SOLAR SOLUTIONS HANDBOOK

SUPPORTING RECOVERY AND STABILITY IN IRAQ THROUGH LOCAL DEVELOPMENT PROGRAM

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PROJECT BACKGROUND

Launched in December 2021, the project Reinforcement of Erbil governorate's Capacities in Producing and delivering solar energy aims at implementing sustainable solar-based solutions to address the challenges of electricity distribution and strengthening the capacities of local government on financing and investment conditions. The project, funded by the European Union and implemented by FMDV in partnership with UNDP, is part of a national program to support the strengthening of local governance and decentralization in Iraq, seeking to improve living conditions in fragile contexts by rehabilitating and improving housing and community infrastructure and services.

Through demonstrative pilot actions based on solar energy solutions, the program's overall objective is to promote a more sustainable, affordable, smart, and low-carbon service provision in Erbil Governorate while reducing its environmental footprint and improving the quality of life for citizens.

In particular, the project aims at increasing the knowledge and capacities of the Governorate through peers-to-peers cooperation to support the development of solar energy solutions to contribute to filling in the production gap via demonstrative pilot actions and to prepare a scale-up phase being proposed to international donors and investors.

This publication is prepared to support the "Building and strengthening capacities and knowledge of local government" component of the program by developing knowledge materials through the realization of a handbook on solar energy solutions.

This handbook aims to guide local authorities on the most relevant and efficient solutions to be developed on their public domains and facilities, to reduce their carbon footprint and energy bills.

This handbook aims to support local government in promoting the use of solar solutions among the population and explore ways of incentives'

mechanisms tested in the region, in Europe, or worldwide.

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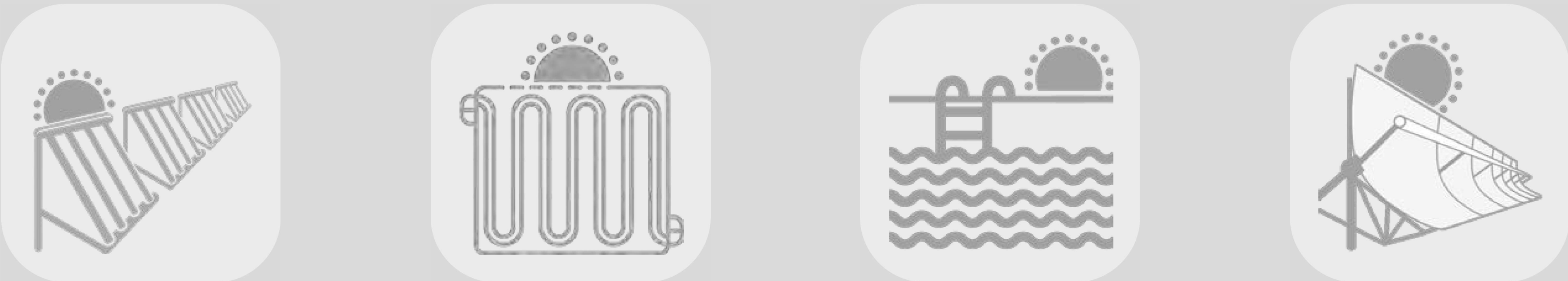
ABBREVIATIONS AND ACRONYMS

$	United State Dollars
°C	Degree Centigrade
CCGT	Combined Cycle Gas Turbine
CO_2	Carbon Dioxide
CSP	Concentrated Solar Power
DC	Direct Current
ESCO	Energy Service Company
FMDV	Global Fund for Cities Development
GEF	Global Environment Facility
ha	Hectare
hp	Horsepower
kWh	Kilo Watt Hour
kWp	Kilo-watt Peak
kW_{th}	Kilo-watt Thermal
LCOE	Levelized Cost of Electricity
LCOH	Levelized Cost of Heat
LED	Light Emitting Diode
m^2	Square meter
MW	Mega-watt
MWh	Mega Watt Hour
PV	Photovoltaic
RFP	Request for Proposal
SEAP	Sustainable Energy Action Plan
SECAP	Sustainable Energy and Climate Action Plan
SSL	Solar Streetlighting
UNDP	United Nations Development Programme
USD	United States Dollars

SOLAR THERMAL



THE WORKING PRINCIPLE

Solar water heating utilizes free solar energy and converts it to useable forms of thermal energy, whether in the form of hot water, hot working fluid, or steam.

Solar irradiance is absorbed through a black body, where it heats a working fluid to provide hot water or steam through either direct or indirect heating, and done in an active or a passive model.

In the case of the hot working fluid, it is used to heat water through heat exchangers, whereby end-use water is heated and then delivered to the final point of use.

Similar to that is the case of hot water, which could also be used more efficiently and directly for domestic hot water consumption, direct laundry, or industrial process use.

In the case of steam generation, which is usually generated through concentrated solar power, it is used in steam laundry systems but more widely runs through steam turbines and generates electricity at both domestic and utility scales.

