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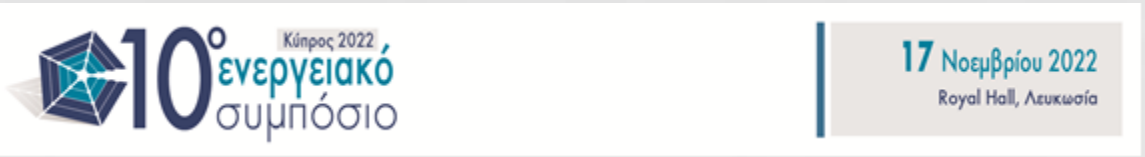
Presentation

"Free Piston Stirling-Solar System with Storage A cost-effective Solar Battery".

A 24/7 grid quality 100% GREEN & STABLE cost effective energy generation Solution



Pavlos Liassides, CEO, Thalis Engineering Co Ltd

How can we reach a 100% Green Energy System using Solar Technologies?

PV could not be a silver bullet to our question

Need of a technology that wouldn't be a direct competitor to PVs
But should be complimentary to cover their failures

Addressing the Challenges

Dispatchability – Baseload Production – Ancillary Services	
Steady & Stable	
Modular & Scalable	
Site Flexibility – No Flat Terrain	
No Water	
PV ≤ L.C.O.E. << PV + Batteries High Efficiency – Min to Zero maintenance	

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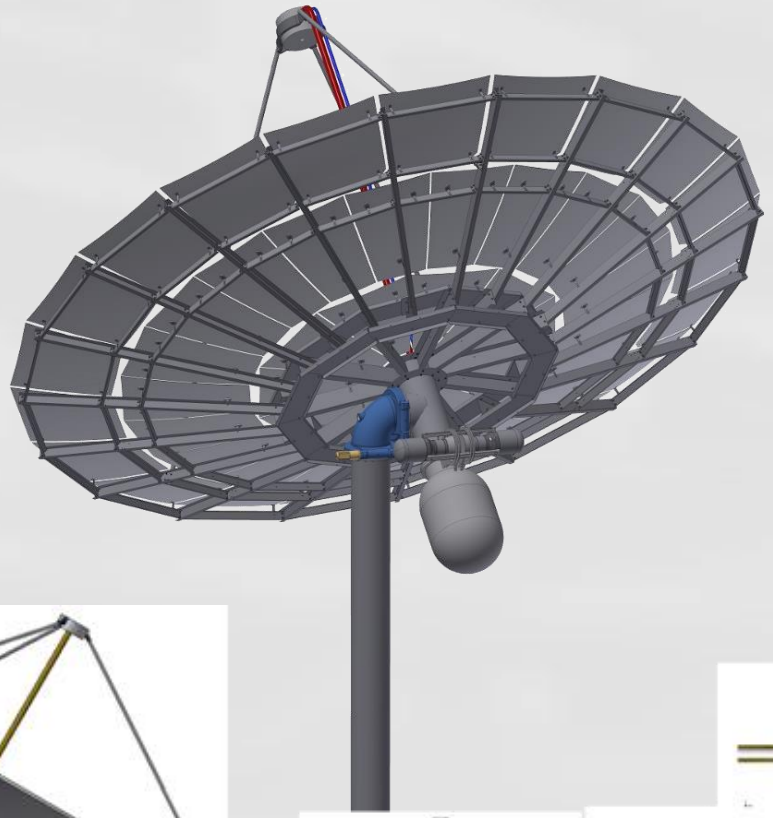
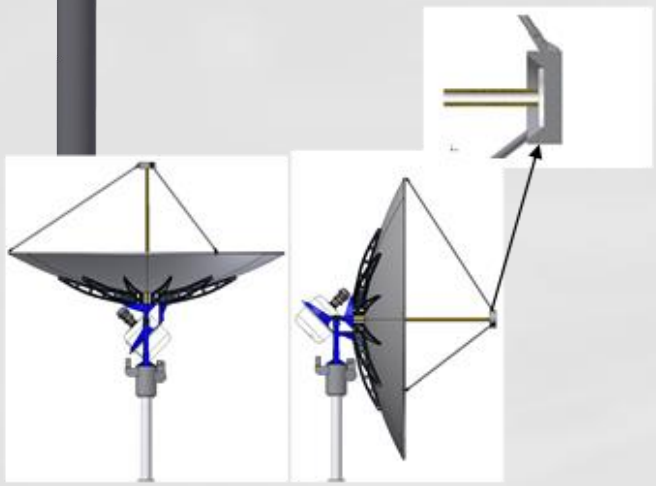
SolarDish System

