SOLAR ENERGY IN ISRAEL

MAPPING REPORT BY INNOVATION CENTRE DENMARK TEL AVIV

Ashalim solar power station in the Negev is the largest of its kind in Israel and fifth largest in the world. shows some of the 55,000 mirrors directing sunlight toward the Ashalim solar tower. Photo by Yonatan Sindel/FLASH90

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1. Abstract

Israel's location and climate allow a high potential for solar energy production. This report investigates solar and renewable energy development in Israel's past, and present, as well as future plans. It presents main players in the space such as existing and future government and independent initiatives. This report aims to develop a comprehensive resource of Israel's research and development in the solar energy field, as well as to gain an overall understanding of the future research and development of solar energy production methods. Specifically, it investigates the potential of Israel's energy grid, as well as technologies utilized for solar energy production such as the various solar energy plants in the Negev desert, and emerging technology in solar energy production and storage.

2. Introduction

The field of solar energy is a highly researched field in Israel, as over half of the country consists of desert terrain and climate proving its potential for solar energy. While solar energy constitutes less than 10% of the country's energy output, the Israeli government is determined to ramp up the county's production of solar energy to 30% of Israel's energy output by 2030[1], realizing the potential 8 billion shekels (2 billion euro) gain this development can provide to the economy yearly. In addition to this, many initiatives have cropped up focusing on utilizing the desert climate in Israel's southern region, such as the Ashalim power station, and the Aora's Solar Tower in Kibbutz Samar.

Solar panels near the Israeli parliament (The Knesset) Photo by Miriam Alster/FLASH90

The government has recently come forth with major initiatives to implement and improve Israel's production and storage of solar energy to reduce both costs and

[1] https://www.gov.il/BlobFolder/reports/future_energy/en/Transforming_the_Future_of_Energy.pdf

environmental pollution. One of the top reasons for this development is the desert climate covering over half of Israel proving the country's potential to exceed in implementation.

Overall, solar energy solutions are dominating the renewable energy sector with implementation strategies including scaling up technologies, expanding solar plants, and installing solar panels on private and industrial rooftops.

Following their goal to increase the production of solar energy, the Ministry of Energy announced new policy targets to achieve their goal. Additional ministries involved in this effort include the Ministry of Environment Protection, the Ministry of Finance, and the Ministry of National Infrastructures, Energy and Water Resources, as well as the Electricity Authority.

The policy aims to drastically change Israel's infrastructure, making it one of the leading in the OECD in the production of solar energy as green energy, rather than natural gas, and improve the country's economy. The national plan is to be evaluated in stages, with the aim for the end of 2025 to increase Israel's solar energy output to 20%. Judging by the results and progress in 2024, the ministry will reevaluate its goals for 2030. This is part of a greater process the country has undergone in the past few years in which Israel has been decreasing the usage of fuel oil, coal, and other pollutants, moving to natural gas and renewable energy. This process should lessen Israel's carbon footprint, and help create a dispersed, efficient, and competitive energy system.

As announced in the cabinet, the government will begin to take the following steps to implement this aim:

- Build solar energy plants in big lands and on top of buildings
- Issue a tender for the project of creating solar fields in the Negev desert
- Incentify entrepreneur with government loans to install solar panels on roofs/property of 500 square meters
- Implement tax cuts for those that use solar energy
- Issue a tender for a PPP (public-private partnership), inviting people in the Negev desert to build plants
- Issue tender for the project to oblige every building with a roof area of over 750 square meters to install solar systems on at least half their roof.
- Build storage facilities for renewable energies
- Engineer the electricity network to be capable of receiving solar energy

- Further investments in clean energy development - in October 2020, according to the Government Resolution 465, Section 12, there has been a decision for the Minister of Energy and Minister of Treasurer to search for areas in which they can increase investments in the field, while no specific number has been given.
- Increase the importation of electric cars into Israel.
- Strengthen existing natural gas plants, and beginning in 2021, implement restrictions on its export.
- In December 2020, The Israel-US Binational Industrial Research and Development (BIRD) Foundation announced that they will invest $7.15 million in eight joint clean energy projects that focus on commercializing clean energy technologies to improve economic competitiveness, create jobs, and support clean innovation. Each of the eight selected ventures involves one Israeli company and one American company, selected by the US Department of Energy (DOE), Israel's Ministry of Energy and the Israel Innovation Authority. [2]

[2] https://nocamels.com/2020/12/bird-foundation-energy-clean-projects-invest/

3. Israel's Energy Market

In order to understand Israel's ambitions in regard to renewable energy, we must gain a comprehensive view of the energy market in Israel to see which players are involved, how the current energy is made, and what steps have been taken so far to implement the transition to renewables.