DIRECT	INDIRECT
The heated working fluid is the end-use water itself	The heated working fluid is used to head the end-use water
The system is more efficient with less heat transfer losses	A heat exchanger or heat exchange unit is needed
⊕ Less thermal losses ⊕ Unit cost is less ⊕ Conventional system	⊕ Can accommodate freezing ⊕ Allows system customization ⊕ More robust

PASSIVE	ACTIVE
Working fluid moves freely without the need for a pump	A pump or a moving motor is required to move fluid
Thermosiphon operation is the most common type	Commonly known as the forced circulation system
⊕ Longer life of components ⊕ No need for external energy ⊕ Less capital investment	⊕ No limitations on distance ⊕ Can be remotely controlled ⊕ Can be of ample capacity

SOLAR THERMAL COMPONENTS

1 COLLECTOR

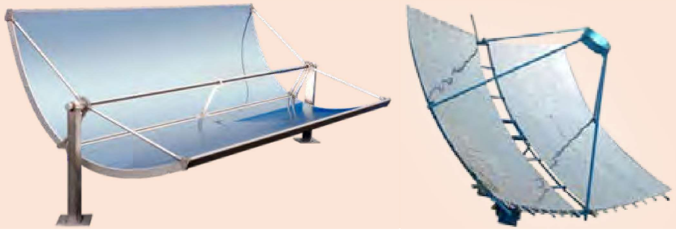
The solar collector is the main component, which receives solar radiation and transforms it into thermal energy.

Collectors' efficiency varies by type and application, with the latest technologies reaching efficiencies nearing 90%.

Flat Plate Collectors

Evacuated Tube Collectors

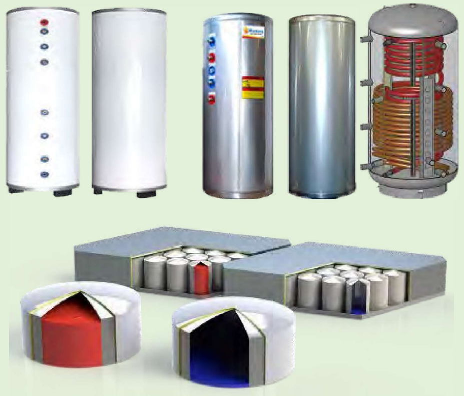
Concentrated Solar Power



2 STORAGE

Thermal energy is stored for later usage on demand.

It is typically done in hot water tanks, with other media such as molten salt.



3 MOVING DEVICE

In the case of an active system, a moving device is needed to move the working fluid, such as a circulator pump.

Moving devices usually include the use of a control system that operates using differential thermostats and temperature sensors.

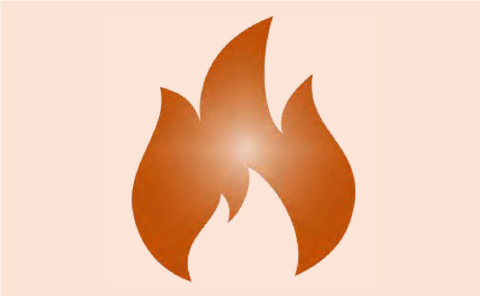
4 TRANSPORT

The working fluid is transported from one location to another through insulated and well-protected pipes.

SOLAR THERMAL IMPACT & BENEFITS

Characterized with the highest efficiency among solar applications reaching more than 80%, solar thermal applications are highly recommended for water heating applications through heating water, producing steam, and preheating applications.

Solar thermal applications can also be used to generate electricity through high-temperature concentrated solar thermal systems that produce extremely high thermal energy fluid and run turbines or other electricity generators.

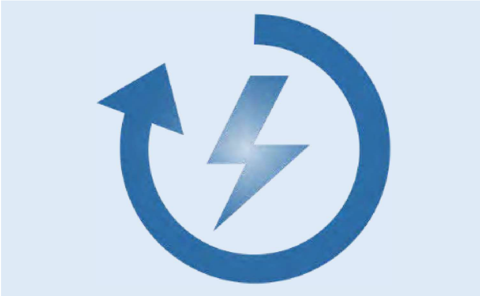


CHEAP HOT WATER

Solar can heat water at the cheapest cost, with thermal efficiency reaching 80%.

With higher capital expenses and nearly no operating expenses, a solar water heater would pay back in 4 years.

20-YEAR LIFECYCLE COST ANALYSIS OF 500-LITER WATER HEATING OPTIONS (USD)	
DIESEL HEATER	$20,000
ELECTRIC HEATER	$12,000
GAS HEATER	$15,000
SOLAR HEATER	$7,500

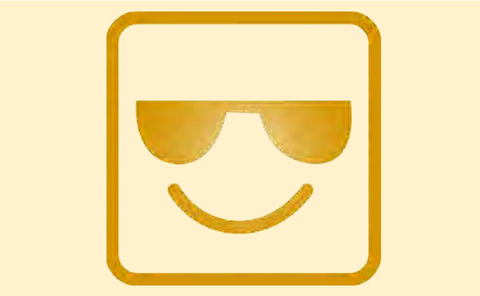


ALTERNATIVE ELECTRICITY

Using concentrated solar power, steam and electricity could be generated.