The SolarDish® System is an integration of six different subsystems/technologies:

1. The Dish / Concentrator,
2. The Solar Receiver,
3. The Heat Transfer System,
4. The Thermal Energy Storage system,
5. The Power Block based on a Free-Piston Stirling Engine, and
6. The Integrated Tracking and Power Control System.





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SolarDish System

Hundreds of Similar systems using the same Stirling Technology Single engine / Front Focus / WITHOUT TES have already been deployed by the former Infinia Corporation (Utah – US) with over 2.7 million operating hours up to now.

Largest and most well-known project the Tooele Military Base Power Plant in Utah, with 420 units.

Unique Generator Platform
Free Piston Stirling Engine

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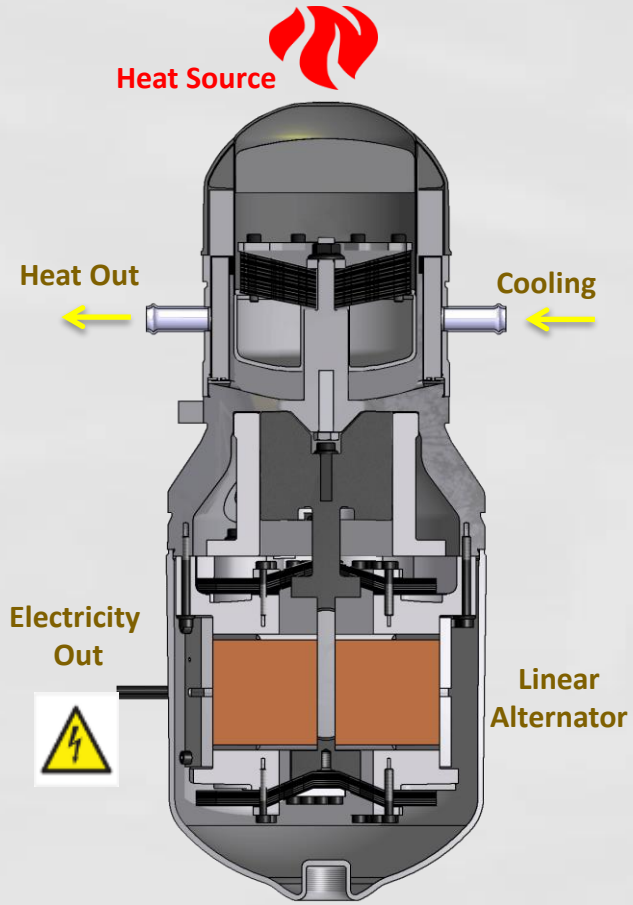
SolarDish System

Best in Class Technology	**Up to 30% thermal-to-electric efficiency** **Adaptable to almost any fuel or heat source** **No Service**
Flexible Power Interfaces	**Flexible AC/DC power outputs** **Single engine capacity up to 7,100 Watt**
Zero Maintenance	**Sealed Engine** **No rubbing parts** **Long Life**
Ease of Integration	**Simple Design *(only 66 parts)*** **Small Footprint and Low Weight** **Comply to both CE and UL certifications**