The energy market in Israel is under the full control of the Israeli government. The Ministry of Energy and Water and the Electric Authority must approve every action relating to energy on the market, such as price changes, renewable energy integration, etc.

Since the 1920s, Israel has been producing commercial energy. The primary producer of energy was and still is Israel's Electric Company. It began as a public company and has since transitioned into a government-owned company. While at the start of the twenty-first century, the country discussed the positive outcomes to bringing competition to the market, it has yet to come into effect. While, until this day, Israel's sole energy producer and distributor remains the government-owned electric company, there has been a reform in the Electricity Company, planning to decrease their production of energy output from 75% as it is in its current state to 35% by 2025. They will implement this reform by selling their energy plants. While the company will still oversee the distribution of the electricity, they will not be the sole main producers by way of breaking their monopoly on the market. There are some private energy producers as well, yet they provide the energy to Israel's Electric Company to distribute through their infrastructure of high voltage lines.

There are multiple plants for renewable energy in Israel. There are four wind turbine fields and four hydroelectric power stations, eight biogas plants, and many solar energy fields using photovoltaic technology. Photovoltaic technology works according to the sun, generally estimated to produce energy from 8 am to 6:30 pm, yet it depends on the season and weather, producing less energy throughout the winter months in comparison to the summer. It produces the most energy when the sun is at its strongest, generally around 1 pm. There are various size fields with photovoltaic solar panels in Israel. These solar energy producers have an agreement with the Israeli government, ensuring the electric company will purchase the energy at a price that fluctuates according to the market's cost production.

Between 2004 - 2017 Israel's energy usage more than tripled itself. There are multiple factors involved in this increase:

- Population growth

- Increased quality of living
- Decreased pricing to import electronics from abroad
- Global warming increasing the need for air-conditioning
- People converting traditional energy in their homes, such as gas, to electric

The demand for electricity in the past has varied, while it is expected to grow by 2.5% to 3.8% a year, according to two different estimations.

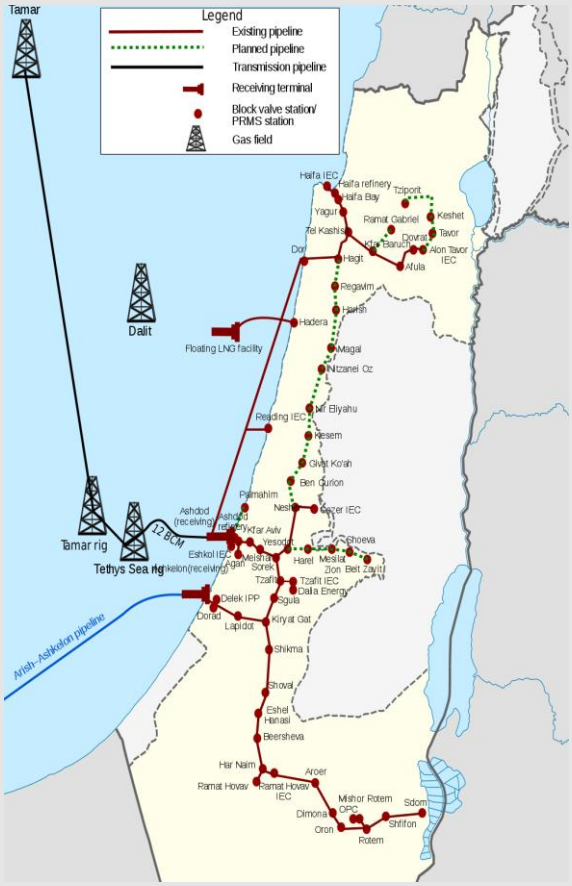
4. Israel's Ambitions

In 2002, Israel had begun the conversation that spans until today: discussing Israel's need to transition to more eco-friendly power sources such as solar, wind, water, etc. Their goals for the coming years marked 2016 as a milestone for Israel to transfer 5% of their energy output to renewable energy sources, and 2020 as the year for Israel to reach 10%. To this date, at the start of 2021, Israel has proved unsuccessful in this endeavor with under 10% of its energy output produced by renewable sources.