Using solar for electricity offers energy security and diversification of sources but is more expensive.

LEVELIZED COST OF ENERGY FOR A 1 MW ELECTRICITY GENERATION PLANT (USD/MWH)	
COMBINED GAS CYCLE	$80
DIESEL POWER PLANT	$120
PV POWER PLANT	$70
CONCENTRATED SOLAR	$180



IMPROVED COMFORT

When used for domestic applications, comfort is rated high among solar benefits.

Solar water heaters create a feeling of comfort with the availability of hot water almost all the time.

SEASONAL CONTRIBUTION OF DOMESTIC SOLAR HEATING SYSTEM IN IRAQ	
JANUARY	45%
APRIL	80%
JULY	100%
OCTOBER	65%

GHG REDUCTION

Solar heaters are emission-free, heating water with no greenhouse gas emitted.

Greenhouse gases are only emitted when using backup heating systems during low solar levels.

ANNUAL GREENHOUSE GAS EMISSIONS OF 500-LITER WATER HEATING OPTIONS (KG $CO_{2\text{-EQ}}$)	
DIESEL HEATER	7
ELECTRIC HEATER	5
GAS HEATER	6
SOLAR HEATER	1

SOLAR THERMAL APPLICATIONS

SOLAR WATER HEATING

THE TECHNICALITIES

Solar for water heating is by far the most widely used and mature application of solar, with probably the highest return on investment and the most attractive financial performance.

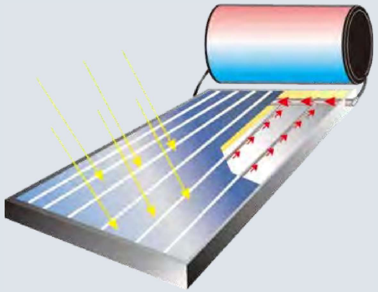
UNITARY HEATING SYSTEMS

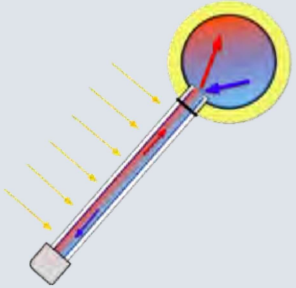
Unitary solar water heaters are massively used for residential domestic water heating applications, with individual units usually on rooftops to replace conventionally used electric heaters.

Different types of Unitary Solar Water Heaters

Unitary systems comprise a few solar collectors and a hot water tank that could be either attached to panels, working by gravity, or installed at a different location, working with a circulating pump.

Configurations of Unitary Solar Water Heaters





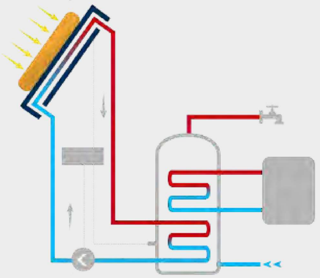
COLLECTIVE HEATING SYSTEMS

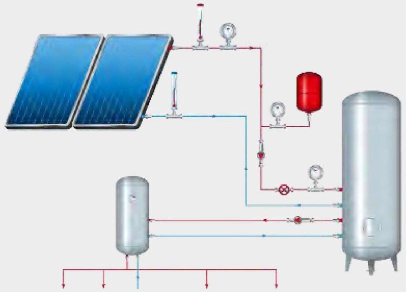
For large domestic hot water applications, collective solar heating systems produce large hot water capacities, usually exceeding 1,000 liters of storage.

Forced Circulation Collective Solar Water Heaters

Such a configuration requires a delicate thermal control system that manages water circulation through a water pump and heat transfer between the solar collectors and the hot water storage volume

Configurations of Collective Solar Water Heaters





FEASIBILITY & APPLICABILITY

Iraq has the perfect conditions for solar water heating, with high radiation levels, significant market potential, and attractive returns.

A 200-liter solar water heater in Erbil can provide hot water to a house of five, fulfilling hot water needs on at least 282 days of the year. Such a system would achieve cost savings of more than $250 a year, with a simple payback period of 4 to 6 years.

HOUSEHOLD APPLICATIONS

Unitary solar water heaters are the perfect fit for household applications. Thermosiphon systems remain the most common and feasible option due to their ability to operate autonomously, with no need for external power. It just needs the cold-water supply tank to be elevated, and water would be supplied by gravity. If tank elevation is not possible, a forced circulation option could be used, with a pump needed to move water. This has some disadvantages, including higher cost, electricity need, and shorter hot water tank life due to pressurization.

