributes, and comply with future-safe standards. Previous corrective transdisciplines in safety and risk management have literally changed the future.

We postulate that the approaches, principles, processes, methods, and tools to build the corrective transdiscipline currently exist. Consider that senior professionals entered university in the early 1980's. It is logical to assume that many people now in their 50's and 60's have been motivated by global warming and other environmental disasters in their careers. Activists have been advocating for environmental protection and raising awareness about global warming throughout this period. Many people have been motivated to develop sustainable solutions, frameworks, and tools. The problem isn't lack of awareness; the problem is *sustainability diaspora*. Adherents in a particular sustainability initiative have worked so hard for so long to develop their ideas, that they

cling to the rightness of their discovery and invest ever greater energy to gain traction for their model, or way of thinking. Mechanical Engineers on the committee shared experience of colleagues advocating for the importance of their specialism, e.g. heat transfer, solid mechanics, design, or numerical modelling, during curriculum review processes. But at the end of the day, all understand and agree that all subjects are essential. The sustainability diaspora has had no such disciplinary convergence.

Diffusion theory of change was employed to discuss the critical mass for the transdisciplinary convergence to occur. We assume that awareness of the need to reduce emissions has been clear to at least 10,000 engineers across all fields in 1980. We then assume that sustainability awareness caused at least 30% of these engineers to contribute to ideas, approaches, methods, and tools that could be employed in downshifting unsustainability. But these 3,000 have been working on downshift transitions in relative isolation, as there has been no recognised corrective transdiscipline involving engineering duty of care. When ten percent of those aware and active senior professionals converge and define the corrective transdiscipline, then the business-as-usual trajectory will change. Figure 2 shows elements of corrective competencies already in circulation, converged and arranged into a disciplinary curriculum framework.

Figure 2. The corrective transdiscipline for downshift transitions could theoretically be achieved by 300 transdisciplinary senior professionals creating a university programme, curriculum, standards and training.

4.3. Precaution in believing our own narratives

Risk Management is a corrective transdiscipline with roots in the Renaissance, when the belief in fate and the will of Gods began to be broken down by mathematics and the theory of probability. Application of statistical probability to safety and failure analysis has allowed the engineering of bold structures, complex chemical plants, rail networks, aeroplanes, and nuclear power plants. The laws of probability made insurance possible, opening the space for people without collateral to gain a mortgage and protect their wealth [16]. Risk Management tools have moved beyond probability, statistics and regression to game theory and chaos theory. But the narrative that risk can be identified, quantified, and modelled using ever more believable computer simulations, will leave us

open to catastrophic failure because we grow increasingly ignorant of what cannot be quantified and modelled. We cannot build resilience, adaptive capacity, or ingenuity to deal with disasters that we believe are unthinkable. Artificial Intelligence is more likely to exacerbate our sense of false security. Using computers to handle incomprehensible complexity on our behalf, will just be concentrating our hubris in believing that we can plan for the future using a semblance of probability while eschewing disruptive, outlying concepts that are beyond our imagination, and cannot be programmed into a computer.

5. Conclusion: Argument for Convergence to a Discipline

Engineering disciplines are familiar to most people, not in the details of their work, but in the trust the public has for engineers and their projects to deliver the energy, appliances, food, goods, and infrastructures that we use very day. Disciplines like Mechanical Engineering are taught at most major universities. Engineering professional organisations accredit university programmes, certify practitioners, and enforce the standards of practice. Professional engineers are trusted because of their discipline, they do the required work, even if it is difficult. Disciplined professionals apply scientific fundamentals, comply with standards, practice duty of care and adhere to the code of ethics that include service to customers, employers, and society. Engineering professions have transdisciplinary code of ethics, which are referenced in their constitutions or founding tenets. Principles and canons are taught in undergraduate programmes and professionals can lose their chartered status if they are found to violate the code of ethics. The corrective transdisciplines have a tenet to "prevent what is preventable" that goes beyond the familiar standards such as "enhancement of human welfare", and "issue public statements in an objective and truthful manner" found across disciplines [17][18].

The corrective transdiscipline for downshifting unsustainability will offer a narrative of engineering culture, experience, and lifelong learning, following the historical pattern. Every time there is a new challenge and/or opportunity arising from technological invention, a discipline forms to bring together the relevant science, modelling, design, and applications cases, the first textbooks are written, and the first programme is launched by professors who are leaders in the field. This institution then carries out the formative research and education that leads to standard practice and recognised qualifications. The corrective transdiscipline for downshifting unsustainability has already started to emerge from research as *Transition Engineering* [19]. The next urgent step is a convergence of academics and professional organisations to define the research and education programme. The trigger to create the programme should be a government funded research project and an insightful commitment by a major engineering university with long history and experience with fossil fuel production, engineering, and enterprise.

5.1. The case for a survivable future: Systems Transition Engineering

The name for the corrective transdiscipline programme will be of utmost importance, and we propose Systems Transition Engineering. The professional organisation, the Global Association for Transition Engineering (GATE) would serve as the accrediting body and convenor of the global convergence of professional organisations [20]. The programme would establish research to support systems transition and rapidly develop and deliver training modules for undergraduates, continuing professional development (CPD) for engineers, executive education, business management, sustainability

professionals, government workers, and academics. The programme would grow the new ethos of the value of all life and the unacceptability of unsustainability, and grow the inquiry, methods, and tools, for all workers involved in all parts of the economy from researcher and expert to consultant, engineer, manager, and technician. Systems Transition Engineering will include everything known about value engineering, risk management, and applied science, but it will also purposefully imagine and create inventive disruptions in unsustainable business-as-usual and work with stakeholders to build adaptive capacity, resilience, and regenerative technical enterprise.

The Insight Committee's conclusion from research and logic argument is that Systems Transition Engineering will be an evolution in human cognition. Imagine a society that never again accelerates toward catastrophe because corrective change is hard. Systems Transition Engineering will require honest feasibility assessment of any solution narrative before it becomes a myth or false belief within policy and financial organisations [21]. Systems Transition Engineering will be the discipline we currently lament that we do not possess and profess to need. Systems Transition Engineering will provide downshift in unsustainability even if it is difficult, for survival in thriving Nature.

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