

Make Arrakis Green Again or What energy for the Fremen?

Vincent Bontems & Roland Lehoucq

Résumé

Le texte propose une réflexion sur les choix énergétiques des Fremen dans *Dune*, à partir d'une approche de design de science-fiction appliquée à la transition écologique. En imaginant l'adaptation humaine à la planète Arrakis, les auteurs explorent la manière dont les technologies dépendent de leur « milieu associé » et de la nécessité d'établir une homéostasie avec l'environnement. Arrakis est décrite comme une planète extrêmement aride, marquée par la pénurie d'eau, des températures élevées et de violentes tempêtes de sable, des conditions qui limitent sévèrement les possibilités techniques. L'analyse examine la viabilité de l'énergie solaire photovoltaïque dans le contexte d'Arrakis, en mettant en évidence les obstacles liés au spectre lumineux de l'étoile Canopus, à la perte de rendement causée par la chaleur extrême et aux dommages provoqués par les tempêtes. En contraste, le texte souligne le potentiel de l'énergie solaire thermique, qui permet le stockage de l'énergie et une meilleure adaptation aux conditions environnementales. Cette discussion est articulée autour du trilemme énergétique (sécurité, équité et durabilité) comme critère fondamental d'évaluation des systèmes énergétiques.

Mots-clés : Design de science-fiction; Transition écologique; Choix énergétiques; Milieu associé; Trilemme énergétique.

Abstract

The text offers a reflection on the energy choices of the Fremen in *Dune*, based on a sciencefiction design approach applied to the ecological transition. By imagining human adaptation to the planet Arrakis, the authors explore how technologies depend on their “associated milieu” and on the need to establish a homeostasis with the environment. Arrakis is described as an extremely arid planet, marked by water scarcity, high temperatures, and violent sandstorms, conditions that severely limit technical possibilities. The analysis examines the viability of photovoltaic solar energy in

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the context of Arrakis, highlighting obstacles related to the light spectrum of the star Canopus, efficiency losses caused by extreme heat, and damage produced by storms. By contrast, the text emphasizes the potential of solar thermal energy, which allows for energy storage and greater adaptation to environmental conditions. This discussion is articulated around the energy trilemma (security, equity, and sustainability) as a fundamental criterion for evaluating energy systems.

Keywords: Sciencefiction design; Ecological transition; Energy choices; Associated milieu; Energy trilemma.

The struggle between the elements of life is the struggle for the available energy of a system.

Dune, Frank Herbert, 1965.

As part of (science-)fiction design workshops on ecological redirection designed for students and companies, Vincent Bontems (a philosopher at the CEA) and Roland Lehoucq (an astrophysicist at the CEA) propose an immersion on Arrakis, the desert planet in *Dune* by Frank Herbert, in order to rethink technological choices—particularly energy-related ones—according to the environment. This is because it is easier to imagine a technological shift by picturing oneself on another planet. As proclaimed by the “Multiversalism Manifesto” (of which they are both signatories), *one must think other worlds in order to think the world differently*.

To better understand their approach, put yourself in the shoes of an Atreides at the beginning of *Dune*: in anticipation of your future settlement on the planet Arrakis, you take part in a “transition workshop” designed to help you better understand your new environment. Indeed, moving from the humid and hospitable Caladan to the arid desert planet entails a complete change in your way of life, particularly in your use of technology. A technical object always operates in relation to its “associated milieu”: it finds there the conditions of its operation and, in turn, modifies them, which feeds back into how it functions. This is the basic principle of planetology: establishing a proper dynamic balance with the environment, a “homeostasis”, in order to be able to inhabit a planet sustainably, and the security of the colony depends on this equilibrium. You are therefore not surprised to find, alongside the mentat Karim Tayiban, the planetologist Rollan LewKynes, who, without preamble, begins to brief you.

The planet Arrakis

Arrakis is the third planet in the Canopus system. This real star is, as seen from Earth, the brightest in the southern constellation of Carina and the second brightest star in our sky after Sirius, the main star of

the constellation Canis Major. Located about 310 lightyears away, Canopus is a star whose mass is 6.9 times that of the Sun. With a radius 71 times larger than that of our star and a high temperature of 7,500 degrees, Canopus is therefore 15,000 times more luminous than the Sun: it is a supergiant whose high temperature gives it a blue color. Canopus even turns out to be the most luminous star within a radius of 500 lightyears around the Sun.

My cousin LietKynes, the Imperial planetologist on Arrakis, tells us that its atmosphere contains «23% oxygen, 75.4% nitrogen, and 0.023% carbon dioxide, with the remainder made up of rare gases.»