INSTITUTIONAL & COMMERCIAL APPLICATIONS

Solar heaters can supply more significant amounts of hot water for intuitional and commercial facilities, such as hotels, hospitals, sports centers, barracks, and others. This could be done by utilizing separate unitary units but much more effectively and reliably through collective forced circulation systems, whereby hundreds of square meters of solar collectors would be installed on rooftops to supply high-temperature water to large 1,000+ liter storage tanks. The process is controlled through a differential thermostat system that only operates the pump when the system is producing water hotter than that in the tank. Hot water is stored in the insulated tanks and withdrawn by users when needed.

CYPRUS: A SOLAR WATER HEATER FOR EVERY HOUSEHOLD

Cyprus is the world's leading country when it comes to solar water heaters utilization, exceeding a 90% penetration rate, with almost every household using solar to heat domestic water.

Cyprus' efforts started back in the 90s through supporting policies, incentives, and promoting programs that led to a cumulative installed capacity of more than 430 kW_{th} per 1,000 inhabitants by 2018, which was surpassed by Barbados only.

The extensive utilization of solar water heaters massively reduced reliance on electricity and shaved valuable MWh during peak periods, helping the electricity utility reduce the peak power requirement

In May 2022, the cabinet approved a €600,000 incentive scheme to support households in the replacement of existing solar water heaters that are approaching their end-of-life time, offering a subsidy of €450 per system, and an additional €450 for mountainous areas, targeting a total of 1,300 households a year.

The cabinet's support for this incentive is based on the feasibility of solar water heaters, saving more than 80% on water heating bills.

SOLAR SPACE HEATING

THE TECHNICALITIES

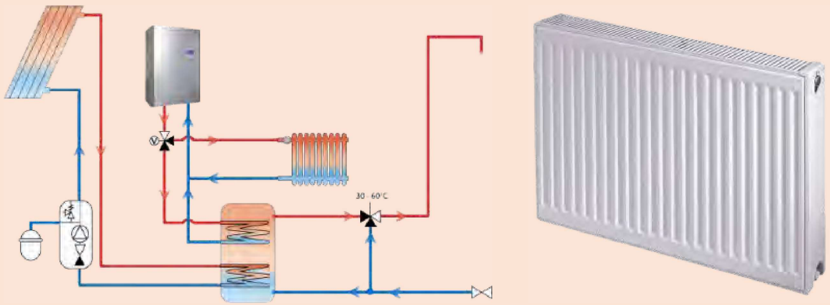
Solar thermal systems can heat indoor spaces by providing hot water to domestic hydronic heating applications, utilizing radiation and convection heating concepts.

DECENTRALIZED SOLAR SPACE HEATING

Solar thermal systems can be integrated into existing hydronic heating systems and newly designed networks. Hydronic space heating is achieved by heating water using a boiler system and circulating it to radiant heaters to heat indoor spaces.

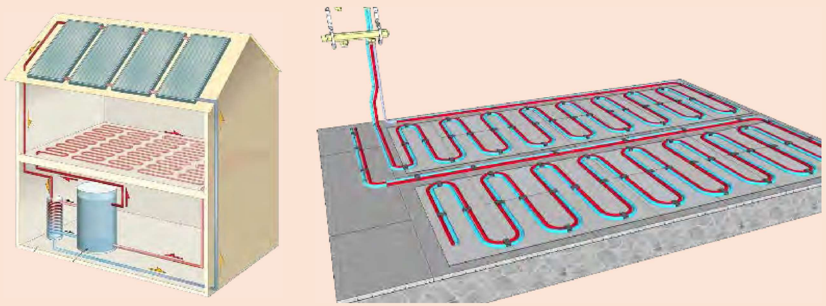
Wall radiators are the most commonly used element for heat transfer, requiring hot water at 80°C.

Solar Radiator Hydronic Heating System



A practical option that works best with solar is underfloor heating, whereby pipes are laid underfloor, and warm water flows at 40°C.

Solar Underfloor Heating System



SOLAR DISTRICT HEATING

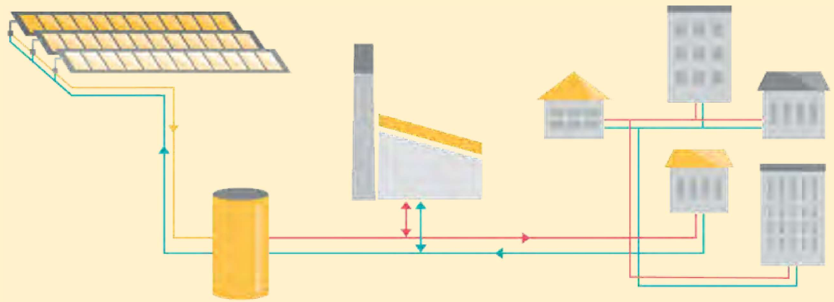
Solar space heating can get as large as it gets. The concept of solar district heating involves large fields of solar thermal collectors producing large volumes of hot water and storing it in massive storage tanks that could be water or other thermal storage media.