Maintenance Free Generator

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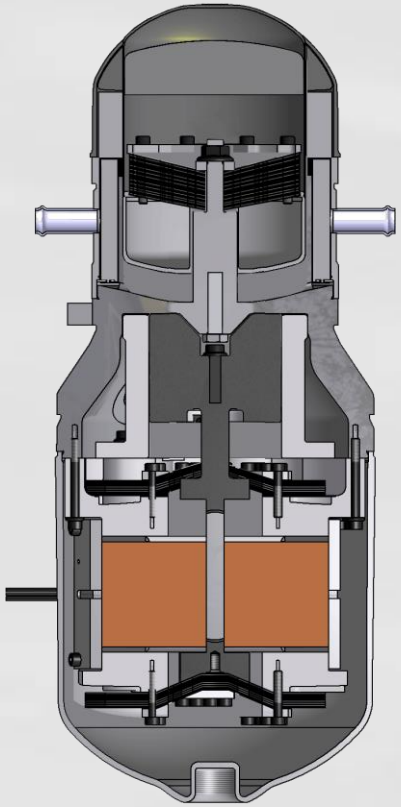
Unique Generator Platform Free Piston Stirling Engines

- Free Piston Stirling Engines are a proven technology used successfully for many years in US space and defense industry.
- Free piston Stirling engines have been demonstrated in critical power applications that require quiet operation, high reliability, and very long, low-maintenance service lives.
- With a record of more than 16 years of continues, uninterrupted, maintenance free operation. https://rps.nasa.gov/news/40/stirling-convertor-sets-14-year-continuous-operation-milestone/
- Used in a number of Military and Space projects. e.g. Spaceship Curiosity

Free piston Stirling engines are distinct from more widely publicized kinematic Stirling engines that have inherent life and reliability limitations imposed by their lubricated mechanical system and sliding seals.



