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GEM - Green Energy Mining

“Green and Gold” A Solution For All

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White Paper

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Introduction – mining challenges of the Climate Emergency

Mining is vitally important to the global industrial world. Yet, under the Climate Emergency and other ecological concerns, our world faces increasing challenges and imperatives generally referred to as ESG (Environment and Social Governance). Here, by mining we refer to the whole spectrum of underground and open cast mining, quarrying, and well drilling to extract metals, other materials and fossil fuels. All are energy intensive activities that also often entail substantial ecological impacts.

Opportunity in mining's double bind

On the one hand, mining activities are under strong pressures to *"clean"* themselves, or even under the threat of being curtailed. On the other hand, mining remains essential to the operations of the industrial world. In fact, as part of efforts to address the Climate Emergency and the vagaries of the global financial system, mining receives increasing demands for specific metals and materials, including gold, other precious metals, rare earths and a wide range of other metals that are crucial to the manufacturing of new energy technology equipment (e.g., photovoltaics, wind turbines, electric vehicles, batteries, and new emerging energy harvesting, conversion and distributions technologies).

Both increasing extraction activities and addressing their ecological impacts entail substantial increases in energy requirements. The latter in turn entail further greenhouse gas emissions, further ecological impacts and constitute a substantial proportion of total cost of delivering end products, metal and materials, to the industrial world. These constraints translate into ever more stringent regulations. **The mining industry, along with the energy supply industry, is caught in a series of seemingly intractable vicious circles.**

This White Paper presents an alternative route, Green Energy Mining, GEM, built on a novel, disruptive energy technology class, the *n*Geni, that can break through the above vicious double binds, substantially reduce costs, transform mining into a *"green"* activity, provide absolute competitive advantage concerning permitting new projects, especially new gold mining projects, and provide mining operations full, s energy independence from all market and regulatory vagaries.

Breaking through – a new take on thermodynamics

The matters are complex. This is not something one can present in a 30-second *"elevator pitch",* bar spelling out the new motto: ***"It's the thermodynamics, stupid!"*** – the shortest pitch ever, incomprehensible to most.

The matters also require new thinking. We all know Einstein's famous quip*: "We can't solve problems by using the same kind of thinking we used when we created them"*. The need for new thinking in mining and the innovation have increased considerably. KPMG's 2020 report highlights the matter:

"What worked 10 years ago does not work in the current environment. Executives are keenly aware of this and are expected to continue to position—or reposition— their companies to better address potential challenges and take advantage of new opportunities…

Commodity prices and permitting risk once again occupy the number 1 and number 2 risks*, respectively. Along with access to capital, community relations and social license to operate these were the top four risks identified by respondents for the second year in a row… We have seen a notable shift in focus by the industry* *to a higher regard for holistic measures reflecting ESG-related risks. Environmental risks jumped 3 spots from number 10 to number 7, and tailings management made a debut in the top 10 risks...*

*Not surprisingly, **we continue to see a trend of increasing regard for disruptive technology as an opportunity**, as opposed to a threat, with companies identifying technology disruption as the number 2 strategy for achieving growth… companies are increasingly seeing technology as a key enabler to executing on growth strategy… 75% say the industry needs to redefine success using a more holistic group of measures that include both shareholder and stakeholder values."*[1]

The *n*Geni GEM approach and technology fits squarely within the above landscape to enable mining companies to simultaneously improve their profit margins and address the permitting and ESG risks through a disruptive technology advance. In short, our objectives are to provide absolute competitive advantage to our industry partners in terms of project permitting, project bottom-line performance, and sustainable energy independence.

While it is customary to assess mining performance in financial terms, all operational factors in the mining world inescapably translate into energy and more specifically thermodynamic terms – hence the thermodynamics centred *n*Geni approach. This in turn drives bottom line performance.

A prime focus on Gold

*n*Geni GEM is applicable to the entire spectrum of mining conditions and circumstances, however, in order to highlight the potential of this technology class, **this White paper focuses more specifically on underground mining in Australia and more particularly gold mining**. This is because direct and indirect energy matters are more particularly important in Australia and concerning underground gold mining and because it is now very difficult to obtain permit consent for new mining projects. What's applicable under those more extreme conditions is even more so applicable to other operations such as coal mining, open-cast mining, as well as oil and gas extraction.

Gold production's energy requirements are estimated at some 200,000 GJ/t Au, resulting in 18,000 t CO_{2e}/t Au in Greenhouse Gas Emissions (GHGs), 260,000 t water/t Au and 1,270,000 t waste solids/t.[2] This is about twice to three times the energy costs of other common metals. The energy figures for gold, however, are low estimates that concern the direct energy cost of mining and retrieving the metal from the ore. One must also consider the energy costs entailed in what is now considered as an urgent necessity, extracting CO_2 from the atmosphere as part of addressing the Climate Emergency, as well as the energy cost of handling the water and the solid waste. In other words, **addressing gold mining in thermodynamic terms enables addressing in one go the whole of the emerging challenges faced by the industry and, instead of resulting in increased costs, transforming these challenges into a substantial source of increased profitability**.

This systemic, thermodynamics-based strategy is all the more important since the industry has been under mounting pressure by activist *"green"* groups to reform and even have a moratorium on gold mining worldwide. In response to this trend, the industry has shown increasing interest in environmental and social sustainability (Environmental and Social Governance, ESG).[3]

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1 KPMG, 2020, *Risks and opportunities for mining - Global Outlook 2020*, kpmg.com/mining.

2 Terry Norgate, Nawshad Haque, 2012, Using life cycle assessment to evaluate some environmental impacts of gold production, *Journal of Cleaner Production*, 10.1016/j.jclepro.2012.01.042.

3 World Gold Council, 2012, *Sustainability*. www.gold.org.

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From waste to riches – a fundamental game changer

To address the above challenges and match the usual assessments of financial cost one must adopt a mine-to-grave systemic approach that encompasses all the energy costs of mining, transport and ore processing equipment and of the personnel involved. In this now necessary perspective, the energy requirements more than double. Furthermore, this perspective reveals that along the complex supply chains that deliver directly used energy, equipment, maintenance and personnel livelihood, **the total energy wastage is in the order of 90%. This wastage is actually paid by the mining company. It is built in the total financial costs incurred.** Globally, total operating expenses are in the order of US$1 trillion. There is thus considerable merit in disruptive technology approaches that can significantly transform mining performance by drastically reducing this huge wastage. Consider the impacts on bottom lines of reducing the wastage by 50% or even more. We outline this on pages 32 onwards.

There are currently numerous attempts to address the challenges faced by the mining industry through incremental improvements to existing technologies. However, when considered systemically, in a mine to grave whole system perspective, **none of those incremental developments addresses effectively the core ecological, energy, health and financial issues.**[4] Whichever way one turns, one remains faced with the same kinds of dilemma. Addressing problems piecemeal aggravates other problems or causes new ones in intractable ways, without reducing overall costs significantly, often increasing them instead.

The time has come to acknowledge that incremental ways of tackling the matters at hand have reached their limit and **a systemic rethink from well-established basic engineering and scientific principles is required.** This is the approach that has led to the development of *n*Geni, as a high efficiency, new energy technology class, IP protected, aiming to substitute for most of the main energy technology classes, that is, internal combustion engines (ICE), turbines (steam, gas and wind), large-scale photovoltaics, large -scale Li and similar batteries. Besides substantially increased energy efficiency, *n*Geni offers the prospect of drastically reduced pollution levels for particulates, other pollutants and greenhouse gas emissions (GHGs) as well as massive extraction of CO_2 from the atmosphere and from exhaust gas streams. This combines with substantially reduced capital, operations and maintenance costs.

Of course, much of the details concerning the *n*Geni Intellectual Property (IP), internationally protected, are commercially sensitive. The present White paper only outlines key features of global strategic importance. As we stress in conclusion (Page 36) full disclosure will be provided to interested parties, under strict NDAs.

[4] Louis Arnoux, 2020, *Thermodynamics, Fossil Fuels and Renewables, The Good, the Bad and the Ugly,* Fourth Transition Wealth Ltd.

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Understand the Problem ➔ Build a Solution

*n*Geni is disruptive and resolutely off the beaten track. So much so that before introducing its features and *"how it works"*, it is necessary to present its rationale. Instead of tackling each problem in a piecemeal way, one at a time through separate solutions, which translates into high inefficiencies, multiple, expensive capital equipment expenditure, and increased operating, maintenance and upgrade cost, ***n*Geni tackles the whole set of challenges reviewed in introduction in one go through the one system.** This makes for substantially reduced capital, operating, maintenance and upgrade costs, as well as drastically reduced GHG emissions and other forms of pollution. **The aim is to make mining *"green"* through improved performance and profitability.**

It's the thermodynamics, stupid![5]

In thermodynamic terms, the generic problems faced by the mining industry are the same as faced by the whole of the global energy sector and by the whole of the industrial world. In effect, most substantial mining operations take place at isolated locations that function as a simplified microcosm of the broader industrial world, involving industrial activities, transport and living quarters. Simply, in the case of mining operations the challenges are exacerbated. Considering the whole of the industrial world ahead of mining specifics enables seeing the core problem in striking fashion: massive thermodynamic inefficiency.

Since the early years of the first industrial revolution, appallingly energy inefficiency has been built in ever-longer and more complex supply chains, to the detriment of energy using industries. Early steam engines used in UK coal mines ca 1750 were 1% to 5% efficient.

What few realise is that now, about 270 years later, current, global, energy technological systems, used in mining operation and globally, are still no more than 12% energy efficient.[6] The outcome at the present time is summarised striking fashion in Figure 1. **While the world currently uses some 19TW-year (TeraWatt-year) of primary energy, only some 2.3TW-year are of any productive use. The global wastage represents over €5 Trillion/year in wasted funds.**

Had the industrial world emulated life's ecosystems and climbed to over 80% productive use of energy, GHGs would have remained well below 350ppm CO_{2e}, global warming would not be an issue and we could still use fossil fuels for at least a century for an easy and smooth transition to 100% solar, while oil reserve depletion would progressively take place. We would then use only some 2.7TW-year of primary energy at some 85% efficiency instead of 19TW-year, wastefully.

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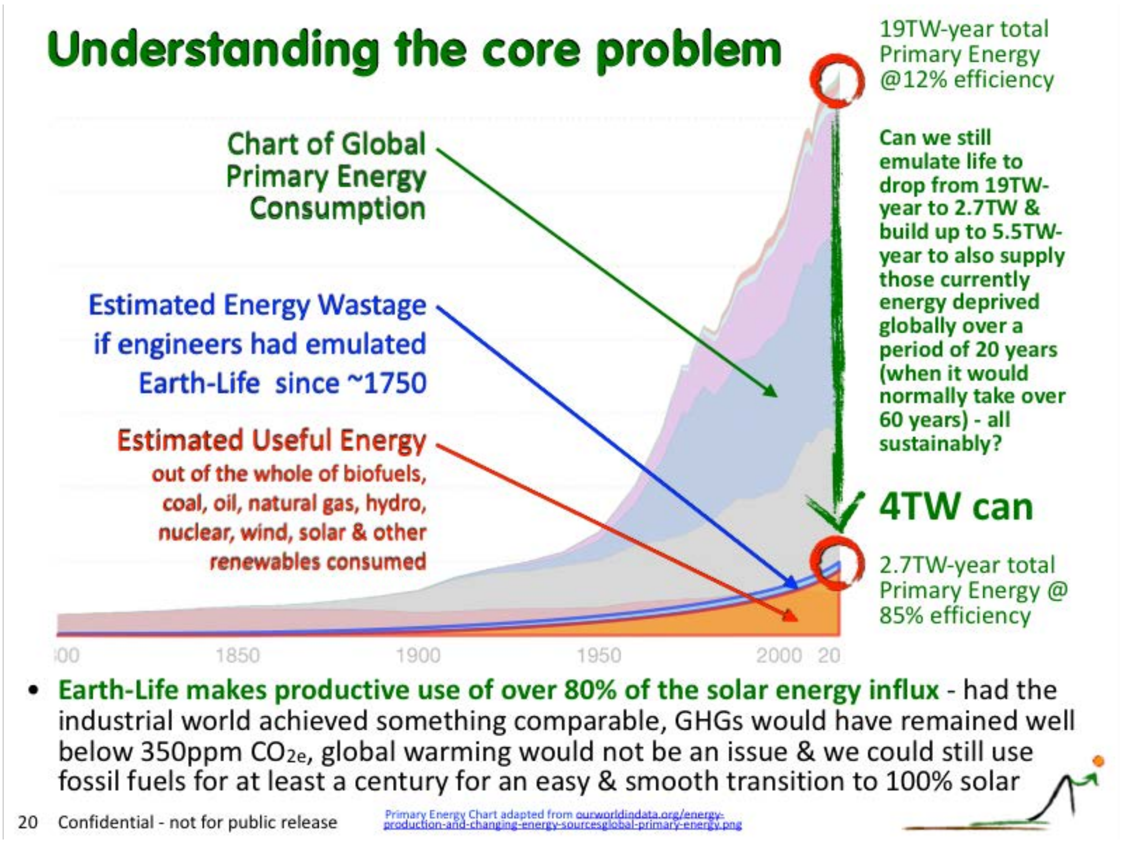
5 Updating the now obsolete 1992 Clinton re-election campaign motto, which was *"It's the economy, stupid!"*

6 Based on: Murray, James, and King, David, 2011, Oil's tipping point has passed – The economic pain of a flattening supply will trump the environment as a reason to curb the use of fossil fuels, *Nature*, 26 January, Vol. 481

Figure 1 – Going 'Schuss" down to minimal energy wastage



It is the above insights that prompted us to reconsider critically all prevailing energy technology classes to figure out how to emulate life in order to drop from 19TW-year to 3TW. In doing so we also figured out how to eventually build up to about 9TW-year to also supply those currently energy deprived globally and also have the energy required to address the climate and other ecological problems currently threatening civilisation. All of this can be achieved, sustainably, over a period of 20 years (when it would normally take well over 60 years).