Solar district heating can supply hot water to villages, communities, camps, or commercial areas.

Solar District Heating Plant

Produced water can be used for space heating, as well as domestic water consumption, process heat, and other applications.

Configuration of Solar District Heating



FEASIBILITY & APPLICABILITY

Space heating is needed most during cold weather, while solar radiation is the lowest during that period. This alone makes solar space heating a less attractive solution in an area such as Iraq.

Considering the climatic conditions in Iraq, space heating would be highly demanded during three months of the year and less demand during 2 to 3 other months. With the lack of proper and effective storage technologies, such as phase change storage material, solar space heating is less feasible than conventional solar water heating.

RESIDENTIAL SPACE HEATING APPLICATIONS

Solar residential space heating would be most practical when applying underfloor heating since solar thermal systems can quickly achieve the operating temperature of 40°C required for such systems. The situation would be less feasible when using solar thermal for radiators hydronic heating, and there would be high demand for auxiliary heating systems to achieve the working target temperature of 80°C.

MULTI-PURPOSE SPACE HEATING CONCEPT

To overcome the small impact of solar space heating due to its limitation to cold months, the overall feasibility of such solutions would massively improve when coupled with another application demanding hot water during warmer months, such as pool heating.

DISTRICT SPACE HEATING

The concept of district heating requires significant infrastructure work and urban planning, making it difficult in existing cities, especially where hot water production is decentralized, like in Iraq.

District space heating coupled with solar would be an interesting pilot project to try out, but with less optimistic financial returns.

THE WORLD LARGEST SOLAR THERMAL SYSTEM IN SILKEBORG OF DENMARK

The city of Silkeborg has a target to become carbon neutral by 2030. Towards this ambitious target, the city implemented the world's largest solar thermal plant with 12,436 solar collectors, and a capacity of 110 MW, covering an area of more than 50 hectares.

Silkeborg's solar thermal plant supplies up to 20% of the city's annual heat consumption, providing 22,000 households and workplaces with hot water for domestic and space heating use.

The plant is designed to produce 80,000 MWh of heat annually, reducing more than 15,700 tons of carbon emissions annually.

Water heated by the solar panels is transmitted over 22 km of piping to four specialized mega heat exchangers, each with around 900 plates, to transfer energy at the highest efficiency.

On a sunny day, the plant supplies 2.7 million liters of hot water per hour, covering 100% of the heating demand of the 22,000 units. Surplus heat is stored in tanks for later use.

WANT TO IMPLEMENT SOLAR WATER HEATING SOLUTIONS?

CONSIDER THIS

1. Evacuated tube solar collectors achieve higher temperatures and have higher efficiency. Still, flat plate collectors are more versatile and less likely to break due to thermal and mechanical shock.

2. Individual systems are best done through thermosiphon design to avoid using pressure pumps. A pressure pump would require electricity to operate and could cause pressure damage to storage tanks.

3. Collective systems offer larger storage volumes, working best for public institutions like hospitals, schools, and universities. For these systems to work perfectly, delicate attention should be given to the differential thermal control scheme.

4. Design the system based on the average daily demand during average seasons, and size the system based on international standards of daily hot water demand to cater to users' needs properly

Residence	40 lit/person	**School**	7 lit/student
Hospital	90 lit/bed	**Office**	3 lit/person
Hotel	60 lit/bed	**Barrack**	100 lit/person

SOLAR POOL HEATING

THE TECHNICALITIES

Solar works fine for heating swimming pools, especially during summertime, without needing high-efficiency solar panels, providing a target water temperature of 20 to 25°C.

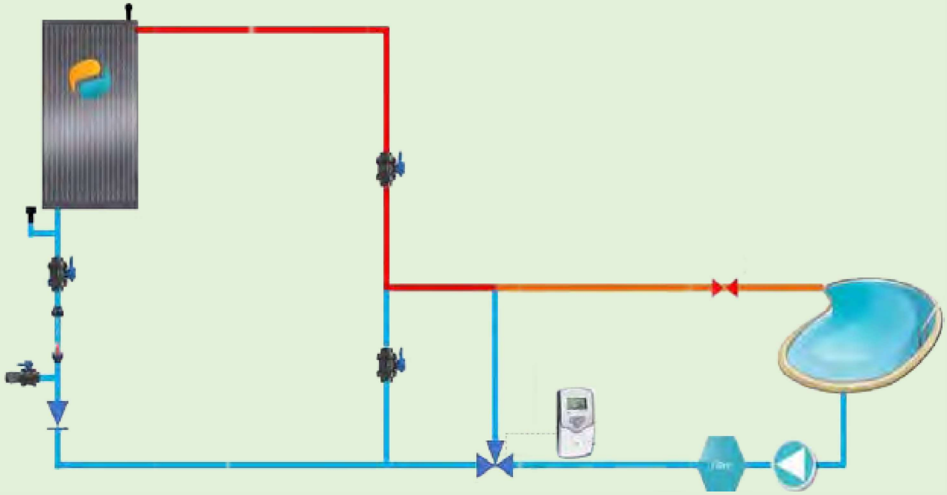
DIRECT POOL HEATING

Swimming pools are usually heated by heat pumps or fuel boilers. Collectors are typically installed by the pool or on a nearby roof.