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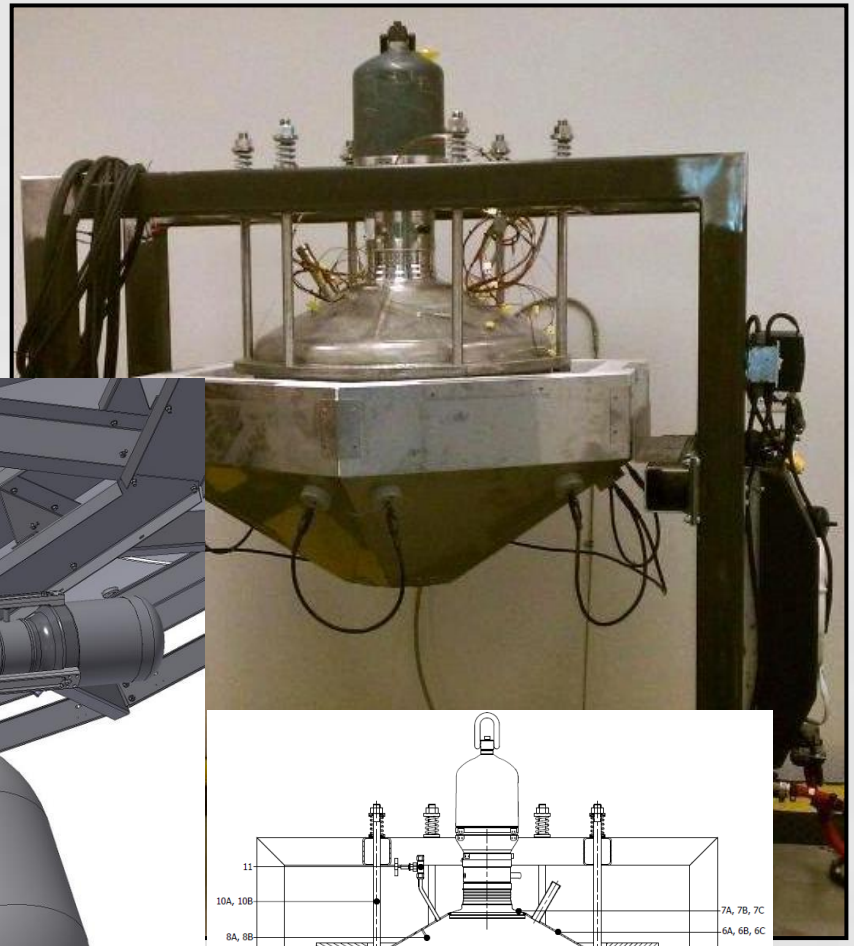
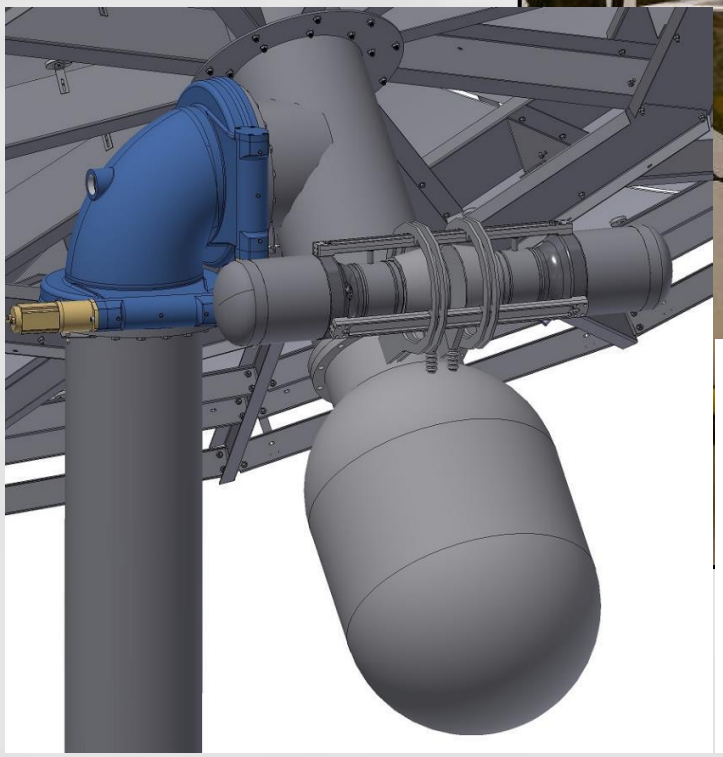
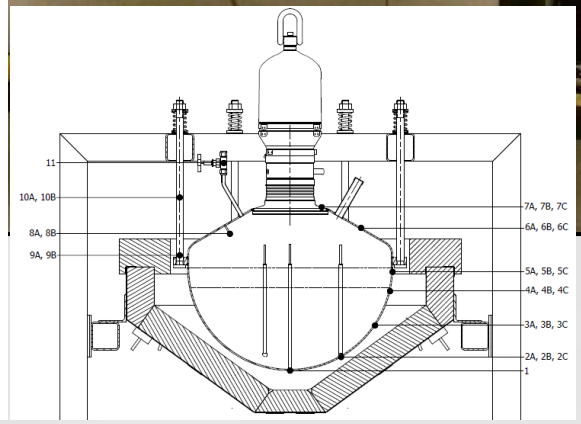
Thermal Energy Storage (TES)

The Thermal Energy Storage (TES) system is based on Phase Change Material (PCM) offering up to twelve (12) hours of storage. The TES system design is a “pool boiler system” where a eutectic salt that melts at 680^{o}C is contained within a high-temperature, hermetically sealed, stainless steel container.







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SolarDish System

Thalis Development Team

David Townley

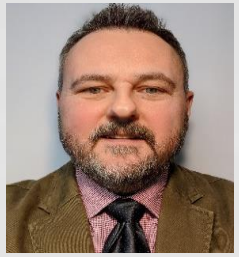
- Maurey White — TES Expert

- Jeff Lowe — Manufacturing Expert

- Orlin Wetzket — Integration Expert

- Creative Engineers Inc — Heat transfer Experts
- Richard Diver — Solar Dish Expert

- Ross Galbraith — Fabrication Expert



- SolarTron / Electron — Dish Experts

SOLARTRON ENERGY SYSTEMS INC.