One of the most immediate application domains for the resulting breakthroughs are in the mining industry and more particularly gold mining.

The necessity of shifting to principle-based developments

As a new energy technology class, *n*Geni is a fundamental step change. To understand what this means and its game change significance, it is necessary to review the status quo critically.

The last 270 years of industrial development have been achieved largely through incremental improvements and additions to what was already in place, and huge increases in complexity. For example, once one has built power grids with central power stations fuelled with steaming coal, it becomes logical to improve them by shifting to natural gas, integrating steam and gas turbines in ever larger plants, and keep improving turbines and other equipment incrementally. Such cumulated incremental developments have reached their limits. In moving incrementally from1% efficiency to only some 12% over 270 years we created the Climate Emergency and an avalanche of other challenges…

Instead, it is now necessary to adopt a principle-based technology development strategy addressing directly and in fundamental ways the problems at hand. As stressed by Einstein in the context of his major physics developments in the early 1900s, science and engineering progress in two exclusive ways:

- **Constructive/incremental:** adding somewhat haphazardly to an existing knowledge and/or technology base. This is usually slow, inefficient, costly, leading to blind alleys (like the situation we are now in). Provisional solutions built that way usually do not survive long the test of time; and
- **Principle-based:** resting on solid, well tested foundation, this leads to efficient, lasting, more broadly applicable and encompassing solutions.

270 years of appallingly inefficient incremental developments have brought us to the edge in terms of the Climate Emergency and other related ecological and energy resources depletion issues. **Let's face it, starting from a zero-base, progressing from 1st principles, with present available knowledge, no one in their right minds would build the present, hugely inefficient, technological energy and mining systems.** Addressing profitably the energy and mining challenges requires shifting to the principle-based approach. This is what we have done.

To the best of our knowledge, our principle-based, solution design approach is unique in how it tackles energy efficiency to redesign how energy is accessed and used. **The overall aim is to achieve 10 times more with 10 times less.**

To achieve such an ambitious but necessary aim, one must differentiate between:

- **Means:** products, services, business and financial models, decision-making processes, as well as related social and financial relationships – e.g., cars, iPhones, washing machines are not *"technology"* but mere products and machines;
- **Technologies**, defining ways of achieving specific outcomes, from specific standpoints and courses of action (i.e., in Greek, the *logos* of *technè*, a critical discourse on the state of the art aimed at improving how we do things);
- **Technology Classes**, each encompassing a collection of technologies all based on the same fundamental principles (e.g., unit operations in chemical and process engineering, ICE, turbines, etc.);
- **Technological systems**, encompassing chains of processes extending from mine to grave, using wide ranges of technology-based equipment and energy.

Tackling the identified challenges requires replacing current prevailing but obsolete means, technologies and technology classes with new ones to redesign technology systems from mine to grave.

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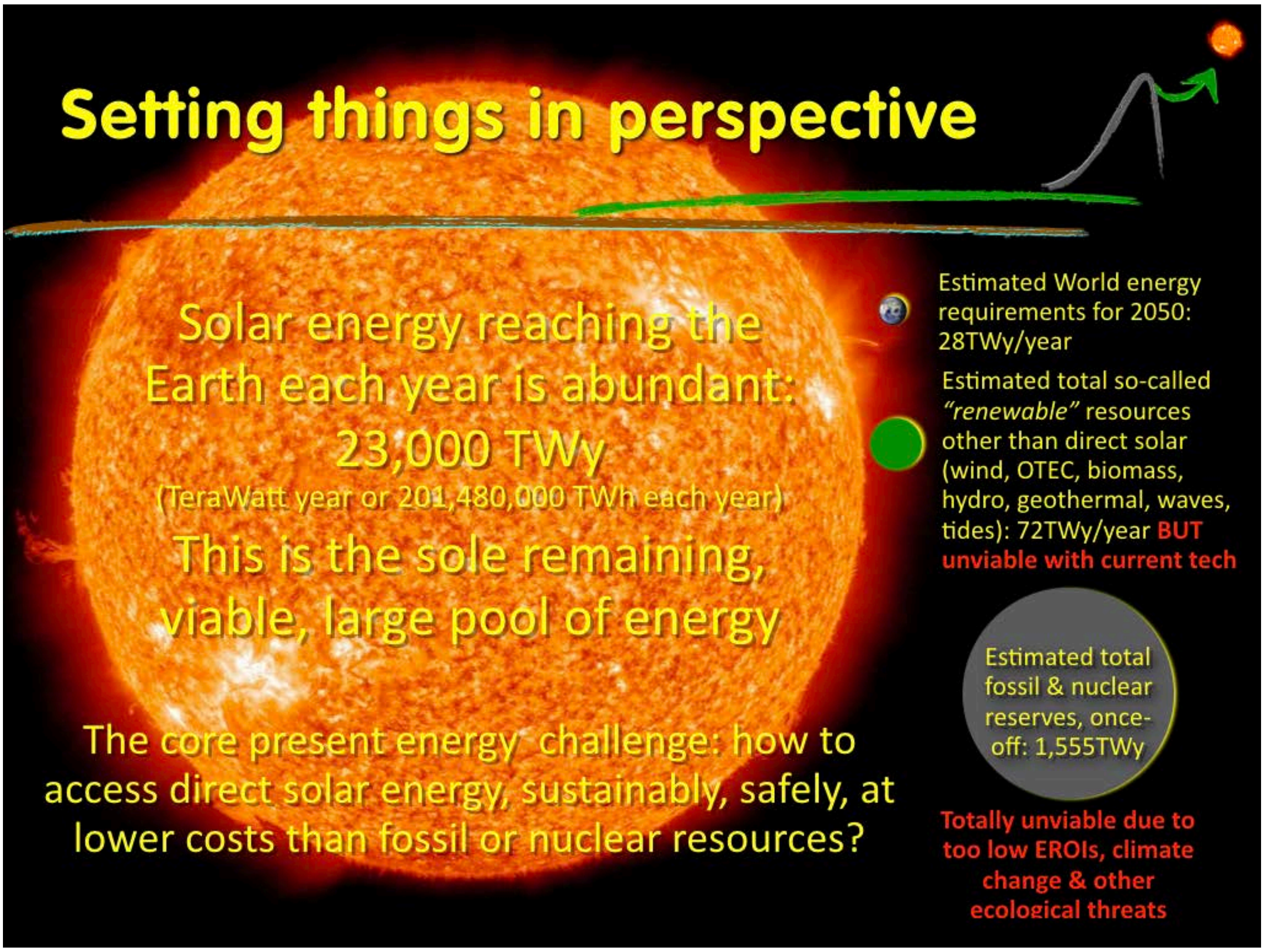
The fundamental challenge

The importance of solar energy is well known. What is less so is the sheer abundance of it. Figure 2 sets matters in perspective. This abundance cannot be effectively tapped into with the current drive to implement massive photovoltaics and wind. The present either/or debate between solar versus fossil fuels contributes to the poorly understood systemic problems with *"decarbonising"* the industrial world. It overlooks the underlying dependence on oil of all alternatives, that is, both other fossil fuels than oil and *"renewables"*. Along with an increasing number of other researchers and engineers we have demonstrated that the present *"decarbonising"* strategy based on photovoltaics and wind with is bound to fail and make matters much worse.[7]

Figure 2 – The ultimate renewable energy pool



It is now urgently vital to steer way from this either/or approach. The way forward is to harvest and use solar energy in novel, highly efficient ways **and** retain the use of high energy density molecules derived from oil and/or biomass. This is absolutely necessary for most transport and remote operations such as is most often the case concerning mining. As we have shown elsewhere, in consequence it is also necessary to extract and

7 Louis Arnoux, 2020, *Op. Cit*.

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recycle CO_2 from exhaust gases and from the atmosphere. **Achieving all of this in one go, through one technology class is the fundamental challenge of our time. It concerns most directly the mining industry, where those challenges are already felt most acutely.**

From demand for "Something-else" to technology

By adopting the above zero-base, principle-based approach along thermodynamic lines, we identified the following key market imperatives that must be addressed simultaneously, in the mining world and beyond:

- **No *"blue sky"*.** There is no longer any time left for long, protracted new R&D technology developments like those that led to current photovoltaics or wind turbines. Any viable *"Something-else"* must be built from the already available *"Lego set"* of well-known and proven means, methods, science and technology elements.
- ***"Keep wheels running"*** for all modes of transport – which implies the ability to retrofit existing transport means. This is an acute imperative in the mining world regardless of Climate Emergency constraints.
- **Retain access to high energy density molecules** from oil or equivalent from biomass as transport fuels (they are some 60 times more energy dense than current Li battery) and use them in non-polluting ways, including by recycling carbon emissions (see below). This is also an acute imperative in the mining world.
- **Achieve cost-effective direct air capture of CO_2 (DACs) and capture from most exhausts.** Current strategies to address the Climate Emergency cannot succeed in time without this, and some will make matters worse. **Instead, carbon recycling on a massive scale is now required.**
- **Re-establish the self-powered status of energy supply chains.** We estimate that within the present decade, two at most, the world's energy supply chains will have completely lost their self-powered status and will be disintegrating. No industry can survive without energy supplies coming from self-powered energy supply chains. This matter is ignored by most in the energy industry and in energy intensive industries like mining. The only way for the mining industry to shield itself from this challenge is **to rapidly achieve energy supply independence** through the kind of approach we are developing.
- **Change the game by redesigning how energy is used.** Our present predicament, and the mining industry is a striking case in point, is fundamentally due to the appalling inefficiency of current energy systems. The imperative is to flip from the about 88% energy wastage to over 80% productive use of energy, in record time, by recycling heat currently wasted.
- **Provide sustainable energy independence to energy end-users**. The energy supply chains are increasingly erratic and volatile. We expect price and supply disruptions to increase substantially throughout the present decade. The *"Demand-for-something-else"* is also for secure, sustainable energy supply independent from those vagaries and from regulatory impacts, such as those stemming from responses to the Climate Emergency.
- **Monetise a substantial part of energy wastage** that can be retrieved by shifting to over 80% efficiency. **Globally this represents an over €5 Trillion per year opportunity**.

In other words, the smart money is in *"disrupting the disrupters"*: instead of the would-be disruption of *"business-as-usual"* (BAU) by *"renewables"* that are bound to fail, the opportunity is in meeting the above market imperatives and changing both the BAU and *"renewables"* game. This concerns first and foremost the mining industry.

For the mining world, the aims are to provide at once sustainable energy independence at lower cost than at present, insulate the industry from the Climate Emergency and other related ecological challenges, and in doing so substantially enhance profitability.

The urgent demand for a "Something-else" technology in mining

The Geological Survey of Finland has recently released a critical strategy report that marks a turning point in the mining industry's global development.[8] Michaux, the author of this seminal work, sets the ongoing supply of the minerals and metals that are crucial to the developing world in its energy and ecological contexts. He demonstrates that the mining industry presently faces an impasse unless it very rapidly re-invents itself to address the energy and ecological challenges that have been left unheeded for too long. Given the importance of this report and the fact that it is not yet well known, we quote key aspects of its conclusion (emphasis of text is ours):

It is clear that society consumes more mineral resources each year. It is also clear ***that society does not really understand its dependency on minerals to function****. The recycling industry is still in its infancy and is only just gaining momentum. Even when fully developed, industrial recycling cannot facilitate the transformation of the industrial ecosystem as a single solution.* ***The mining of minerals*** *is not only necessary in parallel to a fully developed recycling network but* ***will be needed at an unprecedented volume to supply the construction of the post fossil fuel industrial system****. Availability of minerals could be an issue in the future, where it becomes too expensive to extract metals due to decreasing grade. Discovery of new deposits is also decreasing.*

To meet metal demand, future planning for the mining industry is based around another increase in economies of scale…. ***Future underground block cave mines would have a similar size to current open pits…*** *[however,]. the concept of a possible energy shortage or a potable water shortage was not considered.*

Mining of minerals is intimately dependent on fossil fuel-based energy supply*. A case can be made that the window of viability for the fossil fuel energy supply ecosystem has been closing for 5 to 10 years. This suggests that* ***the mining industrial operations to meet metal demand for the future are unlikely to go as planned…***

The fundamental transformation of the global ecosystem predicted by the Limits to Growth study, ***has been in progress since 2005, for the last 16 years.*** *The industrial ecosystem is in the process of transitioning from unlimited growth based economics to economics with limits/boundary conditions.* ***Until a new industrial-technological-economical system is developed to new requirements****, that transition period could be defined with contraction based economics. This will affect all sectors of the global ecosystem, all at the same time (in a 20 year window).* ***We are there now and should respond accordingly****.*

It has become clear that the evolution of the industrial ecosystem over the last few decades has been influenced by three basic trends that were conflicting with each other…:

(Trend1) The current industrial business model is one of technological development, based on the belief that there are no raw material supply limits. This meant that ***an ever increasing quantity of minerals of all kinds was required****.*

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[8] Simon P. Michaux, 2021, *The Mining of Minerals and the Limits to Growth*, Geological Survey of Finland.

(Trend 2) *As technology has developed,* ***the material purity requirements have also increased, which has driven the cost up of production. The grade of most of the raw materials being extracted has been decreasing which has also been driving the cost of production up****. Market forces and economics have been used to maintain production to meet demand. This would have continued if energy raw materials (oil, gas, and coal) were not decreasing in ERoEI quality and deposit size.* ***Now that energy resources are much more expensive compared to 50 years ago, this decreasing grade is now more problematic****. The trend of decreasing grade is something that has not been seen as an issue, as the economics can be forced to manage market forces of supply and demand.* ***The true role of energy has been misunderstood in this context****.*[9]

(Trend 3) ***The third influencing trend is the deteriorating environment*** *and the flora and fauna biosystems that inhabit it. Industrial pollution of all kinds has been observed in all sub-systems: the hydrosphere (rivers & oceans), the biosphere (flora & fauna), the atmosphere and the geosphere. The size and complexity of natural living systems has been vastly reduced on a global scale, being terraformed with industrial agriculture, cities, and industrial activities (United Nations 2005). Global human society have changed ecosystems more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, fresh water, timber, fiber, and fuel.* ***This has resulted in a substantial and largely irreversible loss in the diversity of life*** *on Earth (United Nations 2005).*

Many of the natural biogeochemical cycles are now overloaded (Cameron & Osborne 2015), nitrogen and phosphorus in particular (related to industrial agriculture production) (Steffen et al 2015… To date, the global environment has been required to absorb these impacts, with no real understanding of the implications being reflected in development of the global industrial ecosystem. The flash point for this trend will be around the production of food for the global population.