¹ Since this composition is very close to that of Earth in the second millennium, the greenhouse effect would be comparable there, were it not reduced by the absence of water vapor. Knowing that the average temperature of Arrakis, again according to LietKynes, «[...] has oscillated for thousands of years between 254 and 332 degrees absolute,»² one can estimate that the distance separating Arrakis from Canopus is about 115 times the Earth–Sun distance, that is, 17.3 billion kilometers. Arrakis is an arid planet whose surface is almost entirely covered by deserts—vast expanses of shifting dunes interspersed with rocky plains, eroded plateaus, and a few jagged mountains. Its climate is one of extreme dryness: there is virtually no precipitation, and daytime temperatures reach stifling levels. Yet water seems once to have flowed freely across the planet’s surface, as observed by his predecessor, the planetologist Pardot Kynes, who noted in the Great Erg an immense oval depression some three hundred kilometers long, whose smooth, white surface was made of salt³. Sandstorms of colossal violence, known as “Coriolis storms”, regularly sweep across the planet. Sometimes several kilometers high, with winds reaching several hundred kilometers per hour, they raise clouds of sand capable of eroding, or even burying, any exposed structure.

After this brief reminder of the general conditions for habitability, the mentat in turn takes the floor. He comments on footage taken of a remote part of the desert by a spy drone. A bright spot can be seen on the desert sand.

This document was stolen from the Harkonnens. According to the accompanying report, this image would prove that the mysterious Freemen make use of photovoltaic energy, whose panels were, by chance,

¹ Bontems, V., et al., 2025, “Manifeste du Multiversalisme”, in *Solaris*, Vol. 50, No. 236.

² Herbert, F., 2012, *Dune*, Fr. trans. by M. Demuth, Paris, Pocket, p. 835. [*Dune*, Philadelphia, Chilton Books, 1965].

³ Herbert, F., 2012, *Dune*, Fr. trans. by M. Demuth, Paris, Pocket, p. 834. [*Dune*, Philadelphia, Chilton Books, 1965].

made visible through the reflection of sunlight. We doubt this—both because we distrust anything that comes from the Harkonnens, and for reasons that the ducal ecologist will now explain to you. Now, what interests me is what you think. If the Fremen are capable of machining thumpers and crafting the finest stillsuits, how do they obtain the energy required for this industry? Take a few minutes with your neighbors to discuss this and present us with your hypotheses in a report.

What is the Fremen's source of energy?

Half an hour later, Tayiban analyzes all the reports in a few milliseconds.

Well, I see we have our share of wind turbines, geothermal energy, sand turbines and, as usual, a few clever types who want to use a sandworm as an animal engine... I'll let LewKynes explain to you what seems to us the most likely hypothesis .

To transform their world, the Fremen need energy. Where could it come from? An obvious solution would be to use photovoltaic solar energy, since one can estimate that, when Canopus is at its zenith, a luminous power of about 1,000 watts strikes each square meter of the planet's surface. But this proposal faces numerous difficulties. To better grasp the problem, let us follow the line of reasoning developed by one of my padawans⁴.

A photovoltaic (PV) panel directly converts light into electric current. It is made up of cells composed of a semiconductor material (on Earth, silicon) whose electronic structure consists of two layers. The first of these layers, the conduction band, contains no electrons, while the second, the valence band, does contain electrons. When this material is struck by solar photons, electrons 'jump' from the valence band to the conduction band, allowing an electric current to flow. On Earth or on Arrakis, the received light contains photons of all energies, but not all of them are capable of triggering an electronic transition: for this to occur, their energy must be greater than the energy separating the two bands, known as the band gap. If this gap is small, a large number of photons will be absorbed and the generated electric current will be strong, but the voltage will be low, resulting in low electrical power (since power is equal to the product of current and voltage). Conversely, a large gap is associated with high voltage but allows only photons

⁴Herbert, F., 2012, *Dune*, Fr. trans. by M. Demuth, Paris, Pocket, p. 836. [*Dune*, Philadelphia, Chilton Books, 1965].

with sufficiently high energy to be absorbed: the current will be very weak, and so will the power. For a given light spectrum, one must choose the semiconductor whose band gap makes it possible to obtain maximum power. This compromise is known as the Shockley–Queisser optimum.

On Earth, with the Sun’s light spectrum, the optimal band gap lies in the infrared, around a wavelength of 1,100 nm. The associated maximum efficiency is on the order of 30%. The semiconductor material whose band gap is closest to this value is silicon—very abundant on Earth, particularly in the form of silica found in sand. Sand that Arrakis also possesses in abundance... Except that the spectrum of Canopus, a hot star, is shifted toward the blue compared to that of the Sun and contains fewer lowenergy photons than the Sun. The efficiency is higher (about 33%), but the optimal band gap is instead around 850 nm, at the boundary between the visible and infrared. In this case, silicon is no longer the ideal material: gallium or indium would be more suitable. Unfortunately, they are far less abundant than silicon...