The vast majority of Israel's electricity is produced through the use of the following turbines: Steam turbines, gas turbines, gas turbines that integrate diesel and methanol, and gas turbines that integrate steam into their process. The current processes utilize many pollutants such as fuel oil, coal, diesel, and natural gas. To minimize the level of pollutants used, Israel aimed to increase the level of natural gas used to create energy as it is less harmful to the environment than the alternatives listed. This process to transition to less harmful natural gas began in the 70s when Israel began the search for natural gas. It was not until 1999-2000 that the country found substantial amounts to use toward energy production. Again in 2009-2010, they made another substantial discovery of natural gas which just grew within the coming years.

While Israel had discovered natural gas to create energy at the start of the century, they were not able to use it right away. In 2001, Israel began to build the infrastructure to be able to use natural gas for energy production throughout the country, and in 2004, finally, they began to implement and use natural gas for energy production. In 2005, Israel signed an agreement with Egypt allowing Israel to purchase this gas from Egypt, as Israel still lacked the substantial amount needed to produce large quantities of energy. This agreement was for 20 years and Israel officially began to receive the gas in 2008, however, due to the political situation in Egypt in 2011, they halted selling the gas to Israel the following year. Since 2013, Israel has been using its own natural gas found within the country to produce energy. As Israel found substantial amounts of natural gas, it has been exporting to other countries since 2017. As per the new policy to create more eco-friendly energies, Israel will decrease exports of natural gas in 2021 so that they can be used to produce less-polluting energy than coal and other alternatives. In the photo we can see a map of the Israeli natural gas network dated

2015.



From 0% of Israel's total energy output produced from natural gas in 2004, Israel has increased its numbers, reaching 61% in 2016, and nearly 70% in 2018 of energy output produced from natural gas. The exact breakdown of Israel's energy production in 2018 is as follows: 65% through natural gas, 30% through coal, and 5% through renewables.

This process with natural gas gives insight into why Israel has postponed implementing solar energy production according to their goals. In the OECD, Israel has the highest potential for solar energy production yet their goals have not yet reflected this potential for these reasons. As Israel sees natural gas as a sort of green energy, as it is less polluting than alternatives, it has focused resources on building the infrastructure necessary and gaining the proper resources to scale up the production of this energy. The Israeli government has been actively taking steps in the direction of clean energies, focusing on natural gas, while putting the focus on solar aside as Israel's natural gas local to the country can provide the country with electricity to last for many years. Israel does have plans to scale up its solar energy production to 30% by 2030, as explained in the introduction.

5. Initiatives

Over the years, Israel has had many initiatives throughout the stages of the country's development. The following are a list of initiatives:

- Solar water heaters: Since the fifties, Israel has been utilizing solar energy to heat water. In the sixties, it was a symbol of wealth to be able to afford solar powered water heating, while the heaters also received some backlash due to their negative aesthetic value and high installation price. In the seventies it became obligatory for every new home built - apart from tall buildings and the homes of the Old City in Jerusalem to preserve the view. This initiative reached 95% of Israeli homes, dropping to 85% in current day due to the construction of tall buildings. Altogether, it preserves 8% of the energy output yearly.

Image: solar water heaters on Israeli rooftops. Source: https://www.greenprophet.com/2009/08/israels-pioneering-use-of-bottling-solar-energy-now-has-many-following-suit/

As the Negev Desert has the highest level of sunlight in the country, with the most expansive area, it hosts an array of solar energy initiatives:

- Arava Power Company: Arava Power Company owns 20% of the photovoltaic power fields in Israel located throughout the Negev region, building the following projects: Ketura Sun, Revivim, Choval, Grofit, Yotvata, Elipaz, Maslul, Mitzpeh Ramon, and more.
- Kibbutz Samar: Kibbutz Samar in the Negev Desert is one of Israel's first to

create a thermo-solar tower in 2009 (as was similarly built on a larger scale in Ashalim), built by the company Aora. The plant uses hybrid solar power, switching from solar power during the day to natural gas-powered turbines after dark so that the plant can continue to produce energy around the clock.

- Ashalim: Negev Energy (Negev Energy Ashalim Thermo-Solar Ltd.) is the major funder of the thermo-solar power plant near the village of Ashalim in the Negev Desert, along with BrightSource, and Ashalim Sun PV. The plant generates green energy from thermal, and photovoltaic energy sources, as well as natural gas. The plant is the largest renewable energy project in Israel and growing, providing 1.6% of the country's total energy usage.