If the Limits to Growth study is truly a good model for predicting the industrial ecosystem, then the current industrial practice is inappropriate. The continued development of the economic growth paradigm would become increasingly ineffective, and a waste of valuable resources. All such efforts would be pushing in the wrong direction with poor results…

We are seeing the initial reactions to the shift in fundamentals that support our society. *It could be argued that what we are seeing is merely another cycle. A case can be made to show* ***that the supporting raw materials that make the modern world possible are now depleting and will soon not be able to meet the required demand.*** *This has serious implications for the continued method of operation of our civilization at a fundamental level…*

The rules of industrialization and the sourcing of raw materials are changing into a new era of business model. Change is happening, whether we are ready for it or not.

To transition away from fossil fuels, unprecedented volumes of minerals (battery minerals in particular) will be needed*. Demand for such minerals will spike all over the world, making them much more valuable. The existing approach to do this, which has served us well over the previous 200 years, is going to become increasingly ineffective. At a fundamental level,* ***without a cheap abundant energy source, extracting mineral resources will become increasingly expensive and as time passes, will become harder to prevent decreased production rates.*** *For the industrial ecosystem to return to how it operated when the Internal Combustion Engine technology supported infrastructure was constructed,* ***a method to develop the production of refined***

9 Simon Michaux, 2019, *Oil from a Critical Raw Material Perspective*, Geological Survey of Finland (GTK).

petroleum at a sale price of less than US$20US/barrel [is required] *(Michaux2019). As the quality of oil reserves have been declining for some time, this is highly unlikely to happen.*

Just so, it is now entirely possible that the predicted challenges presented by the Limits to Growth report (Meadows et al 1972) are now in progress, which ***will require a fundamentally different approach to the consumption of natural resources of all kinds****.*

It is recommended to give some thought to ***the development of a new system of how to extract and use minerals, fundamentally different to what is used now****…*

The logistics associated with the net Energy Returned on Energy Invested for each physical action is not considered in the Circular Economy in its current form. ***The true energy cost of the extraction (be it mining or recycling) of resources needs to be embedded into decision making****. Due to energy becoming more expensive (ERoEI), extracting, refining metals and the manufacture of products will become more difficult. As the sourcing of metals and plastics become more expensive, some form of the accounting of what resources are used, where and why is required. Conventional economics market forces will not be of use because the true cost of the whole value chain is generally not included.*

There is a clear need for a methodology and a system to manage the handling of resources and their consumption that allows for the true accounting of the energy required in a balanced form…

As it is possible global free trade may not be as easy as it is now, [and] an unprecedented [amount of] minerals and metals will be needed to transition away from fossil fuels, it is recommended that a ***European mining frontier be opened for exploration and mining operations commissioned****.* [which even more applies to Australia]

Current thinking is that European industrial businesses, will replace a complex industrial ecosystem that took more than a century to build. ***The majority of infrastructure and technology units needed to phase out fossil fuels has yet to be manufactured.*** *Recycling cannot be done on products that have yet to be manufactured. The current focus of the Circular Economy development is recycling, with the perception that mining of mineral resources is not relevant. However, the system to phase out fossil fuels (whatever that is) has yet to be constructed, and* ***this will require a historically unprecedented volume of minerals/metals/materials of all kinds.***

Very preliminary calculations show that current production rates of metals like lithium, nickel and cobalt are much lower than what will soon be required. It is equally apparent that current global reserves are also not enough. ***This will require sharp increase in the required mines to be operating in a few short years.*** *A case can be made that not only is current mineral production not high enough to supply the projected quantity demand for metals, but current global reserves are not large enough to meet long term consumption targets.*

Due to the predicted fierce international competition from large economic blocs like the United States and China, it is proposed that Europe will have to source its own raw materials from mining. A European ***mining frontier will be required to be developed, complete with the capability for refining, smelting and component manufacture.*** *[Again, this equally applies to Australia] This will require all of the geological surveys of Europe to step up to the challenge, to explore Europe for mineral deposits (most of Europe currently not surveyed below 100m). This has a number of implications, all of which are relevant in the management of resource extraction.*

1. ***Technology (like batteries for example) should be designed*** *using different mineral resources (primary and secondary). Find ways to make a viable battery using raw materials different to lithium, cobalt, and nickel.*

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2. *Instead of selecting just one technology resource stream, **all alternatives should be developed in parallel.** Projected demand is much larger than current thinking allows for.*

3. *Long term consumption targets for all raw materials need to be understood**. Full system replacement,** followed by projected consumption for the following 100 years after, for all minerals needs to be mapped.*

4. *Exploration potential and capability needs to be refenced against global reserves and projected consumption requirements.*

5. *Any raw material that might have a supply risk should be assessed for substitution options.*

6. *Those substitution options should then in turn be refenced against global reserves and projected consumption requirements.*

*The list above shows that exploration of minerals, feasibility and mining of **minerals is required, not just [to] support the construction of the new ecosystem, but to be part of the design of that ecosystem.** This should be done from the very beginning of the process. The following tasks should be considered for European Geological Survey's in particular:*

- *Minerals Intelligence is a highly relevant capability to navigate this fast-evolving minerals industry. This discipline should be developed in sophistication and scope.*
- *Development of **a holistic integration of exploration methods to a depth of 3km is now required.** This would have to be developed for a European exploration frontier. Exploration would have to be done **in a fashion, where development on the surface would not be disturbed.** To allow this to happen, a change in paradigm in the communities in Europe would be required to allow this to happen. More exploration campaigns will be required all over the world. The Nordic frontier in particular. This would have to be done by European geological surveys.*
- ***More feasibility studies will be required to be conducted (quickly)**. Geometallurgy could be seen as a support action for next generation feasibility studies. This would have to be done by European operators.*
- ***More pilot runs will be required** once the Captains of industry and senior civil servants understand there is a serious incoming mineral supply shortage. Interaction with mining companies and corporate investment houses will increase and evolve.*
- *Any mining operation planned in Europe will be required to address each and every Social License to Operate (SLO) issue seen so far, funded with legal budgets larger than most current mining corporations. **Mineral processing will be required to be more efficient than ever before, leaving behind mine tailings of reduced environmental impact compared to current practice. The next generation of mineral processing problem solving, and tailings management is required to be developed.***

In short, Michaux's work highlights the sets of double binds the mining industry is getting caught in:

- Ongoing declining quality of accessible ores and consequential substantial increases in mining costs, in particular energy costs – necessity to extend mining underground to 3km depths;
- Major increase in metals demands, quantitatively and qualitatively, in response to the necessary and rapid shift out of fossil-based energy supplies;
- Energy supply constraints dues to the unheeded depletion of accessible oil supplies that is becoming acute in net energy and energy return on energy investment terms (EROI);

- Necessity for mining to take place in carbon neutral ways with near zero ecological impacts, which requires much more energy than present mining methods; and
- Necessity for the energy used by mining to be also supplied in carbon neutral and near zero ecological impacts fashions.

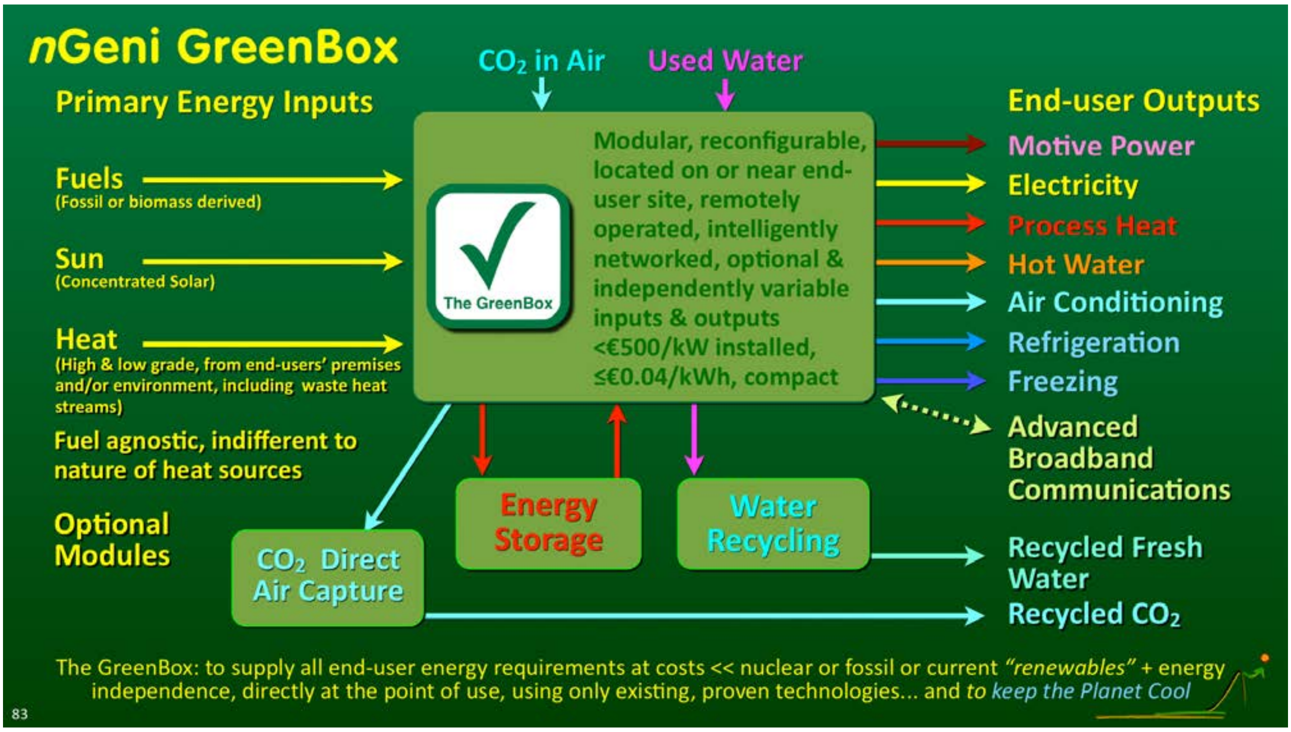
As Michaux stresses, new technology and methods are urgently required that simultaneously address the above challenges and threats. However, presently, the mining industry, in Australia and globally, is getting caught unprepared and does not have viable solutions. This situation is already more particularly acute in gold mining, an industry that is among the most energy intensive.

Addressing the above critical challenges is what the *n*Geni GEM Project is about: to demonstrate that there is a profitable way out of the above double binds and to commercialise those solutions in Australia and globally – making Australia a global mining technology *"Green and Gold"* leader.

Key Features of the *n*Geni Energy Technology Class

The core building block of the *n*Geni is the GreenBox. In the previous Section, we outlined the rationale for our strategy and the market imperatives it meets in a unique fashion. The present Section reviews the range of functionalities and key features built into the *n*Geni GreenBox to achieve at once with one piece of equipment what is presently achieved piecemeal with numerous different equipment items (Figure 3). The next Section presents the technology class principles.

Figure 3 – nGeni GreenBox functionality



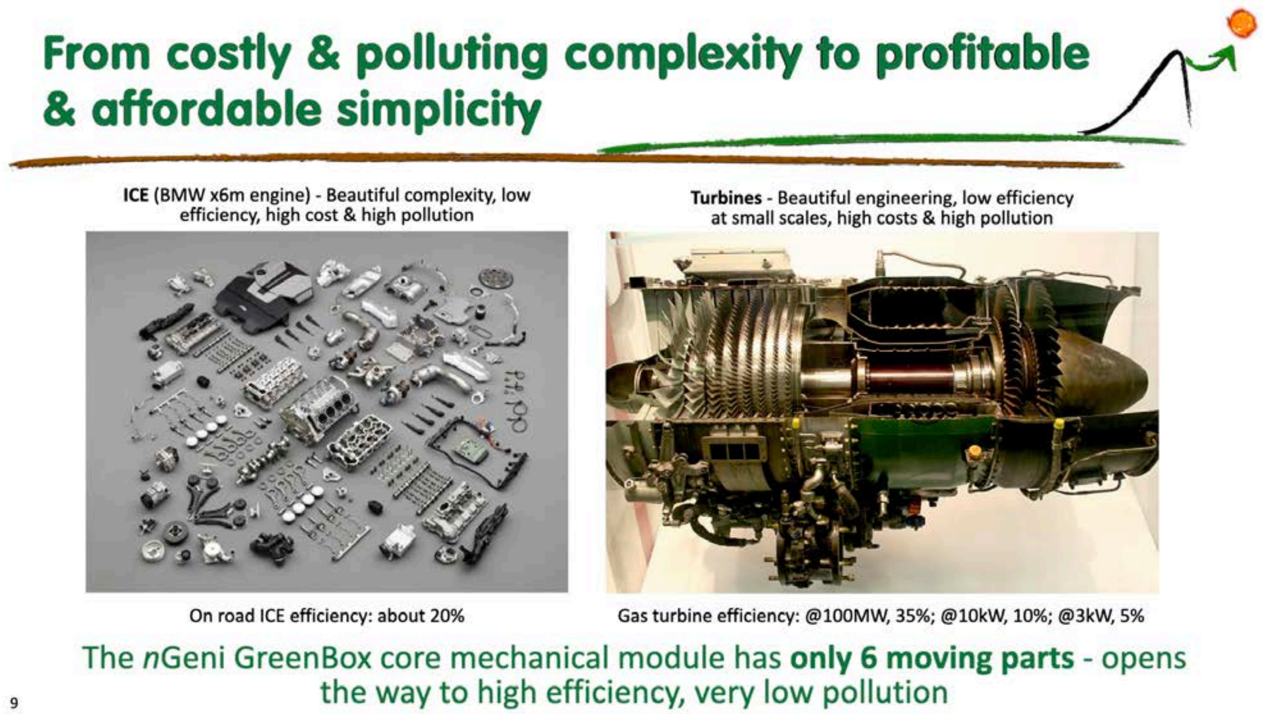
1. **High Efficiency.** The main focus of the *n*Geni technology Class is to do much more with much less in as simple ways as possible (Figure 4, page 17). The core *n*Geni GreenBox unit can achieve over 50% mechanical and electrical power generation efficiency directly at the point-of-use. Even more importantly, its design enables achieving over unity performance due to its advanced heat pump functonality. That is, leveraging modest amounts of high-grade primary energy to bring into productive use very large amounts of low-grade energy sourced in the immediate enviroment of the *n*Geni GreenBox and/or by recycling waste heat. In effect, this shifts overall efficiency from the current pathetic 12% to over 200% in most stationary applications, often over 300%, especially in mining operations.