- Charles Andraka — TES Expert


2014


2017


2014

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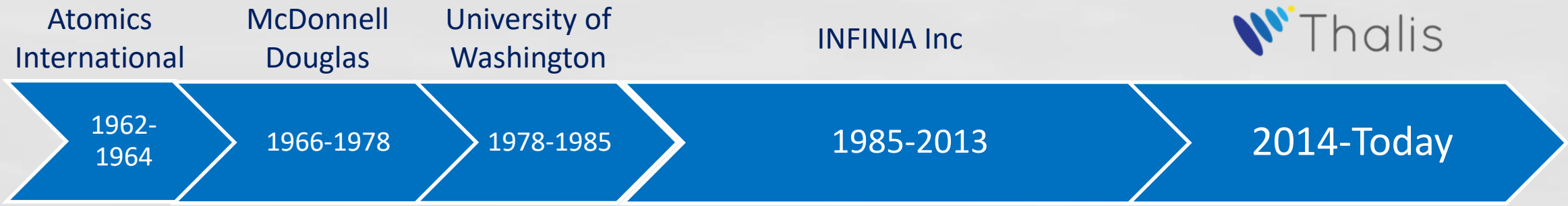
A 60 years Legacy



- First Patent 1969
- White, M. A. et. al., “Double Acting Thermodynamically Resonant Free-Piston Multicylinder Stirling System and Method”, U.S. Patent No. 7,134,279, November 14, 2006.
- White, Maurice and Brehm, Peter, “Systems, Apparatus and Methods for Thermal Energy Storage, Coupling and Transfer”, U.S. Patent No. 8,464,535, June 18, 2013.

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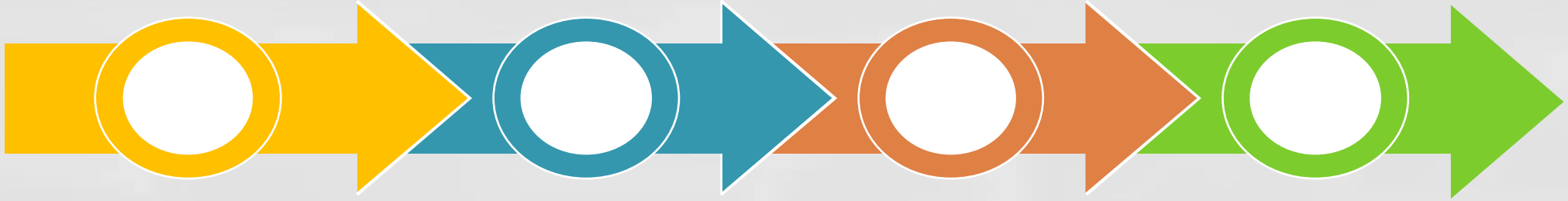
The Next Steps