A view of the Ashalim thermal-solar tower in the Negev Desert, June 19, 2018. Photo by Miriam Alster/Flash90

- Neot Hovav Solar Field: Neot Hovav is a photovoltaic solar field made up of four hundred thousand solar panels on a field of 485 dunam. The field is built on polluted land that has been renewed for this purpose. This is one of Israel's largest solar fields, generating enough energy for 40,000 homes (over 1% of the country's energy output).

Looking ahead, Israel has plans for future initiatives for solar energy development:

- Solar Energy Plant Near Dimona: A tender was published in November 2020 for a new project to build a solar power station that both receives substantial amounts of energy during sunlight hours and during the evening as well as it stores the energy. The process is more cost efficient than gas or fuel powered energy. Currently, there are 27 companies interested in building this plant.

The amount of energy that this plant projects to create is over double the amount of Israel's largest energy plant. This shows that many Israeli companies have the technology to aggregate the energy generated by solar power in a more cost-efficient manner than the current energy market methods.

6. University & Research Related Stakeholders

Many leading Israeli institutions deal with solar energy research. The following is a list of institutions, research centers, and university departments, with leading researchers in the field.

- Israeli Energy Forum - of the Samuel Neaman Institute: The purpose of the Energy Forum meetings is to provide a platform where professionals can discuss specific energy-related topics.The reports serve as a working tool for the Ministry of Finance, the Ministry of Energy and Water, the Ministry of Environmental Protection and others.
    - **Dr. Shahar Dolev** is the research director of the Israeli Energy Forum, researching energy policy and technologies, and developing renewable energy projects.
- The Grand Technion Energy Program (GTEP): A multidisciplinary research and education initiative, uniting experts from across the world and inspiring sustainable solutions to the global energy challenge.
    - A lecturer in this department and innovator in nanoscale photocatalysis, **Prof. Lilac Amirav** works to split water to create fuel using solar energy.
    - In **Prof. Carmel Rotschild**'s research, he engaged with nano-scale devices for solar energy. These include; optical heat pumps, solar powered laser, nonlinear optics in incoherent light for efficient conversion of IR and short wavelengths to electricity, and engineering of thermal radiation.
    - **Prof. Nir Tessler** is the head of microelectronic and nanoelectronic centers at Technion. He has improved the efficiency photovoltaic cells by 50% (as stated in this report, in the chapter: Emerging Technologies)

Ben Gurion University:

- The Ben Gurion National Solar Energy Center: Dedicated to conducting renewable energy research, its research scope ranges from harvesting solar energy to storage, material science, optics, and surface physics, such as high concentration photovoltaics, physics of solar cells at very high efficiency, organic photovoltaics, highly concentrated electrolytes for supercapacitors and batteries, light-matter reactive metamaterials, and electro-molecular surfaces.

- Jacob Blaustein Institutes for Desert Research (in Sde Boker): Investigate ways to meet global challenges related to food security, water scarcity and clean energy.
- Blechner Center for Industrial Catalysis and Process Development: An active partner with the Ilse Katz Institute of Nanoscale Science and Technology in the establishment and operation of advanced facilities for characterization of nano-materials.
    - **Prof. Jeffrey M. Gordon** focuses his research on nanomaterials by highly concentrated solar and lamp light, advanced solar cells, innovative optics for solar concentrators and illumination, algae ultra-efficient bioproductivity.
    - **Prof. Moti Herskowitz**, Director of the Blechner Center for Industrial Catalysis and Process Development, published over 130 papers and 23 patents based on basic and applied research. Some patents deal with novel renewable and clean fuels as well as processes for their production. Others are related to environmental catalysis and green chemistry.
    - **Dr. Taleb Mokari** of the Department of Chemistry and the Ilse Katz Institute for Nanoscale Science and Technology focuses on creating hybrid nano-materials to generate green energy. He hopes to develop materials that would replace silicon-based solar panels and be both cheap and efficient
- Weizmann Institute Center for Energy Research: The institute aims to explore solar-driven thermal and chemical processes, enabling power production, fuel alternatives, long-term storage and convenient transportation options.
    - **Prof. Jacob Karni** investigates new methods of clean fuel synthesis by conversion of solar or thermal energy to chemical potential. For example, studying new methods of dissociating carbon dioxide and water to syngas (a mixture of H2 & CO) and O2 at high temperature.
    - Director of the Center for Energy Research, **Doron Lieberman** conducts research in the solar field.
- Center for Renewable Energy and Energy Conservation - Arava Institute for Environmental Studies: Established in August 2008 and directed by Dr. Tareq Abu Hamed, the Center for Renewable Energy and Energy Conservation (CREEC) is an integral partner in the Arava region's rapid progress to become Israel's "Silicon Valley" in research, development, and technology of

renewable energy.