2. **Reduced Capital Expenditure.** Owing to the simplification and substantially increased efficiency features of *n*Geni we expect capital costs of all stationary and transport applications to be substantially

lower than current costs. Furthermore, where present operations require multiple, different items of capital equipment for motive power, electricity, ventilation, cooling, procees heat, refrigeration, freezing, etc., the *n*Geni integrates this range of functionalities into the one compact, modular equipment item in ways that match the individual requirements of each end-user operations in real time – this is the core functionality illustrated on the right of Figure 3.

3. **Fuel Agnostic.** In *n*Geni GreenBoxes, fuel conversion to heat takes place in an external combustion module – the Burner. The core mechanical parts only receive heated compressed air and remain the same for all applications. In short, *n*Geni offers multi-fuel solutions that equally accept a wide range of fuels of fossil or biomass origins such as bio-oils, ethanol, methanol, alkanes, etc., or natural gas, LPG, hydrogen, etc., or low cost, proprietary, concentrated solar solution. This enables optimisation of fuel costs, geographically and through time, and facilitates a smooth transition to progressively more sustainable fuels and their integration with direct solar operation – this is the core functionality illustrated on the left of Figure 3.

Figure 4 – Keep it simple



4. **Lowered Maintenance Costs.** We expect maintenance costs to be reduced by around 50%. As noted in Figure 4, the module generating shaft power has only 6 moving parts that mostly do not touch, while only clean compressed air flows pass through the power module. The overall system is much simplified compared with ICE or turbine-based systems.

5. **Optional Hybrid Designs**. *n*Geni enables hybrid solutions (direct and / or electric motive power) and solutions integrating fuels and direct solar.

6. **Integrated Energy Supply**. Besides motive and electrical power, energy requirements of end-users are multiple and complex. As noted earlier, *n*Geni incorporates heat transformer and heat pump

functionality enabling sourcing energy from the immediate environment of each GreenBox as well as waste heat recovery from end-use processes. This includes, for example, recovering excess ambient heat down underground mining operations and using it for cooling and other uses.

More broadly this GreenBox functionality enables supplying the various heat flows any end-user may require (hot water, air conditioning, process heat, refrigeration and / or freezing) and varying these flows largely independently from one another to match user requirements in real time. This functionality enables reaching over unity energy efficiencies beyond the reach of other approaches. These features gave this new energy technology class its *n*Geni name: it can generate any number *n* of energy flows to meet user demand. As noted above (item 2), this integration translates into **substantial reduction of total capital costs since one compact, high efficiency piece of equipment can substitute for a large number of separate units** each generating their own energy output and requiring extra energy for their operation.

7. **Drastically Reduced Pollution.** The use of external combustion enables a substantially better control of combustion compared with internal combustion systems (ICE or gas turbines) resulting in a drastic reduction of particulates, NOx, and other pollutants. Furthermore, the major energy efficiency improvements also translate into a substantial reduction of greenhouse gas emissions (GHGs) – recall our motto: doing 10 times more with 10 times less.

8. **Flat Efficiency and Torque Curve.** A particular feature of *n*Geni, compared with ICEs and turbines, is the flat efficiency and torque curves over a large range of rpms (while ICEs and turbines present a distinct peak at a specific rpm). This translates into additional fuel use and gearing costs reductions (only the fuel required for a given power requirement is burnt). This means that *n*Geni GreenBox motorisation solutions do not have a fixed power rating but a power range extending from low to high rpms. Their nominal power rating corresponds approximately to the middle of that range at the level of the slight efficiency peak.

9. **Retrofitting Existing Installations.** The modular character of *n*Geni GreenBox solutions means that they can be fitted into existing spaces very flexibly (there is no single engine block). The character of the Climate Emergency, combined with rapidly increasing pressure on fuel supplies mean that there Is not enough time left for stationary installations or transport fleet renewal through attrition, decommissioning, dismantling or rebuilding. **Retrofitting has become a necessary strategy** in addition to new developments. We do not know of any other technology solution that offers more ease, flexibility and affordability prospects. Concerning new buildings or transport developments, this modularity also allows great flexibility in adapting to any architecture for optimal use of available space.

10. **Direct Air capture of CO_2 from atmosphere (DAC) and CO_2 capture (CC) from exhaust gases.** The GreenBoxes are being designed to incorporate optional DAC and CC modules. Since *n*Geni GreenBoxes *"breathe"* air as part of their operation, using their residual waste heat to operate DACs and CC modules to extract CO_2 from both the atmosphere and combustion gases is a logical extension. The aim is to produce liquefied CO_2 as a commercial by-product and benefit as well from eventual carbon credits. CO_2 markets are expected to increase rapidly under Climate Emergency responses. We expand on this strategically key feature in **nGeni *mass carbon recycling***, page 27.

11. **Substantial reductions in energy requirements of fuel production.** *n*Geni GreenBoxes being fuel agnostic thanks to the use of external combustion, there is no longer a requirement to fuel *n*Geni stationary or mobility GreenBoxes with refined fuels such as diesel, gasoline, or biodiesel, for example. That is, so long as pollutants such as heavy metals or sulphur are removed, just about any lightly processed fuel can be used. This means that lightly refined fuels could be used directly as transport or

operating fuels, thus reducing further energy requirements and losses at the refinery stage. We estimate a potential reduction of energy costs by over 60% along oil or biomass energy supply chains.

Combining this approach with the above DAC and CC potential the prospect is to enable the ongoing use of oil-derived high energy density molecules in a carbon neutral way and extending the life of remaining oil reserves by some 20 years. Furthermore, the concentrated solar version of *n*Geni potentially enables the complete re-engineering of the oil supply chain to render it 100% solar self-powered and carbon neutral, as we outline further in **nGeni *mass carbon recycling***, page 27.

For the mining industry, this means a substantial potential reduction of energy costs and achieving energy independence in accelerated fashion, through sourcing near crude oil or bio-oils directly, by-passing most of the refining stages.

12. **Networked Ecological and Energy Transition.** The *n*Geni Technology Class incorporates a unique energy and communications networking architecture component, the *n*S.O. The integration of *n*Geni GreenBoxes through *n*Geni *n*S.O. enables forming Intelligent Energy and Communications Networks (IECNs) and eventually integrate them into a new ***Cool Planet* Internet of Energy** providing safe, secure, affordable energy while drawing down CO_2 from the atmosphere back to viable levels.

That is, the full *n*Geni provides the means to catalyse the Fourth Transition, i.e., an accelerated and smooth transition, at modest costs, towards sustainable ways, eventually on 100% solar energy bases, once high efficiency, solar-based *n*Geni energy and fuel supply chains have been deployed. We expand on this prospect in the next Section re the fundamental *n*Geni Principles, page 20, and in the **nGeni *mass carbon recycling*** Section, page 27.

For substantial mining operations, this means that a number of GreenBoxes can be distributed at optimal locations on a large site and networked to be operated as a virtual power station for further energy efficiency gains and cost reductions.

The above *n*Geni features enable meeting all the market imperatives reviewed earlier (page 10).

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*n*Geni Technology Class: key principles

The *n*Geni technology class is based on an innovative adaptation of the Brayton-Ericsson cycle, integrated with heat pump functionality. We stress **integrated** and not added. The power generation and heat pump functionalities are not separate. They form an integrated whole. This is core to our patents. The Brayton-Ericsson cycle is implemented in recuperated fashion, preferably with indirect heating, where the compression and expansion stages do not use piston machines or turbines.

The *n*Geni incorporates 5 key principles:

1. **Cascade Free Energy Flows** at the point-of-use to maximise the recycling of waste heat, using advanced, novel heat pump functionality – enables over 80% overall energy efficiency in waste heat recycling mode and over 200% performance when sourcing low-grade energy from the ambient environment of the GreenBox (and often over 300%) – already proven;
2. **Use a variant of the Brayton-Ericsson thermodynamic** cycle for high efficiency at above 850°C and preferably above 1100°C – enables reaching over 50% mechanical and/or electrical efficiency (eventually in the order of 70%) – already proven;
3. **Use external combustion** for efficient combustion, very low emissions, low wear of mechanical parts and efficient recycling of air and heat flows – already proven;
4. **Shift to advanced positive displacement machines (PDM)** instead of Internal Combustion Engines (ICE) or turbines for higher efficiency, lower equipment, operating and maintenance costs – already proven
5. **Intelligently Network both energy and communications** between point-of-use generation units: autopoietic, layered, fractal mesh network architecture – already proven.

Figure 5 to Figure 8 below summarise the key principles and facets of the technology.

Figure 5 – Cascade Energy Flows

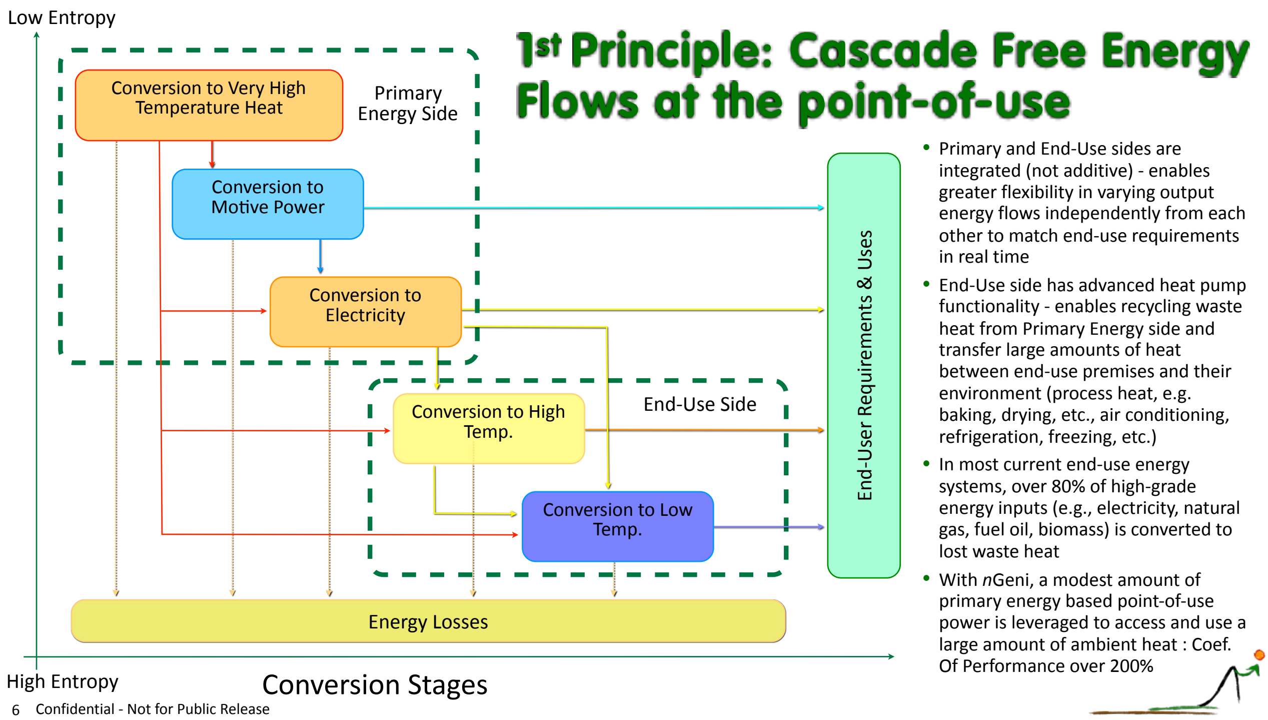

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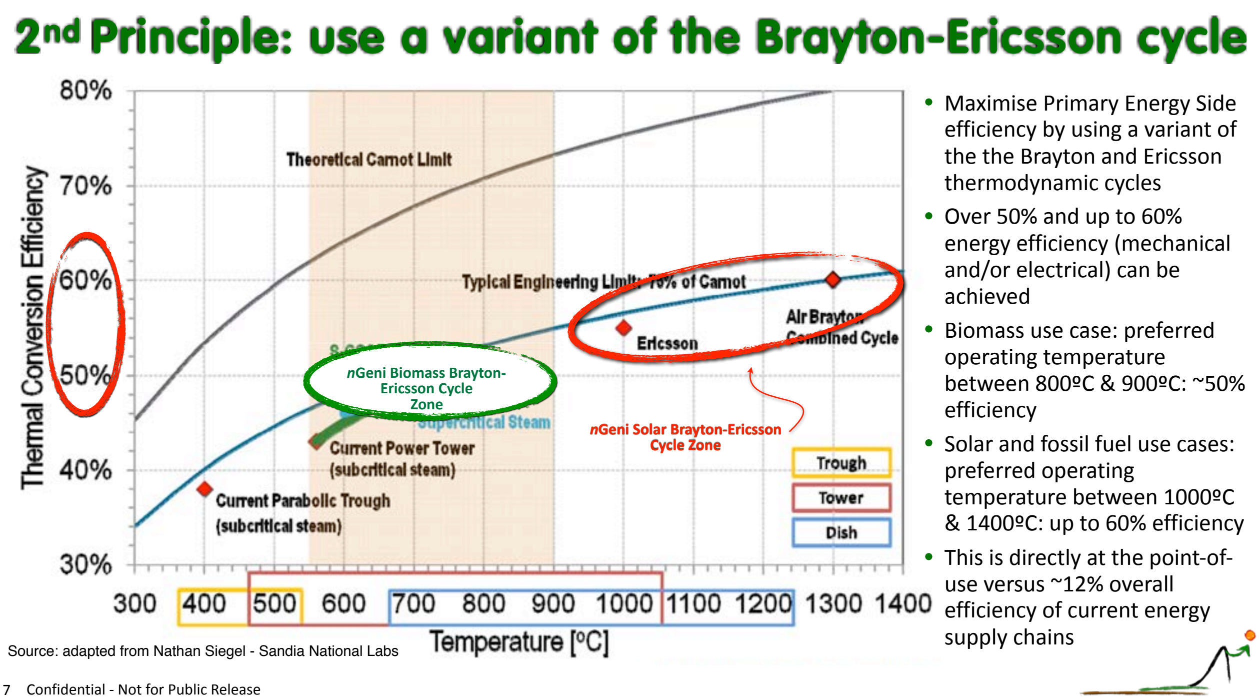
Figure 5 presents the overall integration of the technology components, highlighting the energy cascading of the system's architecture.