As if that were not enough, the star’s spectrum is not the only parameter that must be taken into account: temperature also plays a role, as does the planet’s sometimes stormy weather. Indeed, the efficiency with which a PV cell converts light into electric current depends on its temperature: it decreases by about 0.5% per degree. This is somewhat counterintuitive, but a very sunny yet very hot region will not necessarily produce more solar electricity than a slightly less sunny but cooler one. In the very hot climate of Arrakis, this effect is devastating. Finally, the Coriolis storms that strike the planet could severely damage solar panels and, above all, cover them with dust, thereby limiting their ability to capture light. A significant portion of the energy produced by the panel would have to be used just to clean it—without even mentioning the water required for such an operation in a context where water is extremely scarce. All these difficulties therefore constitute as many arguments that could explain the absence of PV panels on Arrakis.

If photovoltaic solar energy does not seem very usable on Arrakis, why not turn to solar thermal energy? Heat can be stored far more easily than electricity, and concentrated solar power can therefore handle the day–night intermittency by storing heat, making nighttime electricity

production possible. This is the case, for example, with the Cerro Dominador concentrated solar power plant near Calama, in the Antofagasta region (Chile), in the Atacama Desert. Operating in combination with a photovoltaic power plant, it was able, in the 21st century, to supply 17 hours of electricity without sunlight at its nominal capacity of 110 MW.

The mentat then steps in to offer another historical reminder:

The idea of using the Sun as a source of thermal energy for industry is even older. In 1866, Augustin Mouchot (1825–1912) invented the first solar engine, using a parabolic reflector and a cylindrical glass boiler to power a small steam engine. In 1877, a subsidy from the General Council of Algiers enabled him to build, on the same principle, a large device covering 20 m², which received a gold medal at the 1878 Universal Exhibition in Paris. He was subsequently awarded the Legion of Honour and granted the opportunity to continue his work in Algeria. Together with his new associate, Abel Pifre, he filed a new patent in 1878. At the time, France's coal production was insufficient to meet the needs of industry, and Mouchot's invention seemed destined for success. However, the discovery of coal deposits in Lorraine, imports made possible by the Franco-British trade treaty of 1860, and improvements in the railway network facilitated coal supply and accelerated industrial development. This led the French government, after conducting studies, to conclude that solar energy was ultimately not profitable and to stop funding Mouchot's research. What might have happened if his discovery had encountered more favorable economic conditions? For example, a century earlier, in the agrarian France of the Physioocrats, which needed energy to power irrigation pumps during the summer? Examining Fremen society will undoubtedly help us understand how to make use of this ecotechnology.

The energy trilemma

LewKynes takes the floor again:

Like any energy system, that of the Fremen rests on three complementary pillars:

1. Energy security, to avoid any risk of supply disruption (the safety of installations, the stability of the electrical grid, and the geopolitical dependencies linked to exchanges of energy resources);
2. Energy equity, so that access to energy (the development of infra-

structure and the cost of energy) is possible for everyone;
 3. Energy sustainability, in order to preserve the planet's resources and limit pollution and climate change.'

If one pillar is too weak, the ecotechnological system becomes dysfunctional. Clean, affordable but unstable energy cannot ensure the operation of a country's vital systems, such as hospitals. Clean, stable but unaffordable energy exacerbates social inequalities by increasing energy poverty. Affordable, stable but environmentally harmful energy is also detrimental to humans, as it degrades the global associated milieu of all living beings, as established by planetology (and as climate-change models on Earth already suggested as early as the 20th century). Managing these three pillars is the purpose of ecotechnology in its energy dimension (the other dimensions concerning the management of matter and information). It requires analyzing the feasibility of a technical system and the consequences of its use, in other words, characterizing what constitutes a 'technology of the future' on each planet.

The technology of the future on Arrakis: solar steampunk

The Mentat concludes:

As we might have suspected, the Fremen have opted for a technology that reconciles three imperatives: a lack of carbon footprint (a greenhouse effect is the last thing you could wish for on Arrakis!), agility (to evade surveillance and Coriolis storms), and the efficient use of resources (the abundance of sand for mirrors and the valorization of water reserves essential to their survival). I therefore invite you to take inspiration from them, to think and act like Fremen, if we are to survive on Dune. On Caladan, we were able to make prudent use of combustible algae and we had our tidalturbine installations, but the associated milieu of Arrakis is far more hostile to living beings and machines alike. During the first decades, we will be able to draw on the stock of nuclear material and antimatter from our ships, but ultimately, as on any planet, we will have to adapt to our environment if we do not wish to remain dependent on imports (and thus at the mercy of a CHOAM blockade⁵). This is why we must completely rethink our energy strategy... just as the inhabitants of Earth had to do in the 21st century.

⁵ Suchet, D., 2020, "Une histoire de trilemme énergétique", in *Dune. Exploration scientifique et culturelle d'une planète-univers*, Lehoucq, R. (ed.), 2020, Saint-Mammès, Le Béal, pp. 97–120.

Le CHOM, ou Combinat des Honnêtes Ober Marchands, est la structure économique unique de l'Imperium.