- Directed by **Dr. Tareq Abu Hamed**, the center conducts research in a wide variety of subjects focusing on energy policy, solar fuels, photovoltaic technologies, biomass, wind and solar thermal energy, as well as innovative building construction techniques customized to conserve energy in desert climates.

Tel Aviv University:

- Renewable Energy Research Center (Tel Aviv University): Research in the field of solar energy: having developed and registered patents for a solar cogeneration technology – the first of its kind to simultaneously produce electricity and heat, which could serve as the world's most efficient solar energy converter; Energy conservation, having registered several patents for a new technology – the world's smallest, simplest and most effective so far – that could dramatically reduce fuel consumption of trucks; and more.
  - **Prof. Joseph Appelbaum** is a researcher in the following fields: Optimization methods for electromagnetic devices; Electrical machines and drives; Solar energy; Photovoltaic systems (terrestrial and space), Solar radiation on Mars.
  - **Prof. Abraham Kribus** researches solar energy, energy conversion - photovoltaic, thermal, and thermionic, energy storage, renewable fuels, thermodynamics of power plants, radiation and convection heat transfer.
  - **Prof. Diana Golodnitsky**'s research focuses on synthesis, characterization of materials and study of ion-transport phenomena in new nanostructured electrodes and solid electrolytes for energy-storage devices.
- Department of Environmental Studies (Tel Aviv University): The Department initiates and develops innovative research and teaching fields, which have relevance to environmental studies, raising environmental issues to the public agenda and promote discourse in the local and national levels, as well as constructing collaborations for environmental betterment with all relevant factors: environmental organizations, government ministries, local government, public sector, business enterprises and industrial factories.
  - **Dr. Nir Naftali** is a lecturer in this department with a wide and extensive background in physics, including infrared radiation, lasers,

sensors, non imaging optics and renewable energy. He is an expert in the use of solar energy, such as photovoltaic cells and solar-thermal energy.

  - **Dr. Taleb Mokari** has recently been awarded an ERC grant from the European Commission for 1.5 million Euros to further his pioneering work in the field of photovoltaic nanomaterials.

- Etgar Research Group of the Hebrew University: Etgar's research group focuses on the development of innovative solar cells, concentrating on functional materials for solar energy application and the assembly and the characterization of the solar cell.

  - **Prof. Lioz Etgar**'s research group focuses on the development of innovative solar cells. Prof. Etgar is researching new excitonic solar cells structures/architectures while designing and controlling the inorganic light harvester structure and properties to improve the photovoltaic parameters.

7. Relevant Stakeholders

As mentioned in the introduction there are many stakeholders in the solar energy industry in Israel especially from the government:

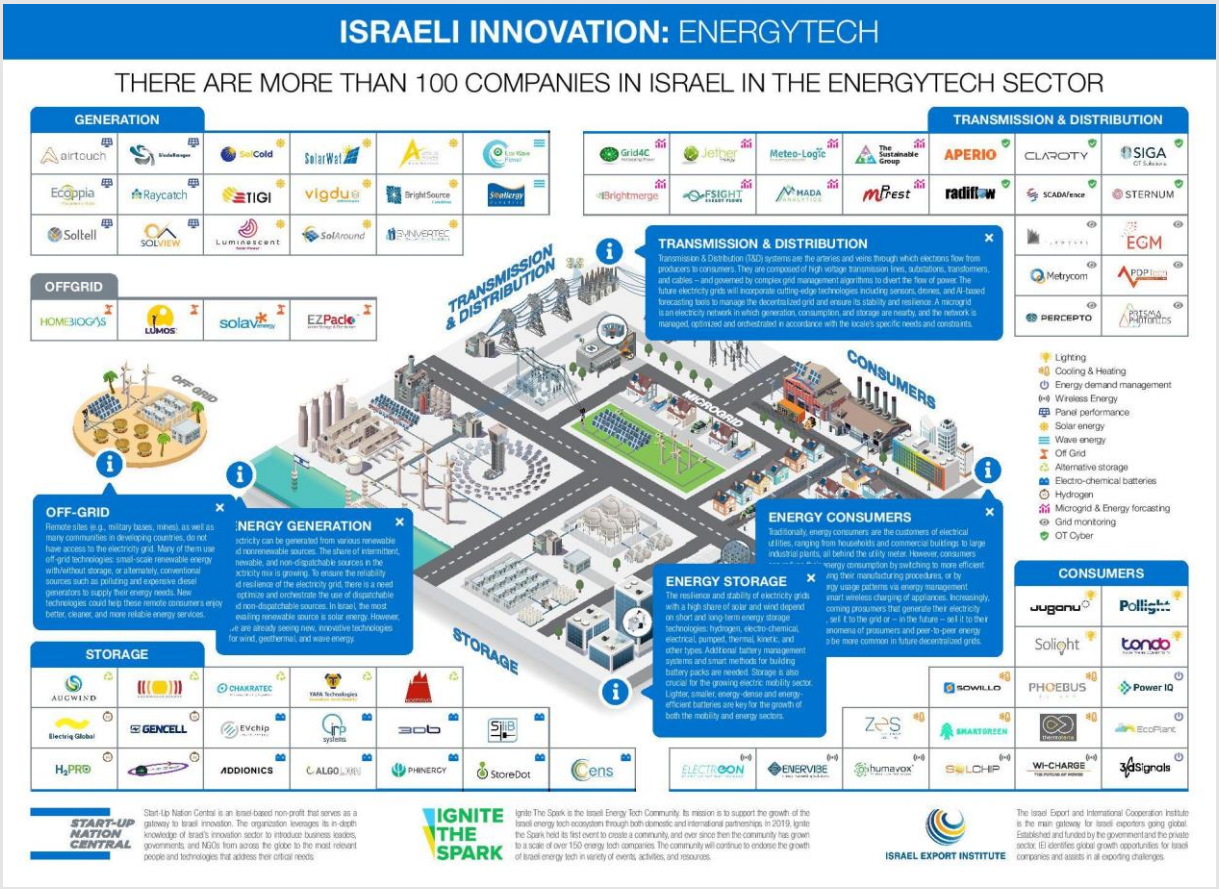
- Ministry of Environment Protection
- Ministry of Finance
- Minister of National Infrastructures, Energy and Water Resources
- Ministry of Energy
- The Electricity Authority

Organization:

- Green Energy Association of Israel (GEA-IL)
  - Lists of members as part of the association - companies engaging in renewable energy.
  - List of companies' part of the association that build infrastructure for renewable energy.

Startups and Technology providers:

As Israel proves efficient in the installation of solar energy publicly and privately, there are many companies that excel in the field, innovating solutions to maximize energy output efficiency. The following startups specialize in designing and implementing solar energy efficiency and energy management projects utilizing photovoltaic technology. They provide design, construction, and maintenance to ensure maximum energy output, and streamlining processes. Some of these companies provide solutions for private homes, and some in industrial and commercial sites, working in Israel and internationally.



Source: startupnationcentral.org

While most of these startups perform all of the following, they are divided into categories based on their specialization:

- Engineering and design:
    - Solar Edge
    - Ormash
    - Nofar Energy
    - Enerpoint
    - Keren Shemesh
- Improving efficiency:
    - Scala Energy
    - Senergy Site
    - Kedma Solar

- Green tops

- Implementation and Installation:
  - Fa Energy
  - Green Edge
  - Inbar Solar
  - Israelse
  - Tadmir
  - Tahlit Solar
  - Amit Sun Solar
  - Smart Solar
  - Solar Green
  - Rakia
  - El Mor Re
  - Green Insight
  - Magalim
  - Greenco Energy
  - E Systems
  - Sun Benefit
  - Menergy
  - Selatash
  - Freenergy
  - Shahar Energy

8. Emerging Technologies Within Solar

In this chapter we will be discussing emerging technologies within solar energy and each technology's respective potential:

- Hybrid photovoltaics: this method utilizes solar panels installed on building roofs or private homes for individual or business gain. While the solar panels generate energy, hybrid technology does not depend solely on solar energy. The solar panels provide energy in times of sunlight, but during the evenings and cloudy weather, the homes or buildings utilize an alternative source of energy. This can be in the form of standard connection to the power grid, through a generator, or another renewable source - such as wind turbines to provide energy in the windy winter months. This way, solar energy is used when possible creating green and cost-efficient power, however, there is always an alternative source of energy to rely on.