It is this cascading that enables the integration of the Brayton-based Primary Energy Side with the heat pump functionality of the End-Use Side.

A key rationale for this is that most of our energy requirements on farms, in industry, in commerce and at home are for low-grade energy. That is, some 90% of all energy uses are for low-grade heat (typically below 250ºC) at power ratings below 1MW. We require only modest amounts of high-grade. All of the low-grade energy can be sourced in the local environment (where it is free), using only a modest amount of high-grade energy in the process (the latter preferably solar sourced through proprietary concentrated solar technology – the solar influx is also free).

Figure 6 shows the operating efficiencies enabled by a Brayton or Ericsson cycles operated with air as the working fluid.

Figure 6 – Choose the most appropriate cycle

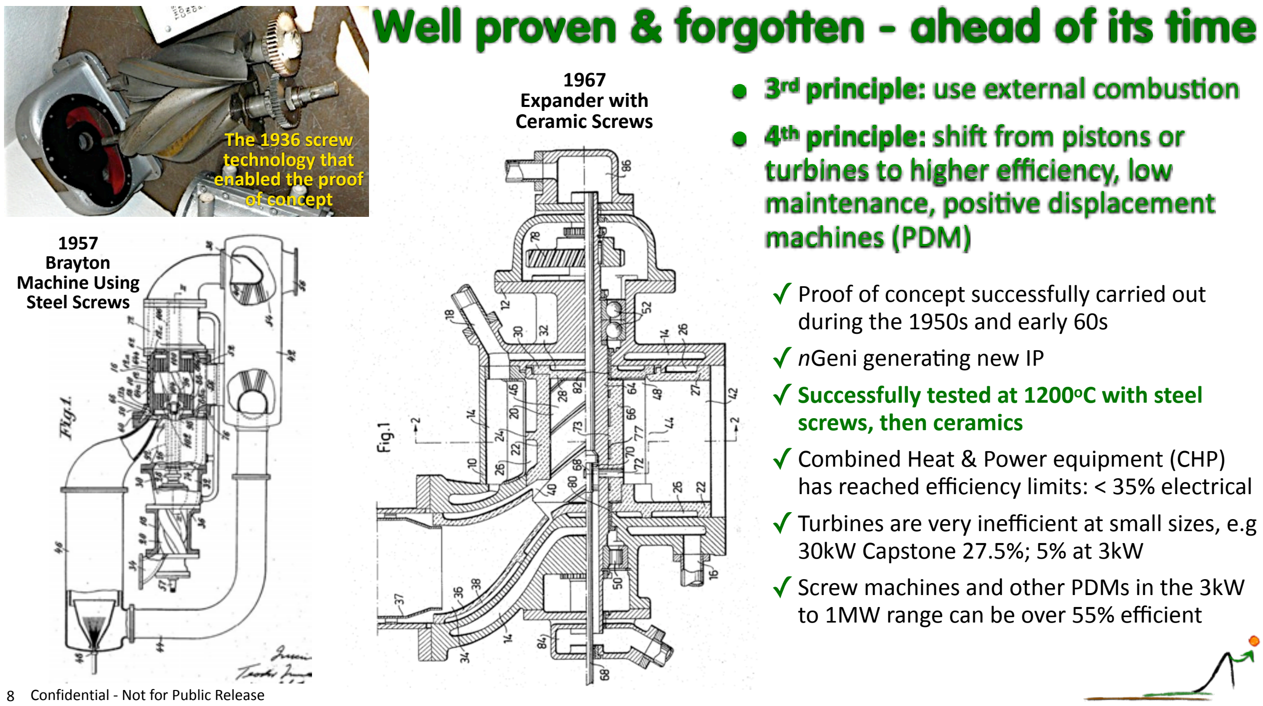


This diagram was originally produced to show the potential high efficiencies of concentrated solar systems operated at high temperatures using gas turbines, and air or CO_2 at pressures in the order of 200 bar or even higher. Such installation would inherently be large, multiples of 10MW, and expensive. As we show below, we have found how to implement a variant of a Brayton-Ericsson cycle at substantially smaller sizes, at pressures of 3 to 4 bar, using positive displacement machine (PDMs) instead of gas turbines.

This solution enables achieving the 60% energy efficiency potential at the shaft in much smaller power units located at or near the point of use, matching end-user requirements in industrial, agricultural, commercial, and residential settings, thus enabling the recycling of waste heat and the capture of large amounts of ambient low-grade energy through heat pump functionality, thus meeting on site end-user requirements for medium to freezing temperature heat streams. We are confident that this 60% potential can be achieved through a short series of development stages. These high efficiencies concern the primary energy conversion (top left corner of Figure 5). In addition to these efficiency levels, further efficiency gains result from the other features of the integrated *n*Geni.

Figure 7 presents the preferred type of PDMs.

Figure 7 – Select the most appropriate conversion from heat to mechanical power



Both ICEs and turbines have high costs of capital expenditure, operation and maintenance, with high part counts, and low thermodynamic efficiencies, especially at lower power ratings used in point-of-use applications, such as on mining sites (compared with central power stations in the multiples of 100MW).

Screw PDMs have low part counts (each module has only 6 moving parts) and very low friction combined with high efficiency potential when used in a Brayton-Ericsson configuration as shown in Figure 6. They were successfully demonstrated in the 1950 and 1960s but remained an engineering curiosity, soon forgotten. At the time, in the post WWII accelerated growth period, the focus was on *"the bigger, the better"* for power generation and the intensive use of oil for transport. The application of screw PDMs was ahead of its time.

Since then, screw PDM expanders have become extensively used commercially in waste heat recovery for power generation (at medium temperatures) – a limited market niche. They have also been retested experimentally at high temperature b but in settings substantially restricting their overall efficiency potential. We are bringing this undervalued technology into the 21st century, adding our own patented IP to it, to enable its use at high temperature for all forms of transport and, in stationary mode, for point-of-use, very high efficiency power generation.

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Figure 8 presents in summary fashion the integration of the Primary Energy Side of the *n*Geni GreenBox. The heat transformer and heat pump functionalities are not shown, nor is the DAC functionality. The full system is commercially sensitive and IP protected.

Figure 8 – Integrate heat pump functionality for maximum efficiency with minimum emissions and costs

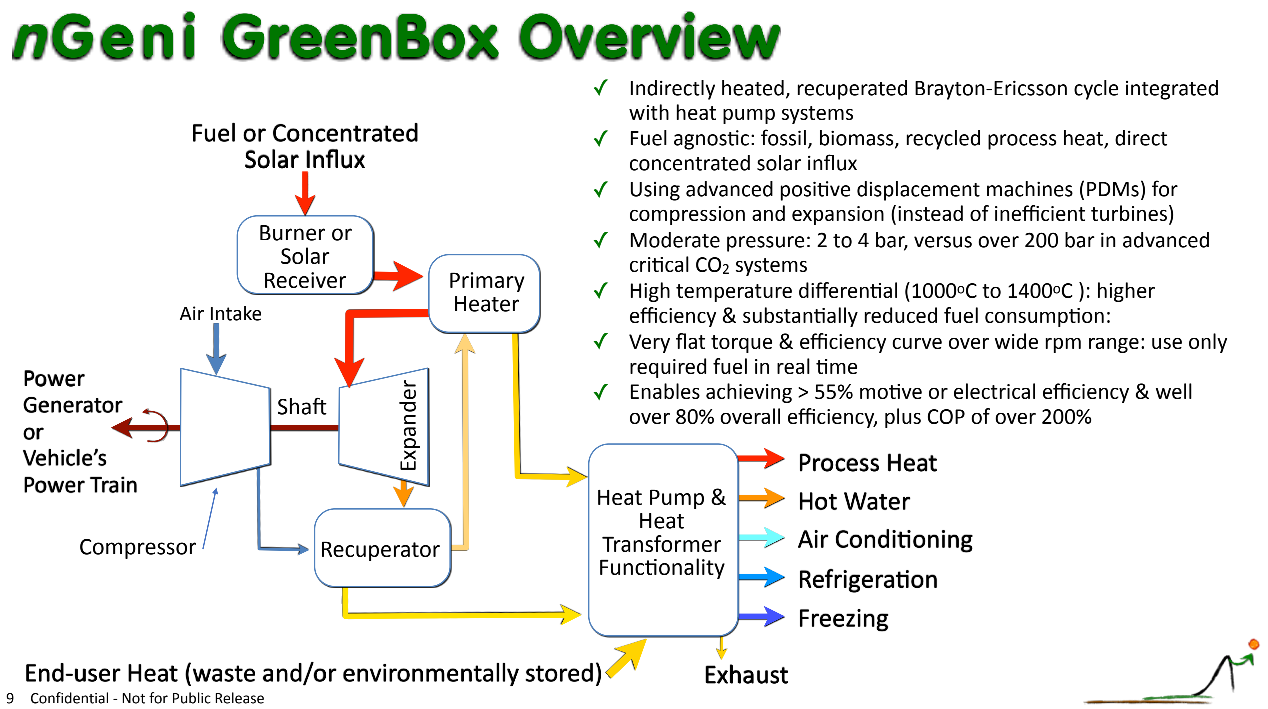


Figure 9 – Technical illustration

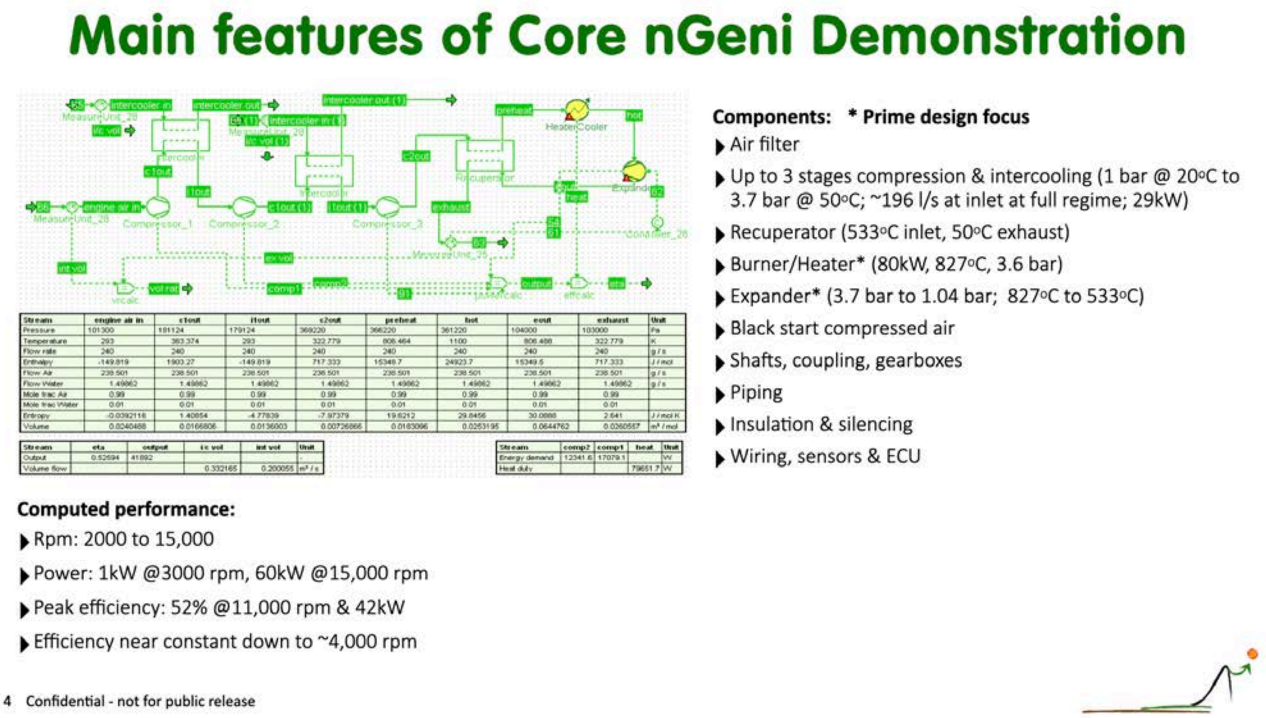


Figure 9 illustrates the main features presented above for a small-scale demonstration of the Primary Energy Side of an *n*Geni GreenBox. Note:

- The wide rpm range – 2,000 to 15,000 rpm;
- Peak efficiency of 52% at 11,000 rpm in this particular configuration and operating temperature (827°C);
- Efficiency near constant over the 4,000-15,000 rpm range;
- Power range extending from 1kW (about 1.3 Hp) at 3,000 rpm to 60kW at 15,000 rpm (i.e., about 80.5 Hp).