Pool Heating Collectors

Through direct pool heating, the same water heated is pumped into a pool, reducing thermal losses and allowing for faster heating.

Configuration of Direct Solar Pool Heating



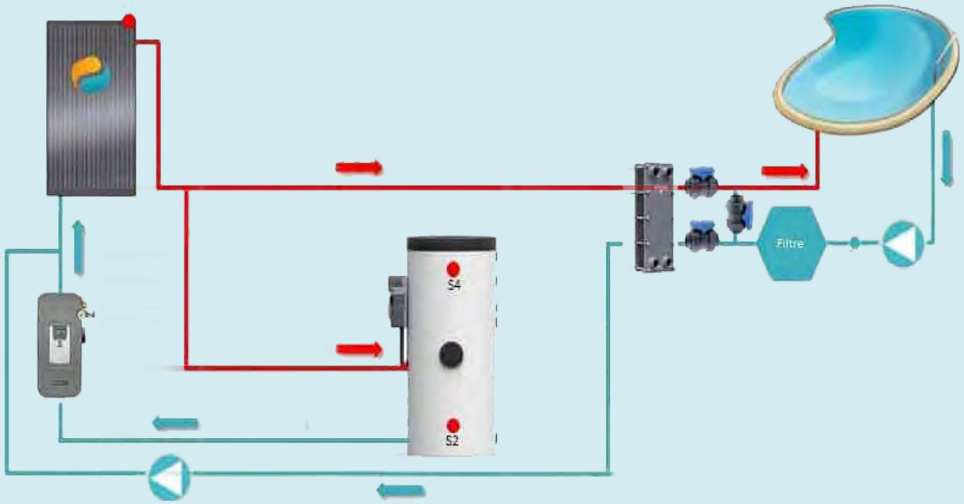
INDIRECT POOL HEATING

Some sophisticated pool heating systems use a heat exchanger to heat water indirectly, with panels usually on roofs.

Pool Heating Collectors

Indirect pool heating allows using working fluids, with water not necessarily required to be clean.

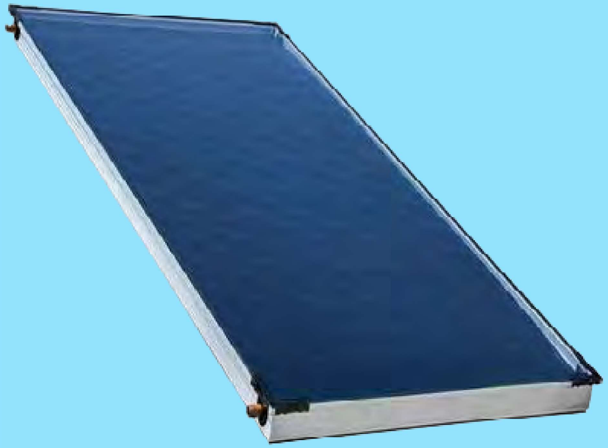
Configuration of Indirect Solar Pool Heating

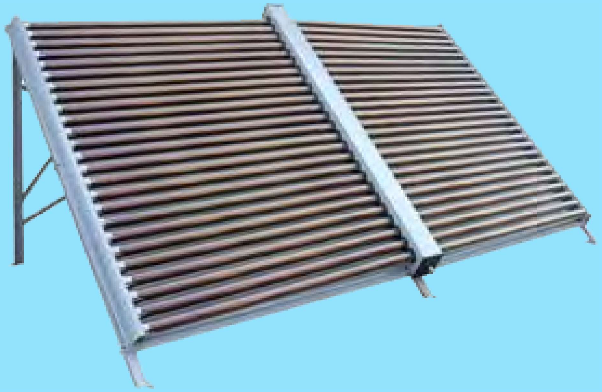


Pool heating applications could work even with the lowest efficiency solar panels that do not have to be insulated, glazed, or adequately quoted. Different types could be used with various topologies but share the same working principle, through which water or the working fluid moves through pipes or heating elements and collect thermal energy from solar radiations.