First 2 Demonstration Projects – 1MW each CYPRUS

Abio Greenergy

ROYAL VALLEY

Manufacturing Plant

1st Large Scale Project 50MW – 7.142 units Agrinio - Greece

Commercialization Phase Delivering 14.000 units per year

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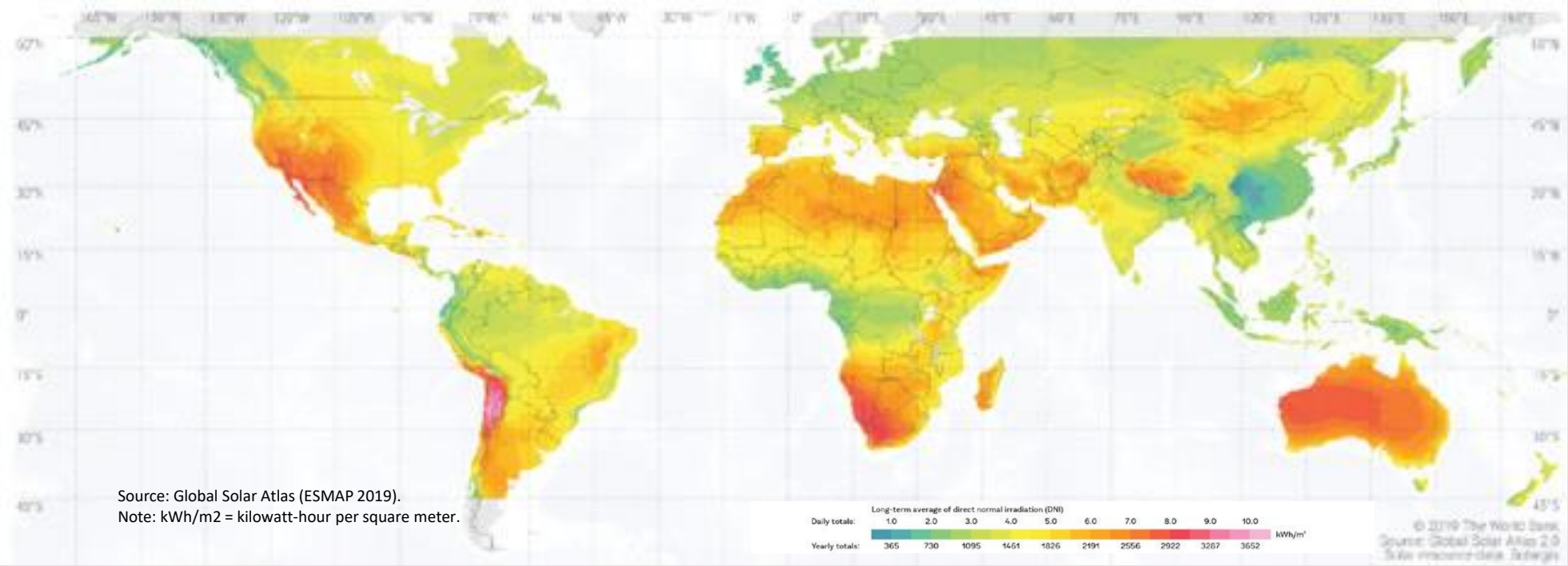
SolarDish System

Market Demand and Size



Source: Global Solar Atlas (ESMAP 2019).
Note: kWh/m2 = kilowatt-hour per square meter.

CSP in general addresses a vast geographical area around the whole globe, and according to the World Bank will be a “must have” for regions with high to excellent DNI. (Yellow to dark red area on map)

WORLD BANK GROUP

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SolarDish System

IRENA
International Renewable Energy Agency

Concentrating Solar Power: Clean Power on Demand 24/7

World Bank / IRENA report Vs SolarDish – Comparison

Recently (January 2021), the World Bank with IRENA released a new updated report on CSP and made a presentation to the global industry.