One of the merits of *n*Geni is that, due to its modular character and the characteristics of the positive displacement machines used, GreenBoxes are readily scalable to a wide range of power sizes up to multiples of Megawatts. We can consider, for example, a motorisation using an ICE engine power rating in the 500-600Hp range in terms of fuel consumption, translating into 180Hp up to a maximum of 240Hp at the shaft depending on operation regimes.

In the case of a corresponding *n*Geni solution the maximum power requirement at the fuel input would be in the order of 300Hp to 400Hp, that is, from around about 66% to half the current motorisation requirements. The required system would scale about 3.7 to 5 times the above example in Figure 9. We estimate that the total weight of the *n*Geni solution would be in the order of 30% of the weight of a standard Diesel motorisation.

As stressed in introduction, the details of GreenBoxes are commercially sensitive. Further detail will be provided under NDA.

The fifth key principle is Intelligent Networking. *n*Geni technology class incorporates intelligent networking for both broadband communications and energy.

At first, this may appear a secondary feature in the context of mining. In fact, the intelligent networking functionality of *n*Geni substantially enhances its efficiency and positively impacts on the bottom-line performance of a mining operation. The huge advantage of *n*Geni is to access and use energy highly efficiently directly at the point-of-use. For maximum efficiency, this does not merely mean a mine site. When we say point-of-use, we mean it. On a substantial mining operation, there can be over one hundred points-of-use, some stationary and others mobile, including very large machinery. Networking all of these points presents numerous advantages in terms of remote management of the GreenBoxes, their maintenance, balancing energy requirement between networked GreenBoxes, managing local energy and other networks (e.g., gas, water, managing underground air circulation and CO_2 capture and recycling (see next Section) and above all maximising efficiency – all factors impinging positively on the bottom-line. This is why the complement of the *n*Geni GreenBox is the *n*Geni *n*S.O., the networking component of the *n*Geni Technology Class.

The networking functionality is also an advantage re project permitting. The networking features of *n*Geni offer the prospect of bringing sustainable energy independence and advanced communications to local communities around a project, within for example, a 50km radius and more as required (e.g., farms, local businesses and residents, schools, health centres, etc.). Such communities are often remote and poorly supplied. This eventually may include transport fuels and closing the carbon loop as we discuss in the next Section.

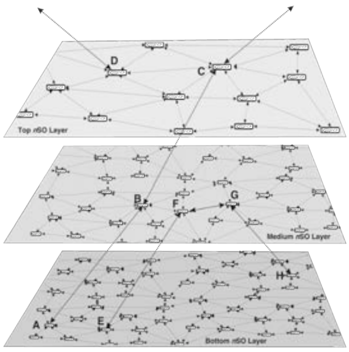
Given the commercially sensitive nature of the *n*S.O. functionality, we can only provide a broad high-level outline in this White Paper. Further detail will be provided under NDA. As summarised in Figure 10 and Figure 11, the *n*S.O. is a fractal, layered mesh network architecture creating a resilient *"small world"* for efficient communications and energy networking. Current networking involves shared bandwidth and capacity to supply. The more demand per node in any given area the less is available per node, i.e., per point-of-use. In the *n*S.O. the more nodes point-of-use per square kilometre the more aggregate bandwidth and thus the ability to guarantee supply to each point-of-use regardless of the overall load on the IECN. The extended capabilities of the GreenBoxes, *n*S.O. integrated, codependently arise with each other and with the whole network. This unique and revolutionary feature enables the build-up of advanced Intelligent Energy and Communications Networks (IECNs) integrating stationary and transport GreenBoxes at any scale, from a single mining operation, to nation-wide operations and beyond.

Figure 10 – Intelligent Networking

*n*S.O. Intelligent Energy & Communications Networks (IECNs)

The challenges:

- *"'Juice' requires bandwidth & bandwidth requires 'juice'":* non-dualistic logic missed by most developers
- Present large-scale comms networks are of the shared bandwidth type: the greater the number of users, the less bandwidth per node - Internet < 50% below its initial logistic growth curve: lacks appropriate infrastructure, current infrastructure very expensive and inefficient
- ICT networking (& IoT) → > 50% global electricity supply by 2030: impossibility → demand for *"something else"*



***n*S.O. IECNs, mostly wireless, cost ~1/10 of legacies - Key Features:**

- **Local data traffic:** if data traffic is sufficiently local, aggregate capacity grows more than proportionally to the number of nodes (Tim Shepard, 1995)
- **Must minimise number of hops** between any 2 nodes, preferably < 4 hops
- **Features & characteristics of *"small world"* networks** (Watts & Strogatz, 1998, Watts 2003)
- **Solution: fractal layered mesh network architecture meets Shepard's & small world requirements:**
  - ~20% of a link capacity available to each node (& thus users at that node)
  - Traffic engineering of data packet transfers and caching to minimise cost of ICT networking beyond interconnect points
- **Autopoietic:** self organising, operating, managing, & healing - **Highly scalable** to over 1 million nodes/ km^2,
  - Very low latency - Symmetrical up and download speeds - No shared bandwidth
  - Multiplicity of independent parallel uses, highly secure
  - Low costs to deploy, operate and maintain
  - **Test trialled, no known equivalent**

- **Energy networking:** ditto fractal architecture with finely distributed energy storage
- **Non-hierarchical, non-centralised** operations, Blockchain-based (or equivalent)
- ***n*S.O. IECNs function as a bank** - participants deposit or withdraw energy, information & funds
- **Long distance transfers are minimised** to what's required to balance surpluses or deficits
- **Most exchanges take place locally** → substantial reduction in cost of long distance network upgrades
- **Existing networks** (e.g. power, gas, water) can be progressively recycled and integrated

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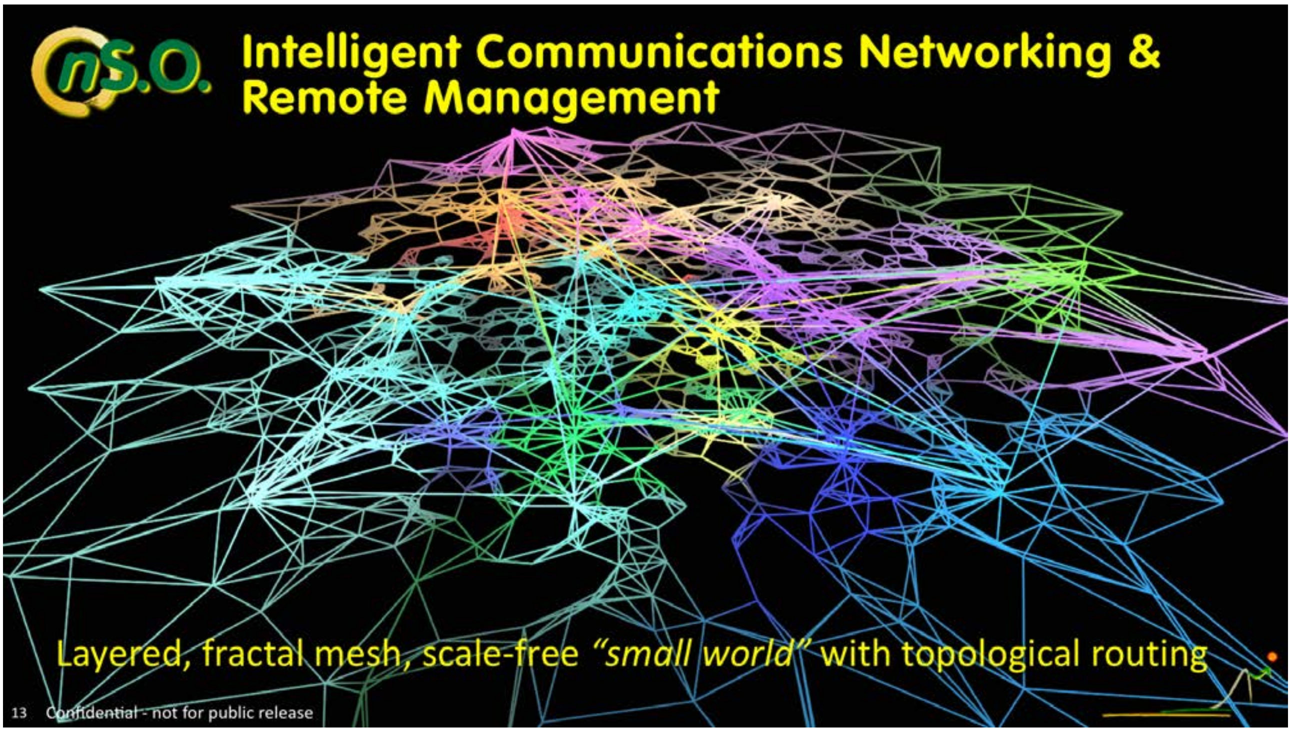
Figure 11 – Intelligent Networking



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*n*Geni mass carbon recycling – why and how?

Mass retrieving CO_2 from the atmosphere and from exhaust gases is becoming an essential component of all energy intensive industries' ongoing operations and development. It is even likely to become compulsory in the near future, a daunting prospect for the mining industry.

To date, only the most lucid players in the mining industry have seen the strategic importance of mass CO_2 capture. Few have anticipated the first mover advantages it presents in a world where drawing down CO_2 has become an urgent necessity. In all energy intensive industrial operations where the price of carbon has to be factored in, this can be either a significant cost factor impinging negatively on the bottom-line or, for those who can capture CO_2 competitively, a source of added profits.

Mass CO_2 capture of is already being implemented in a number of oil and gas extraction operations (e.g., in the USA) and is also considered concerning some large mining operations. However, none of the schemes currently implemented or under development can viably scale beyond exceptional situations and none can match what *n*Geni can achieve on a routine, industry wide basis. **This is all the more strategically important concerning permitting for new gold mining operations and securing energy supply independence.** Mass CO_2 capture offers also the prospect of further improved bottom-line thanks to the commercialisation of liquefied CO_2 and/or securing tradable carbon credits.

Understand the problems

We have stressed earlier the sheer necessity in response to the Climate Emergency to extract CO_2 from the atmosphere and from exhaust gases to store it safely and/or recycle it in a wide range of industrial uses (direct air capture from the atmosphere, DAC, and carbon capture, use and sequestration, CCUS, from exhausts). All current technologies present severe limitations and cannot scale to the magnitude of the problem. They all face one or more of the following challenges:

- ❒ **Stand-alone facilities dependent on a separate energy source.** In some cases, individual implementations can benefit from the use of waste heat and/or power from a power generation plant. However, this dependence considerably limits the scalability of these approaches.
- ❒ **Footprint and equipment requirements versus economies of scale.** Some of the approaches, e.g., using chemical solvents, are potentially viable only at large scale, again limiting the number of potential sites close enough to a source of power.
- ❒ **Dependence on sourcing materials with limited supplies.** This is the case, for example, of some metal-organic frameworks.
- ❒ **High energy requirements** that translate into still prohibitively high production costs. This means that only a limited number of projects can expect to at least financially break even, e.g., through integration with enhanced oil recovery, high added value food production, etc.
- ❒ **Focus on CO_2 as the product of a single purpose process** – this is the single problem-single solution syndrome encountered numerous times earlier and that prevents addressing effectively the Climate Emergency and the avalanche of related energy, ecological, social and financial threats.

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➔ Build a Solution

The *n*Geni Technology Class enables addressing the above challenges creatively. Concerning the CO_2 capture methods, *n*Geni focuses on non-solvent approaches (lower energy, material and footprint requirements). We are not wedded to any single solution, although for most applications we have a preference for compact modules using ion-exchange resins. In this respect, we do not seek to *"reinvent the wheel"*. Instead, we focus on making use of the most cost-effective means in modular fashion so as to enable mass deployment of DAC and CCUS functionalities.

The *n*Geni approach integrates the following elements:

- **CO_2 as a by-product of a multi-purpose system.** Instead of the single problem-single solution syndrome of current DACs and CCs, the *n*Geni DAC and CC modules are integrated in multi-streams energy supply facilities, the GreenBoxes (i.e., motive power, electricity, high, medium, low temperature process heat, air conditioning, refrigeration and freezing as required specifically by end-users). As highlighted earlier, Item 10, page 18, since *n*Geni GreenBoxes *"breathe"* air as part of their ongoing operation, integrating a DAC facility is a logical move. The CO_2 harvested is only a by-product whose production benefits from synergies with the main services rendered by the point-of-use *n*Geni GreenBoxes.

- **Access to low-cost process power.** Most GreenBoxes are intended to incorporate low-cost energy storage to buffer fluctuations between primary energy supplies and end-users' requirements. In most instances, end-user requirements vary substantially throughout the day, from week to week and seasonally. The DAC and optionally CC functionalities act as complements to the energy storage buffering. On an ongoing basis, they use low-cost baseload power for their operations. They can be reduced or even interrupted in case of peak end-user energy demands. Alternatively, they can power up when end-user energy requirements are low.

- **Maximising waste heat recycling.** A defining feature of *n*Geni is cascading energy from low to high entropy levels (Item 1, page 20). The sorption-desorption processes we focus on require low temperature heat flows that correspond well to the residual waste heat available at the tail end of the energy cascading, i.e., the air outflows from GreenBoxes. We can therefore make use of extremely low-cost energy directly at the point-of-use to generate an increasingly valuable by-product and thus maximise the overall energy efficiency of the GreenBoxes. This and the above low-cost process power contrast favourably with the dependence of current DACs and CCs on costly external energy sources and their high energy requirements.

- **Low footprints and equipment requirements.** We have noted that an important feature of the *n*Geni is to substitute for multiple pieces of equipment. For example, a supermarket requires electricity for lighting, computing, air-conditioning, plus specific air-conditioning equipment, plus further equipment for refrigeration, freezing, baking, and so on. Similarly, a mining operation requires motive power, electricity, ventilation, air-conditioning, and the above requirement for personnel's living quarters. GreenBoxes substitute for this capital expensive multiplicity, translating into substantial capital expenditure and maintenance costs reductions. This substitution potential applies as well to the energy flow requirements of DAC and CC modules (electricity, motive power, e.g., for compressors, heat flows). Some of the current approaches, e.g., using chemical solvents, are potentially viable only at large scale, again limiting the number of potential sites. Instead, the *n*Geni solution can be deployed in distributed fashion at any scale, thus transforming a costly climate problem into an additional source of profitable revenue.