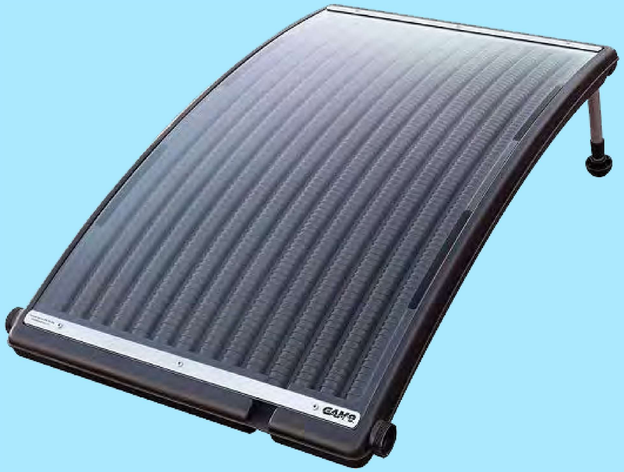
Types of Solar Collectors for Pool Heating

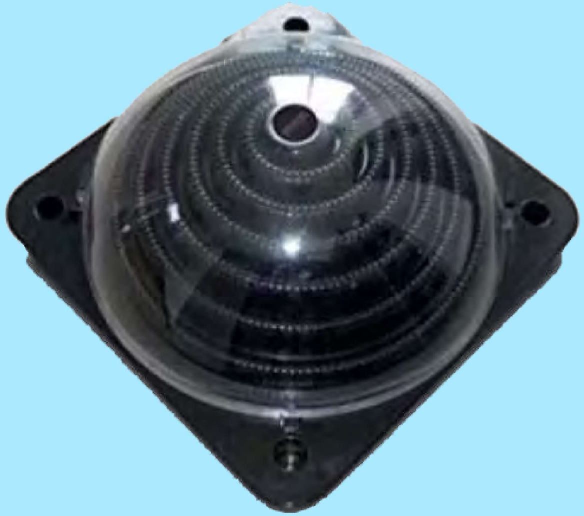
GLAZED METAL COLLECTORS



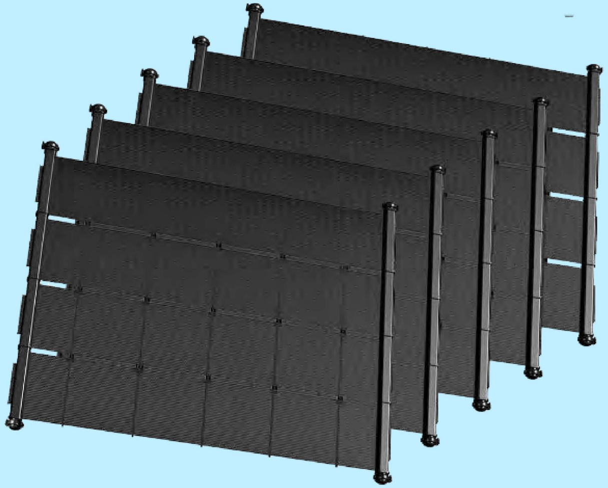


GLAZED PVC COLLECTORS





UNGLAZED PVC COLLECTORS



FEASIBILITY & APPLICABILITY

The good thing about solar pool heating is the sufficiency of low hot water temperature, which allows cheaper solar collectors, sometimes comprising of just black PVC pipes.

A typical solar pool heating system would save at least 75% of the summer pool water requirements, reducing the dependence on other heating sources to early morning and late evening.

A solar pool heating system can pay back its investment in less than four years, averaging two years in a typical application in Iraq, benefiting from the high summer solar radiation levels.

RESIDENTIAL POOL HEATING

Direct solar pool heating works best for residential systems, where hot water demand is limited and can be adequately and efficiently managed.

Such systems could utilize simple PVC pipes without needing high-efficiency panels as long as there is sufficient space.

In a typical Iraqi city, a rule of thumb for the collection area is 50%-70% of the total pool surface for unglazed collectors and 40%-50% for glazed collectors.

COMMERCIAL POOL HEATING

Both direct and indirect solar pool heating could be used for commercial applications, with indirect having the benefit of faster heating and better possibility for hot water storage.

In a typical Iraqi city, a rule of thumb for the collection area is 70%-80% of the total pool surface for unglazed collectors and 50%-60% for glazed collectors.

HUDSON'S HOPE: THE PUBLIC ENJOYING SWIMMING IN THE SUN, BY THE SUN

In the Canadian state of British Colombia, where cold weather dominates, the District of Hudson's Hope implemented a massive solar energy system for its public pool that includes pool heating, as well as solar electricity generators

The Recreational center gets most of its pool heating requirements through a dedicated solar thermal pool heating installed on the center's roof.

Under normal circumstances, the pool has a capacity of 125 and often fills up on weekends and holidays. According to Terry Webster, the Counselor of the District of Hudson's Hope, the solar pool heating system was installed in 2008, leading to 50% cost savings.

The solar pool heating system cost was $107,288, of which $13,796 was provided as a grant and another $13,796 as a soft loan from Northern Development.

In addition, the center has implemented a solar PV plant with half a mega-watt capacity, covering an average of 75% of the facility's energy consumption and relevant costs.

