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A New Age of Exploration

Space: The Next Energy Frontier

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The choice to bridge the chasm between the Earth and Outer Space is an accomplishment worthy of tribute, and one of the greatest technological feats ever undertaken by humankind. It has opened to us a universe of breathtaking new possibilities right at a time when the world's 'energy insecurities' make it necessary for us to take the quantum leap of utilising stellar substances as the raw materials for new ways to power the Earth.

Currently used global energy resources have become troublesome, not only because of cost, availability, and political as well as environmental issues, but also because they appear to be the shrinking output of a zero sum game. Providing a supply of abundant, cheap, and clean energy has and will increasingly become the 'hot issue' of profound implication for the next half century.

A NEW 'AGE OF EXPLORATION'

Doomsday prophets admonish us (as they have for centuries) that economic and environmental degradation is the only realistic scenario we can expect from our population-bloated and emission-poisoned planet. I would beg to differ. We have only to 'lift our eyes to the heavens' to encounter a whole new seedbed of clean and renewable energy possibilities. These stellar energy frontiers give the term 'age of exploration' a whole new meaning for energy research and consumption in the 21st century. Economical use of the wealth of materials and energy that surround us in space may well be the next new horizon to which we raise our sights and aspirations.

Astrophysicists have for some time now been in discussion about ways in which to classify stellar civilisations based on the way that these (hypothetical) life-forms would source and utilise energy. Russian astronomer Nikolai Kardashev and Princeton physicist Freeman Dyson have suggested three tiers to such a classification system. ***Class-I Civilisations*** are ones that would have mastered the use of all available forms of energy available *within their own planet*. ***Class-II Civilisations*** are ones that have learned to extract additional energy from sources within their *own solar system*. ***Class-III Civilisations*** are ones that have expanded to the manipulation and use of energy resources from within the *larger system of galaxies.*

Theoretical physics professor Michio Kaku advises us that we are currently only a ***Class-0 Civilisation***, using mostly dead plants (coal and oil) to energise our machines. By the measure of this planetary scheme of things, we are but infants taking our first tenuous steps into maximising our own planet's resources and then hesitantly looking beyond.

THE NEXT BIG LEAP

There are several rationales for proposing a decisive change in energy procurement strategies (some might prefer to call this process further 'diversification'). One is due to the imminent exhaustion of fossil fuels here on earth. 'Peak Oil Theory' estimates suggest that maximum output levels could be reached within the next decade.

The second and larger impetus for exploring extra-planetary energy scenarios relates to the future survival of our species. Our colonisation of space brings to humanity (or future progressive transhuman life forms) the option of outliving possible astronomical or ecological disasters. Such potential planet- threatening catastrophes include the possibility of the fatal disintegration of the ozone layer and the depletion of that thin life-protecting layer fifteen miles above the earth's surface that protects us from the sun's radiation.

Meteor or comet impacts could also decimate life as we know it. Astronomer Tom Gehrels of the University of Arizona estimates that an asteroid only a kilometre in diameter could impact the earth with the force of a million Hiroshima bombs, raising a cloud of global atmospheric dust and dirt that would cut off the sun and cause temperatures to plummet. Supernovas too could also bathe our planet in a lethal rain of X-rays, extinguishing all life forms. But while these threats are far from immediate (some of them on the very far horizon for which scientists could give ample lead-time), they demonstrate the fragility of our existence and underscore the prudence of taking on the challenge of becoming a fully realised ***Class-I*** **or** ***Class II Civilisation***.

Two critical issues dominate the discussion of procuring energy from sources outside of those immediately available on earth. The first question asks what substances in space can in fact be used for serviceable energy consumption, and the second focuses on a reliable and affordable transport system for these substances.

There is the possibility that these two issues (power & transport) are intrinsically inter-related because any viable energy source discovered in space could possibly be used as a power source to fuel the propulsion of inter-stellar transport vehicles or mechanisms back to earth. Consumable propellants and life-support materials found in space would dramatically reduce the costs and boost the performance of the transport vehicles.

POWER AND TRANSPORT TECHNOLOGIES

Leveraging Light

One of the first power sources to be considered for energy procurement in space is our primary star, the sun. On a per second basis the sun pumps out 40 million times as much power as we need to sustain human energy requirements. Space expert and professor of planetary sciences John S. Lewis suggests that light is one of the most valuable commodities available to us. He posits the question this way: "What is worth more, a pound of gold or a pound of light? The answer is light, hands down."

Light energy is also a commodity that can be relatively easily transported back to earth from space. The power of solar radiation can be harnessed by means of beaming high-powered lasers from outer space back to earth. The sun is already widely used to generate electrical power for satellites in low earth orbit (LEO) and could increasingly be used for the transmission of energy to earth.

The question arises as to why we should go to all the effort of sourcing solar power via satellites in space when solar energy is already readily available to us on our planet in the form of sunlight. The answer lies very simply in the fact that the capacity to maximise solar energy on earth is highly limited both by weather factors and by the earth's diurnal cycle (nighttime). A satellite whose orbit is located on a fixed point above earth's equator (called a geosynchronous orbit or GEO) is in unobstructed sunlight more than 99% of the time. Lewis suggests that hooking up a network of these GEO based satellites could offer interesting new energy opportunities on which we are not presently capitalizing.

Excavating Extra-Terrestrial Territories

Moving a step beyond sourcing energy through fluid solar forms as mentioned above, we arrive at the possibility of mining solid solar derivatives in space. The planets in our stellar system are constantly being bombarded by strong solar winds that mercilessly whip the surfaces of any bodies that are not shielded by protective gases or magnetic fields such as those that surround the earth. Planets and moons that have no atmosphere, such as our own moon, have solar wind particles slamming into their surface and implanting themselves at full speed.