- **No dependence on sourcing materials with limited supplies.** Our focus is on rugged systems minimising exotic material requirements (such as rare earths, Li, etc.) and on maximising materials recycling throughout the life cycles of GreenBoxes.

- **Low overall energy requirements.** The above features translate into much lower energy requirements than current DACs and CCUSs. That is, the ability for the by-product CO_2 streams to more than cover the cost of CO_2 extraction and processing.

- **Leveraging *n*S.O. Intelligent Energy and Communications Networking (IECNs).** A feature of the *n*Geni highlighted in the previous Section (page 25), is its IECN capability based on the *n*S.O. mesh network architecture. This feature enables energy trading and balancing energy requirements between networked GreenBoxes. In effect, *n*S.O.-networked GreenBoxes equate to a finely distributed power generation system that recycles the waste heat that otherwise would be lost in a central power station. The broadband communications part of the *n*S.O. mesh networking enables the intelligent remote management of the GreenBoxes and the balancing of local grid, of other energy networks (e.g., natural and/or bio gas) and of water networks. Surplus broadband communication capacity is provided to the end-users. This set of features enables further improving the overall energy efficiency of the networked GreenBoxes and optimising the DAC and CC functionalities. It also enables the reliable accounting and trading of the harvested CO_2.

- **Ability to scale to very high levels of deployment.** The *n*Geni features, once GreenBoxes are mass manufactured and deployed, enable energy supply at very low costs. The Fourth Transition Initiative's business model leverages this for rapid market uptake globally, i.e., going viral (detail will be supplied to interested parties).

  The overall aim is to fill in the present market vacuum for sustainable, affordable, secure, energy supplies for both stationary and transport uses. That is, substituting 90% of the current approximately 19TW of installed power over a 20-year period. The prospect is thus to fit most of stationary GreenBox implementations and most large transport vehicles (trucks, railway trains, marine shipping) with DAC and CC modules. The overall potential is in billions of units, providing the bases for successfully bringing down CO_2 levels below 350ppm while retaining the use of high energy density molecules.

The above range of integrated features stands to benefit greatly energy intensive industries such as mining operations and do so well beyond the strict confines of their operations on individual mining sites.

nGeni's mass carbon recycling potential

Up to this point, we have highlighted how, given their high energy intensity as well as their dependence on fossil-based transport fuels, on site, on land and for global ore and coal shipments, implementing mass carbon recycling has become of the utmost strategic importance for all existing mining operations and for new projects. We must now go further. **The new imperative, concerning permitting new projects, and especially winning permits for new gold mining operations, is to demonstrate an ability to fully close the carbon loop,** that is, at least capturing all the CO_2 emitted by mining operations and preferably capturing more than what has been emitted, and recycling it commercially. Yet, bar exceptional cases, the industry is not in a position to abide by this new imperative – **hence the critical first mover advantages for whoever may achieve this**.

Figure 12 and Figure 13 outline the general principles of *n*Geni closing the carbon loop in accelerated fashion and its game changer potential in transforming what is presently a stumbling block into a new source of added profits, giving mining technology users an absolute competitive advantage. With concentrated Solar *n*Geni GreenBoxes deployed over the whole oil-based fuel supply chain at all stationary points and in all vehicles along the chain all the way to end-users, the outcome is a substantial reduction in the supply chain's and end-user energy costs as well as massive GHG emission reductions.

Figure 12 – Closing the loop in accelerated fashion

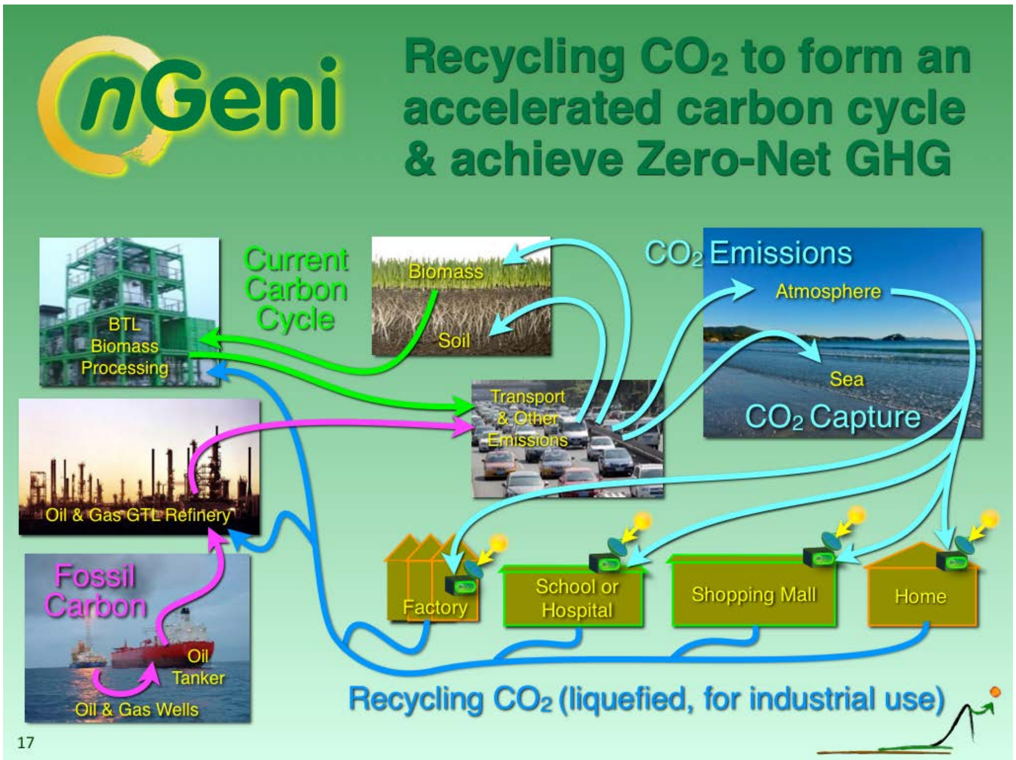
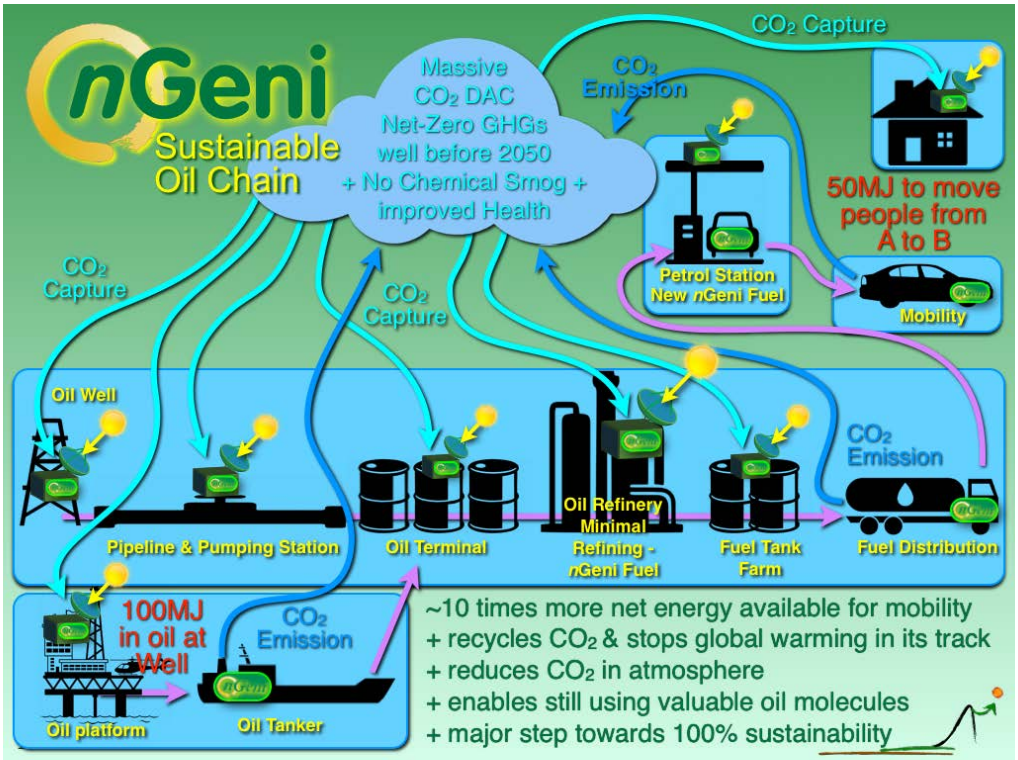


Figure 13 – Potential nGeni transport supply chain



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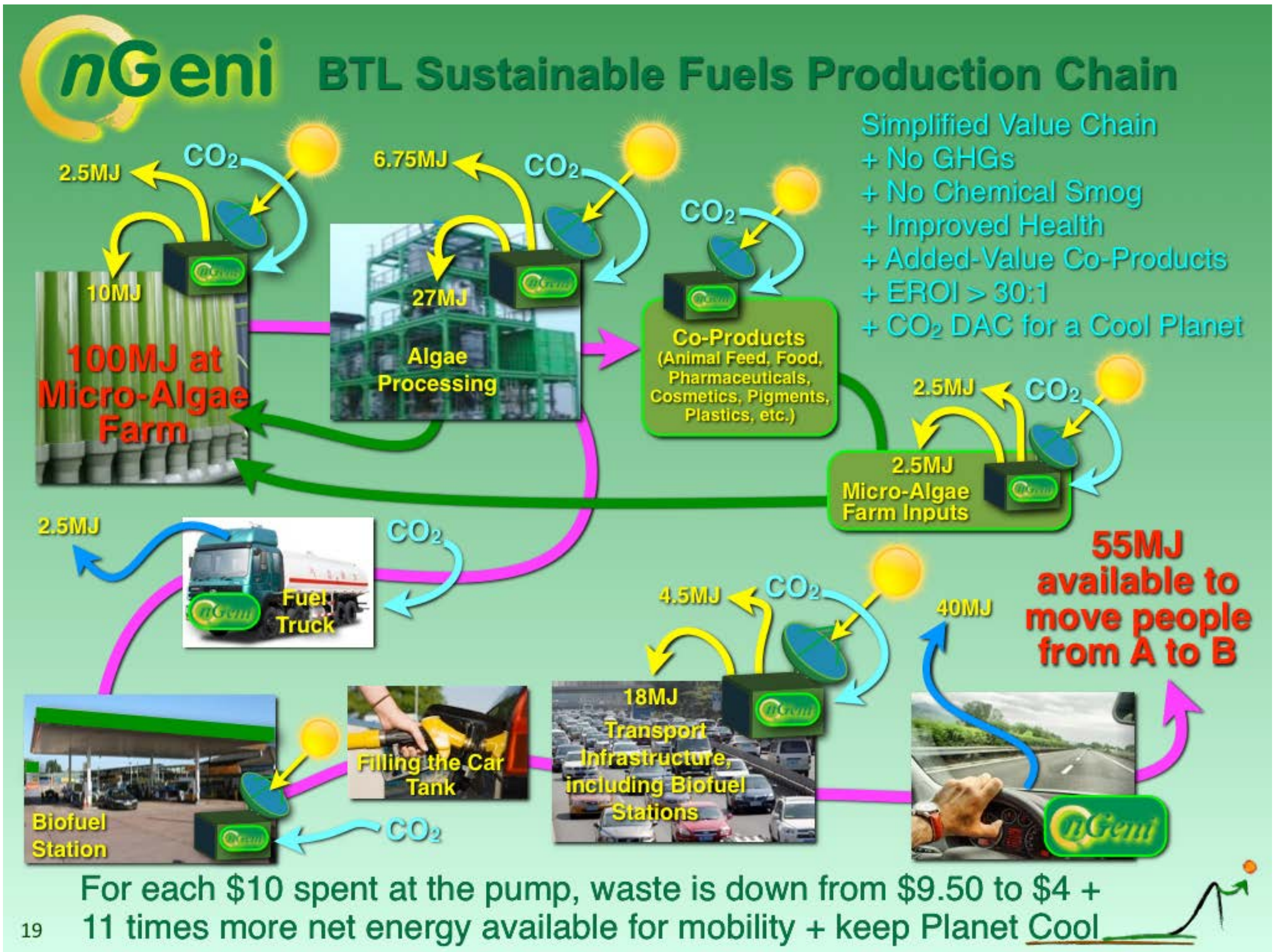
As shown in Figure 14, the absolute competitive advantages of fully closing the carbon loop extend all the way to the competitive development of micro-algae-based biofuels.

Figure 14 – Closing the loop Biomass-wise



In all cases, with fossil or biomass feedstocks, solar energy input means that fundamentally the **oil is extracted and used only in order to ensure the ongoing use of high energy density molecules as a form of concentrated energy storage**.

At present the oil industry is no longer able to supply any net energy from oil in a self-powered manner. In fact, along with other researchers, we estimate that the present well-to-wheel efficiency of transport is in the order of 5%. Instead, the deployment of concentrated Solar *n*Geni GreenBoxes re-instates the self-powered status of the chain as **a *"solar-augmented"* oil supply chain,** while increasing the efficiency of the whole transport chains by a factor of 10 and simultaneously making the re-engineered chain carbon neutral.

The prospect for mining is thus to retain access to valuable, high energy density oil-derived molecules regardless of the Climate Emergency for all forms of transport, to win absolute competitive advantage for permitting new projects, to win sustainable energy supply independence, to substantially improve the bottom-line for existing and new projects, and to make a smooth eventual transition beyond fossil fuels feasible, rendering the whole of transport operations 100% sustainable in accelerated fashion.