  Most of the use of solar energy in Israel is hybrid, utilizing the electric company's power grid, as there are not yet substantial storage methods for solar energy in Israel. Additionally, many of the solar power plants incorporate other means of electricity production. Now, Israel has begun the process of building storage facilities for solar energy so that the country can rely more on solar energy sources.

- Organic photovoltaics: This technology utilizes organic cells, generally made of polymer solar cells (also known as plastic solar cells.) These cells can absorb sunlight and generate energy utilizing the photovoltaic effect. These cells have great potential as they can be designed in any shape and form as they are printable and can be printed according to specific requirements, flexible - unlike traditional solar panels - lightweight, with semi-transparent qualities that can be used to generate shade in sunny areas while it has the dual purpose of absorbing the sunlight. The cells can be printed as an extremely thin layer, allowing 1 kilo of the material to cover an entire football field, thus these cells can cover lots of ground, buildings, and other outside areas to generate energy. Carbon based, as opposed to metal, the material is more environmentally friendly than panels. It also has the advantage of durability: while solar panels do not fare well during winter months, these cells are durable throughout snowy weather conditions.

  The conversion potential of organic cells can be further utilized, according to Israeli researcher, Professor Nir Tessler, head of microelectronic and nanoelectronic centers at Technion. By changing the structural aspects, he has developed the cell to improve the efficiency of converting solar energy into electric current inside the cell, improving the efficiency of organic

photovoltaic cells by 50 percent.

Israeli designer Anai Green has utilized this technology to develop an outdoor fabric for urban shading that is embedded with organic solar cells to provide lighting at night. Her application can be used in a variety of ways, from umbrellas to large canopies.[3]

Illustration by Anai Green of Lumiweave which won one of four prizes at this year's international Women4Climate Tech challenge. (Credit, Anai Green)

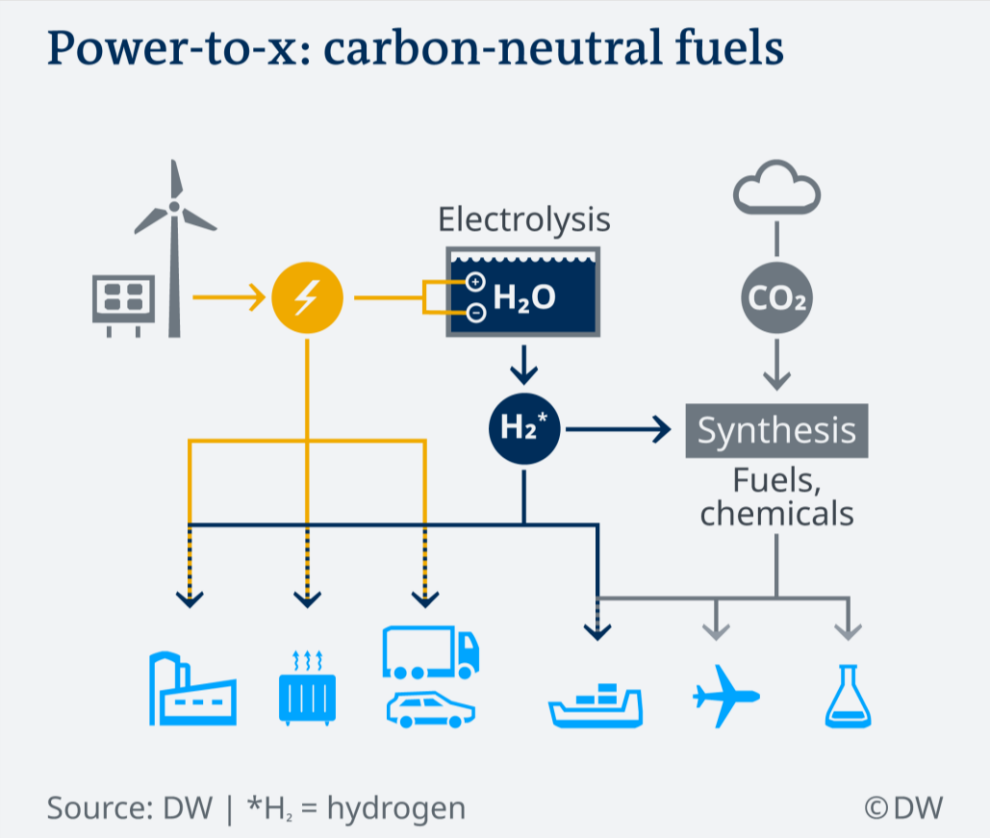
- Perovskite photovoltaics: This technology utilizes perovskite solar cells, a type of solar cell which includes a perovskite-structured compound which has a low-cost production rate and simple manufacturing process. The main advantage is the low-cost manufacturing rate, as well as the ease of production. The cells can be printed, they are thin, lightweight, and flexible, and absorb energy efficiently.