In *Mining the Sky*, Lewis informs us that these solar wind particles penetrate about a ten-thousandth of a centimetre into any solid material or surface before coming to a full stop. This decelerates and traps the particles, fusing them into a concentration on the top layers of the regolith of the moon's surface. This surface granule exposure to solar particle radiation leaves a residue that could theoretically be mined to extract the stored solar energy. Mobile or permanent 'mining' stations could be set up on the moon, with the capacity to mitigate against the vulnerabilities of the handling equipment. Should the surface concentrations of solar wind particles be high enough in the regolith, this could prove a means to liberate their trapped power as a potential energy source.

Farsighted Fusion

A last stellar energy consumable cited by Lewis, Helium-3, is also a possible complementary power source for earth. The moon (and perhaps the giant planets) are central players in this proposal to meet some of the earth's millennium energy requirements. First highlighted by Gerry Kulcinski and his colleagues at the University of Wisconsin, the light isotope Helium-3 can be used for fuel in fusion reactors and has been found in small amounts on the moon's surface. The significance of this isotope lies in its ability to produce energy efficiently (it is a 'clean' fuel) without discharging neutrons that irradiate the walls of fusion reactors thereby exacerbating the problem of future nuclear waste disposal.

Particularly of importance is the fact that the Helium-3 gas is difficult to extract on earth, whereas Kulcinski posits that on the lunar surface it is prevalent (albeit in minute concentrations) in the mature regolith. Lewis notes that *Science Plus*, in its youth readers guide, makes rough projections suggesting that 10 tons of Helium-3 could power all of North America for over a month. In addition, he suggests that at a current cash value of over $16,000,000 per kilogram, Helium-3 is worth 100 times its weight in gold and could well be worth a trip outside of our gravity well.

TRANSPORT CONSIDERATIONS

As stated earlier, a second critical factor influencing technical and economic incentives for sourcing power from space is the feasibility of transport mechanisms. Historically, financial launch outlays for NASA transport vehicles have been prohibitive, with payload costs of approximately $10,000 per kilogram on the Space Shuttle.

The reusability of spacecraft, however, could be a key factor in bringing down space transport costs. A case in point is the X-33 VentureStar, a reusable launch vehicle which, courtesy of the National Aeronautics and Space Administration, is scheduled to replace the Space Shuttle early this century. This unconventionally shaped space vehicle uses advanced composite resins on its surface, which help shield it more effectively from blistering temperatures caused by air friction upon re-entry into earth's atmosphere. Vehicles such as this one are leading the way for the fulfilment of John L. Lewis' dream of the day when a trip into outer space will cost little more than a transatlantic flight. Recent news coverage indicates that commercial entrepreneurs such as Virgin Atlantic Airway's CEO, Richard Branson are also sponsoring the movement towards making space travel more accessible to the public.

Other transport mechanisms are also being studied as options for inter-stellar conveyance. In his book *Visions,* Michio Kaku described a fusion ramjet which, shaped much like a funnel, channels hydrogen from deep space as its fuel and uses it much like the conventional jet aeroplane sucks in air as an oxidiser. Nuclear pulsed rockets have also been proposed, using multiple hydrogen bomb detonations to propel a starship forward. Nuclear pulsed propulsion, however, would pose another set of potential risks for humans should the vehicle be manned.

Several other 'transport' ideas have emerged in the field. For example, as Kaku notes in *Visions*, stellar or galactic energy resources could be extracted and transported by means of *robotic space probes* that could land as far away as the moons of distant star systems and build self-replicating factories and information centres.

Alternately, humans could stay closer to home in their energy procurement journeys and themselves man shorter-term launches onto orbiting asteroids. This has been described as a type of 'stellar hitch-hiking' in *Mining the Sky*. The low gravity of asteroids could be used as an easy entry and exit point for joining in on orbital rotations that closely graze other desired destinations. Asteroids could also be hollowed out and used as 'travelling hotels' whose interiors would provide protection from long-term exposure to solar and cosmic particulate radiation, rapid temperature fluctuations, and impacts of small meteorite fragments. As travel-friendly destinations themselves, asteroids may also be sought because of their internal composition that could also offer on-site energy mining potential.

THE OUTLOOK

Whilst venturing out into space, humanity expected to find a plethora of nothingness, a void of silence. Instead we have found that space offers an abundance of resources, even bigger than our supply on earth, and a supply that could well be used to augment power generation demands for the next millennium. Viable and complementary sources of energy do in fact exist and offer themselves right outside of the perimeters of our own planet. Ignoring these potentialities could cost us the price of a more secure collective human future. In the words of H.G. Wells,

"There is no way back into the past.
The choice is the Universe – or Nothing."

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members of the South African Futures Society. As a futurist and academic, Stauffer has lived for a third of her life in the Middle East, for several years in North America, and for 16 years in South Africa.

POINTS FOR THE CLASSROOM** (send comments to forum@futuretakes.org)**:

- *Stauffer discusses several prospective enabling technologies for power and transport in space. Identify spin-off technologies that may emerge from them, and their possible consequences including social consequences.*
- *After reading this article, what other hidden assumptions regarding energy production and consumption can you identify? Consider everything – changing living and working patterns, consumption patterns of various socioeconomic classes, post-industrial society, concepts and patterns of "growth," values, etc.*
- *In addition to space, what new energy frontiers can you identify? Which ones are most likely to be explored within the next ten years, and why?*
- *How will new sources of abundant energy change the geostrategic interests of various nations and regions?*
- *Also see synopsis of Robert L. Olson's program "Beyond Oil? The Great Energy Transition," in the Winter 2004-2005 issue.*