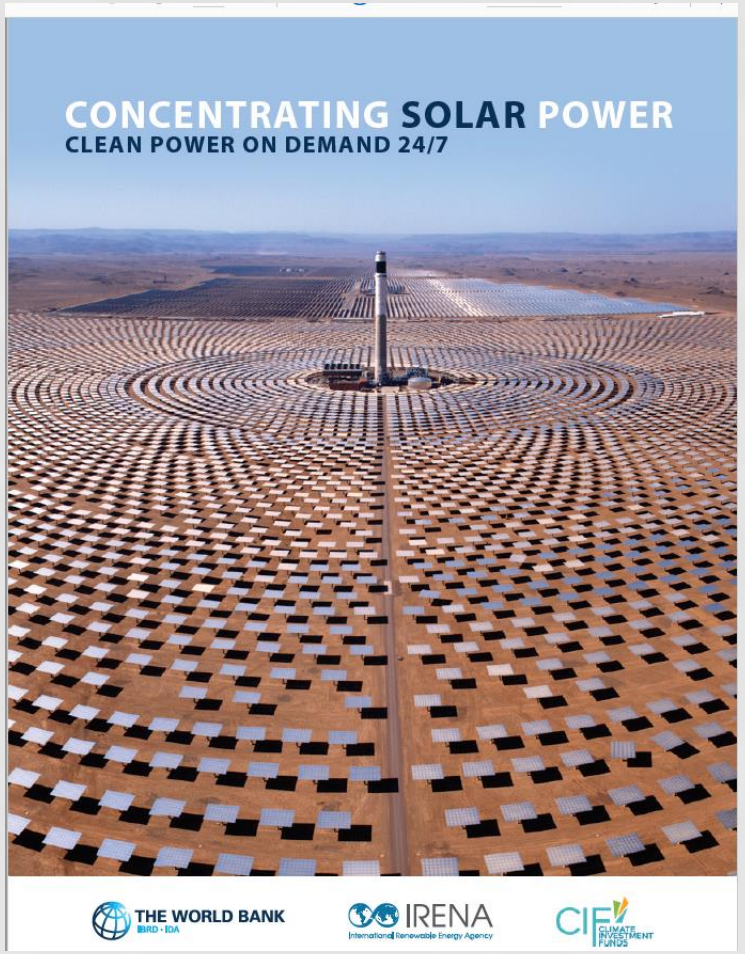
Both the report and the presentation can be found at the following link:

WB-IRENA REPORT

The main points of this report are two:

- CSP can be the most efficient solution for regions with high DNI resource, towards the path of a 100% green, sustainable and net zero carbon emission power grid system.
- To achieve this target, CSP technologies need:
  1. To reach levels of LCOE close to PV and Wind (Report Chapter 2.3 & presentation, slides 9 to 11).
  2. The efficiency improvements that will reduce the cost significantly are expected to come from "High-Temperature Molten Salts" technologies, which the report claims that they are still in the very early stages of R&D and will need some years to hit the market (presentation slide 6).

If we compare the above expectations with SolarDish® technology description (above), we can conclude that these breakthrough innovations expected after several years can be delivered by SolarDish® technology when fully commercialized within the next one year!



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10ο ενεργειακό συμπόσιο Κύπρος 2022

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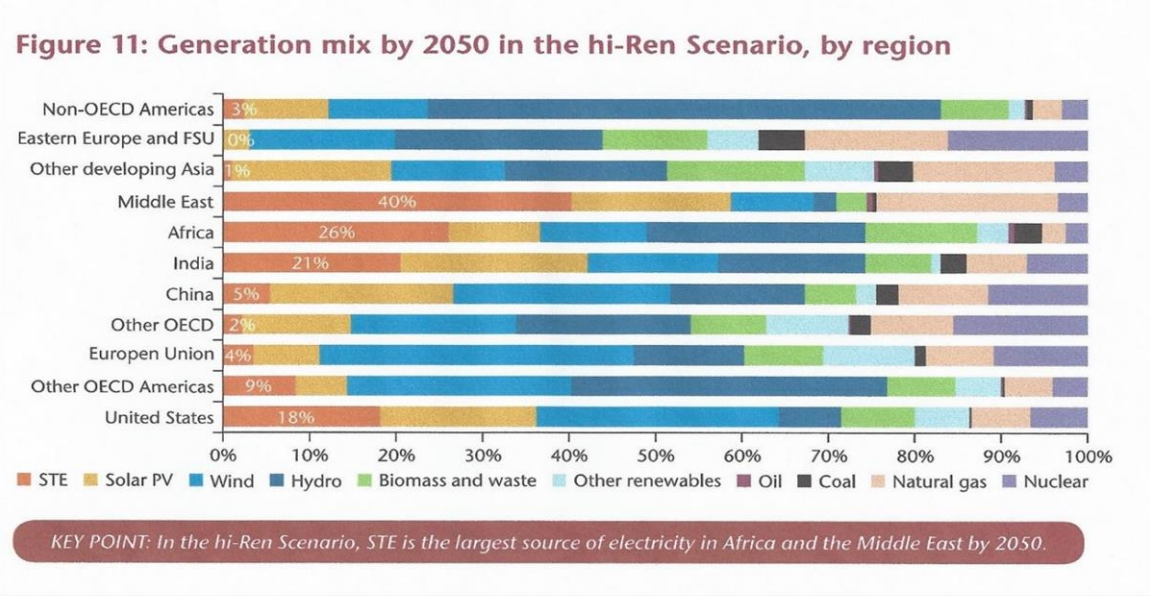
Market Demand and Size