  Israeli researchers Avi Schneider, Ariel Efrati, Stav Alon, Maayan Sohmer, and Lioz Etgar of the Excitonic Solar Cells-XSC Etgar research group of Hebrew University[4] contribute to this development, studying perovskite solar cells and its promise in the field of solar energy.

[3] https://w4c.org/profile/anai-green

[4] https://www.pnas.org/content/117/49/31010

Power to X: This refers to the process of taking existing power and converting it through a chemical process into another energy source, such as gas or liquid fuel. This process is effective for two reasons: Firstly, power generated by renewables is dependent on outside factors and cannot be relied on as a constant. By translating the energy into other sources, it can be stored for later use. Additionally, not every system is receptive to renewable energy such as transportation which runs on fuel. By converting renewable energy into fuel, it can be used as an alternative to fossil fuels and other harmful materials. This process can result in a significant drop in greenhouse gas emission.



- Power to liquid: in this process, water is converted to hydrogen. Combining hydrogen with carbon dioxide creates a carbon neutral fuel that can be used to power cars and airplanes powering them with this green energy source, minimizing the emission of harmful greenhouse gas.
- Power to gas: in a similar manner, natural energy can be converted into gas for use in the home, or other purposes, utilizing green energy.

In Israel, we can see this technology utilized through different research institutes and companies. A collaboration between The Technion – Israel Institute of Technology, Ben-Gurion University of the Negev, and the Weizmann Institute of Science have won a tender to create an Israeli Center for Research Excellence (I-CORE) focusing on

renewable liquid fuels to further develop research in the technology as explained above.

The research group consists of 27 senior researchers leading in production of biomass, photo-catalysis of CO2 and water to fuels, gasification of biomass and production of liquid fuels from biomass and mixtures CO2 and water. Some of the researchers from Ben Gurion University involved include Prof. Moti Herskowitz, Director of the Blechner Center for Industrial Catalysis and Process Development and Vice President and Dean for Research and Development, and Prof. Sammy Boussiba, Director of the French Institute for Agriculture and Biotechnology of Drylands. Another researcher involved is Dr. Taleb Mokari, who has recently been awarded an ERC grant from the European Commission for 1.5 million Euros to further his related, pioneering work in the field of photovoltaic nanomaterials.

The Israeli company, SWAP Technology is a major innovator in renewable energy storage, tackling this challenge of matching power supply and demand when producing energy from renewable sources. SWAP Technology founded by MSc. Shay Cohen, Dr. Or Yogev, and Joshua Mesinger - a private investor, partnered with the company Augwind, and developed a system that stores energy and enables the energy to be dispatched between peaks to off-peak times. The system that they developed consists of several water and air tanks connected to hydropower turbines. Through force, the air and water tanks are pressurized through the cylinders, providing a means for energy storage.

9. Conclusion

Israel, a small Mediterranean and Middle Eastern country with over half the country covered in a desert climate ideal for solar energy innovation, has much potential for further innovation and development in the field of solar energy. Since the fifties, Israel had begun to use solar-powered water heaters, and now it is implemented in 85% of the country's homes. Looking into other of Israel's existing initiatives, as well as future plans for expansion and growth, we can see the emerging technologies within the field of solar energy in Israel and internationally that can be utilized in other such climates specifically, as well as around the world.

The Negev Desert is home to many initiatives and emerging initiatives in the space of solar energy as both the climate and land allow for solar fields to be developed. It is home to existing and developing photovoltaic, thermo-solar, and hybrid technologies.

While expanding to renewable sources of energy production, Israel has faced difficulties such as: Israel's grids development to accept solar energy. Infrastructure development will allow solar energy to be more usable once it becomes cost efficient for the country to invest in.

Taking example from the existing initiatives and emerging technologies, this report will serve as an example for further development in the solar energy field.