*n*Geni GEM Potential for the mining world

Figure 15 – Power generation and transport paradigm change

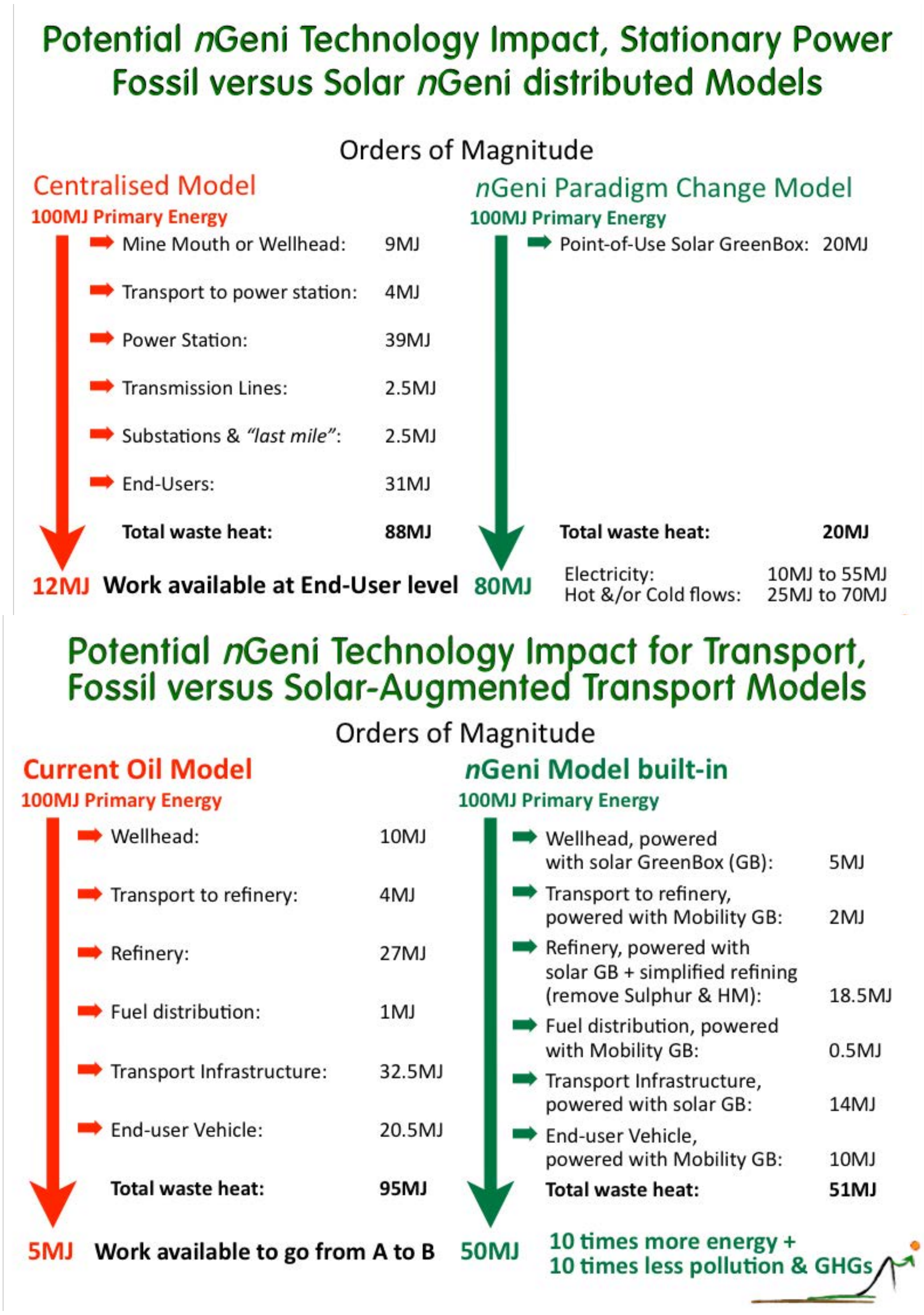


Figure 15, concerning both stationary power generation (top part) and transport (bottom part), highlights in striking fashion the contrast between the present highly inefficient status quo and the paradigm change introduced by *n*Geni. Both parts of Figure 15 show the feasibility of retrieving a significant part of energy currently lost as waste heat and put it to productive use thus resulting in a substantial reduction in primary energy requirements and/or alternatively achieving much more with current levels of primary energy use. The benefit is further highlighted in the case of the solar application where low cost, solar-based energy can be used to access high energy density molecules from oil in sustainable ways as highlighted earlier in the context of the **nGeni *mass carbon recycling*** Section, page 27.

Let's now consider the above prospects in the cases of typical gold or industrial metals underground mining operations rated at, say, 1million t/year:

Total of 10MW diesel gensets, with at least 500kW backup for maintenance and emergencies, operating:

- Mine:
  - Surface fans (1 to 1.5MW per fan) and AC ducting for down the mine ventilation, underground fans, typically a twin 90kW fan per level – ventilation is typically 42% of actual mine energy use (excluding mill and other surface operations), 0.5m^3/kW of diesel power;
  - Chillers to cool underground operations – typically 300kW;
  - Drilling operations – typically 9% of mine energy use;
  - Other underground operations (blasting, crushing, backfilling, mucking, dewatering, transport underground, underground support) – typically 29% of mine energy use;
  - Hoisting to the surface – typically 13% of mine energy use;
  - Transport to mill – typically 7% of actual mine energy use;
- Mill operation;
- Surface logistics:
  - Air-conditioning of living quarters/camp and offices – typically 200 to 300 people, one air-conditioning unit per room or office;
  - Refrigeration and freezer units for food;
  - Baking and cooking facilities, i.e., process heat;
  - Hot water supply for bathrooms and kitchens;

In the above set-up, diesel is converted to mechanical power that is then converted to electrical power, that is then converted back to mechanical power (fans, drills, hoisting) as well as low grade heat (chillers, fridges, air conditioning units, hot water). **We estimate that the total energy efficiency of the above mining operation would be in the order of 20%, possibly less. In fact, much less when one factors in upstream wasted energy in a well-to-metal supply perspective.**

Instead consider a set of about 10 to 20 networked *n*Geni GreenBoxes, direct concentrated solar surface units, and biofuel operated underground units providing direct mechanical power where appropriate (e.g., fans, part of mill's operation) as well as electricity supply underground and surface, and also supplying directly chilling, refrigeration, freezing, air conditioning, hot water, and process heat, that is without using electricity to provide those services. For example, this would also remove the need for several hundred air conditioning units, all

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the chillers, fridges and freezers. The surface Solar GreenBoxes would incorporate high temperature energy storage in refractory cells, enabling ongoing operations day and night, and during bad weather episodes. **We estimate that the total power requirement could be reduced to 5MW, possibly less depending on the mine specifics. That is, to do substantially more with significantly less.**

In addition, through a series of steps, it would be possible to eventually install *n*Geni DAC modules on the surface units to recover CO_2 as a by-product. As stated earlier the fuel operated GreenBoxes could use unrefined bio-oils and/or lightly refined oil-derived fuels instead of diesel.

Overall, we estimate feasible to reduce overall capital expenditure by some 50% to 70% depending on site specifics, operating cost by about 70% and maintenance costs by 80%.

Referring back to the KPMG survey quoted in introduction, the above illustration shows how *n*Geni fits with the emerging demands of mining executives and their Boards to simultaneously improve their profit margins and address the permitting and ESG risks through a disruptive technology advance. **The above mining case shows how it is possible to deliver at once sustainable energy independence at lower cost than at present, insulate the industry from the Climate Emergency and other related ecological challenges, and significantly increased profitability.**

Who we are and the GEM Opportunity

About us

***n*Geni Australia Pty Ltd** is a joint venture of Silver Lining Investments Pty Ltd (SLI) and Fourth Transition Wealth Ltd (4TW), the operational arm of Fourth Transition Ltd (4T) a cutting-edge technology development company that addresses the Climate Emergency by redefining how we access and use energy.

4T is the catalyst for the Fourth Transition Initiative, the formation of 4TW and the *Cool Planet* Foundation, the developer of the *n*Geni™ Technology Class and of the *Cool Planet* Internet of Energy™, of a comprehensive science, technology and market intelligence base covering all aspects of energy supply and use globally, and of related methods, business and financial models, that together form the *n*Geni Technology Class.

4TW integrates the capabilities of 4T, David Fitzpatrick of Regency Wealth Managers, Adrian Godwin of OakTree Financial Services Ltd, the *Cool Planet* Foundation and Jesse Bywater, Chair of the *Cool Planet* Foundation. 4TW is the implementation arm of the Fourth Transition Initiative based on *n*Geni, targeting a total addressable market (TAM) of well over 5 Trillion Euros per annum globally. 4T and 4TW are hereinafter referred to jointly as 4TW.

4TW brings together an international team of entrepreneurs, engineers and scientists mustering over 50 years' experience in wealth creation and management, market and technology intelligence, cutting edge energy technology development, technology marketing and licensing. Together they form a highly proactive task force mastering accelerated technology development, minimising costs and lead times to market.

4TW has mustered what is demonstrably the most cutting-edge science, technology and market intelligence to date regarding the present, interrelated, global, energy, climate, ecological, social and financial threats – we refer to this combined set of threats as the **Energy Seneca**. Our intelligence concerning the Energy Seneca rests on over 50 years of research by thousands of scientists and engineers internationally from a wide array of disciplines. In short, the mustered evidence that backs the Fourth Transition Initiative is massive.

SLI has similar objectives as 4TW and focuses on the Australian markets. SLI has developed extensive market and technology intelligence in Australia concerning gold exploration and mining, remediation of gold mining impacts, and the development of bio-energy solutions to address Australia's strategic transport fuels security issues.

Based on SLI and 4TW intelligence and expertise, ***n*Geni Australia has identified and is developing viable, safe, sustainable, solutions to the threats Gold Mining and Australia are currently facing. *n*Geni Australia has integrated these solutions in its flagship GEM project.**

GEM meets the identified markets imperatives and its applications can be profitably deployed over the next 20 years at lower costs than most *"business-as-usual"* (BAU) or *renewable* based solutions. GEM also integrates a set of methods and techniques enabling any business, governmental body or government in the mining world to leverage their strengths, compensate for their weaknesses and **chart a resilient course through the stormy uncharted waters ahead**.

The partners we are seeking

***n*Geni Australia Pty Ltd** is looking for discerning investors and robust industrial partners:

- Understanding the opportunity at the heart of the challenges presented in this White Paper;
- Understanding the strategic and competitive advantages of *n*Geni in the current and emerging global market context for mining;
- Understanding that the usual risks entailed in the development of the *n*Geni mining applications are modest, especially in regard to the risks of doing nothing and letting the present situation inexorably degrade concerning the Climate Emergency, other ecological, social and financial challenges and institutional responses to them (such as permitting, regulations, financing challenges, etc.);
- Capable of taking part in financing the development of the *n*Geni Australia mining applications range; and
- Capable of effectively taking part in the global commercialisation of the applications on a licensing, value-adding joint venturing basis structured through an Application x Regions matrix.

The investment opportunity

In short, we have found how to build a safe, highly profitable, *"Middle Way"* that disrupts both obsolete BAU and illusory *"green"*.

While drawing atmospheric CO_2 back down to viable levels, retaining access to precious high energy density molecules from oil and biomass as well as extending the life of remaining oil reserves by over 20 years, **the prospect is to take a turn towards a 100% Solar, Sustainable, Affordable, Safe operations in record time, at lower cost than anything else, unleashing unprecedented prosperity for all stakeholders involved in the *n*Geni GEM Applications development and deployment.** This is readily feasible in ways that neither those plumping for BAU nor *"greens"* have ever considered.

To achieve the above objective, *n*Geni Australia's development is structured into two main Phases:

- **Phase 1: demonstrate the GEM potential** on a tenement located within the Victorian *"Golden Triangle"*, an area with a potential comparable to the Fosterville mine, i.e., some AU$2M net/month once developed; and
- **Phase 2: licensing the *n*Geni GEM IP and joint venturing with industrial partners to develop and commercialise the full range of GEM applications in Australia and globally.**

We estimate the total addressable market (TAM) at well over €1 Trillion/year for all GEM applications. Retrieving funds currently lost as waste heat, GEM can achieve what presently no government or business can do: develop green mining in a way that is necessary to combat global warming and address the related energy, ecological and financial issues, effectively and profitably, through investments in a series of application-focused ventures specifically created to contribute to the Fourth Transition.

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In summary the Opportunity presented by *n*Geni Australia's GEM Project is:

- ❒ Leading to a 100% solar-based, sustainable, affordable, global mining *"Middle Way"*;
- ❒ Built on proven, well established science and engineering components integrated in radically novel ways to produce a new Energy Technology Class, *n*Geni, in substitution for most internal combustion engines (ICE), turbines (steam, gas, wind), PVs, and batteries – IP protected;
- ❒ Emulating what nature has been doing for some 4 billion years;
- ❒ Focused on licensing the *n*Geni GEM IP and forming a wide series of downstream value-adding partnership joint ventures (VAP-JVs) with carefully selected licensed industrial partners to develop the full range of *n*Geni GEM mining applications;
- ❒ With over 100% IRR estimated for investments in each of the downstream developments VAP-JVs.

Our invitation

Amidst the Covid-19 mess, it is easy to miss what's really important. We will be delighted to brief potential investing parties in detail, including how we can assist them strategically to map out a new resilient course through the uncharted, stormy waters ahead, as well as involving them in the Fourth Transition.

Owing to the highly sensitive nature of the intelligence information and of our technology any such briefing is to take place in strict confidence under a two-way NDA. Under NDA, details of the funding options will be supplied to qualifying parties. They will have access to full disclosure, regarding *n*Geni Australia, the GEM flagship project, the *n*Geni Technology Class, the *Cool Planet* Internet of Energy, the *n*Geni Services, allied and related technologies, the development and commercial deployment strategy, the budgets, business and financial models, and return prospects.

Websites: *n*Geni Australia Pty Ltd, Fourth Transition Wealth Ltd and Cool Planet Foundation

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