Source: International Energy Agency - Renewable Energy Technology Roadmaps

According to IRENA, the last 10 years globally, 6 GW of CSP has been installed, which represents 2% of the total global needs by year 2050

As per the International Energy Agency (IEA) CSP by year 2050 will have a significant share in the generation mix of geographical areas as:

- Middle East 40%
- Africa 26%
- India 21%
- USA 18%
- South America 9%

This defines a global potential market of $1.15 trillion

At least 20% of this market, can not be covered by traditional and known CSP technologies (Tower, Fresnel, Through) and do need more modular &/or scalable &/or dry &/or stable technologies as the SolarDish.

This defines a potential market for the SolarDish of $230 billion within the next 30 years.

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SolarDish System

Market Demand and Size

Additional Market prosects and Revenue Streams.

SolarDish® as an integrated system of a number of subsystems and technologies, each one of them being on the edge of the state of art, with plenty of innovative features, in combination with Thalis' very strong and knowledgeable R&D team and its production capabilities, has the ability of expanding its operations' circle towards various directions.

In practice each subsystem can evolve into a product of its own with significant market demand in other applications. Free-Piston Stirling engines can be used in many different applications as a main power generation unit. TES using PCM storage media is a need for many other sectors of the industry. The EM pump and the high-temperature Heat transfer System can provide breakthrough solutions in many prospect technological solutions that require very high temperature fluids and gases.

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SolarDish System

Astrom Technical Advisors SL (Madrid, Spain), one of the World's leading independent technical advisory services company in renewables, www.astromta.com has performed in October 2017 an in depth Product Due Diligence of the system.

FINAL CONCLUSION HIGHLIGHTS:

- **ATA remarks that the Thalis Development team have a wide knowledge and experience accumulate highly valuable within the Dish/Engine technology.**
- **In ATA's opinion, the common components of the SolarDish751 present low technical risk. These equipment and systems have been widely tested and proven in Dish/Stirling prototypes and pilot plants.**
- **It is important to highlight that the TES based on PCM offers advantages over the command sensible heat storage in molten salt, especially the fact that the latent heat storage provides two to five times more energy per kilogram.**
- **It is worth noting that the system can be designed as dispatchable.**
- **Free Piston Stirling Engine is friction-free, has no crack or rotating parts and is built as a hermetically-sealed unit. These are essential factors to understand the free-maintenance of the SolarDish751 Stirling Engine the key advantage compares to kinematics solutions that have been traditionally used within the Dish/Engine industry**
- **Thalis Engineering, together with the rest of the Companies, has defined a well-organized Plan where the different steps and milestones are properly sequenced. In ATA's opinion… this preliminary plan is achievable, especially considering the important experience of the Companies in developing R&D programs**
- **ATA highlights that given the experience of the team, the relevant know-how within the Companies and with appropriate funding, the SolarDish751 product concept is feasible and achievable. And, following a demonstrated prototype, the final system could be a successful commercial product providing the electric grid with a valuable service of stable, dispatchable and clean energy.**

CSP in general addresses a vast geographical area around the whole globe, and according to the World Bank will be a “must have” for regions with high to excellent DNI. (Yellow to dark red area on map)

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