CONCENTRATED SOLAR POWER

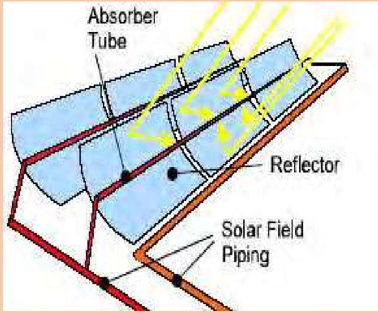
THE TECHNICALITIES

Solar radiations can be concentrated to receivers and converted into high-temperature water and steam in some cases to achieve higher temperatures.

A parabolic trough is the most common concentrated solar power (CSP) application, with more than 90% of the current installed capacity worldwide. Other techniques are becoming standard for various applications, almost all utilizing single-axis or dual-axis tracking.

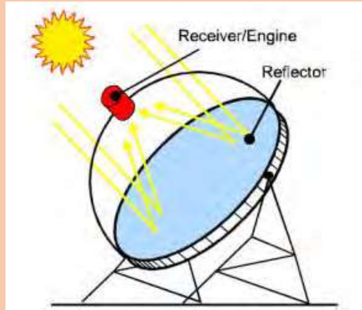
PARABOLIC TROUGH

Parabolically curved trough-shaped reflectors focus radiations into the receiver pipe, where heat transfer fluid reaches 400°C.



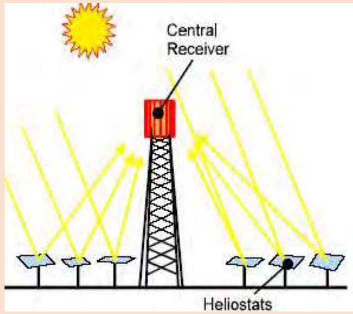
SOLAR DISH

A parabolic dish reflects solar radiation at a receiver mounted at the focal point, which could be a heat engine (Stirling engine).



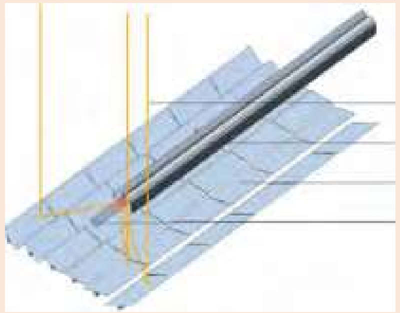
SOLAR TOWER

Distributed tracking reflectors focus radiations into a central receiver that would reach 400°C to generate steam.



LINEAR FRESNEL

A variation of a parabolic trough, but with a linear concentrating field installed flat and reflecting radiations to a heat pipe.

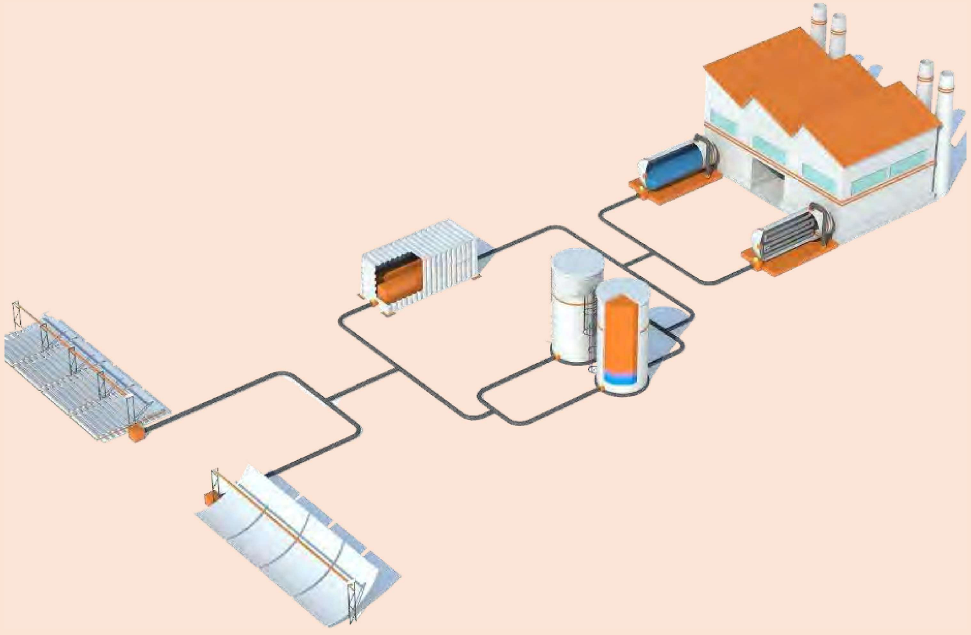


SOLAR PROCESS HEAT

Industrial processes are usually energy intensive, with the majority having high demands for thermal energy. This is where concentrated solar power becomes very practical and feasible.

Temperatures exceeding 150°C can be achieved and used either as steam during the industrial processes, or as thermal energy supply to certain operations in various industrial applications, like water desalination, enhanced oil recovery, food processing, chemical processing production, and mineral processing.

Concentrated Solar Power for Process Heat Configuration



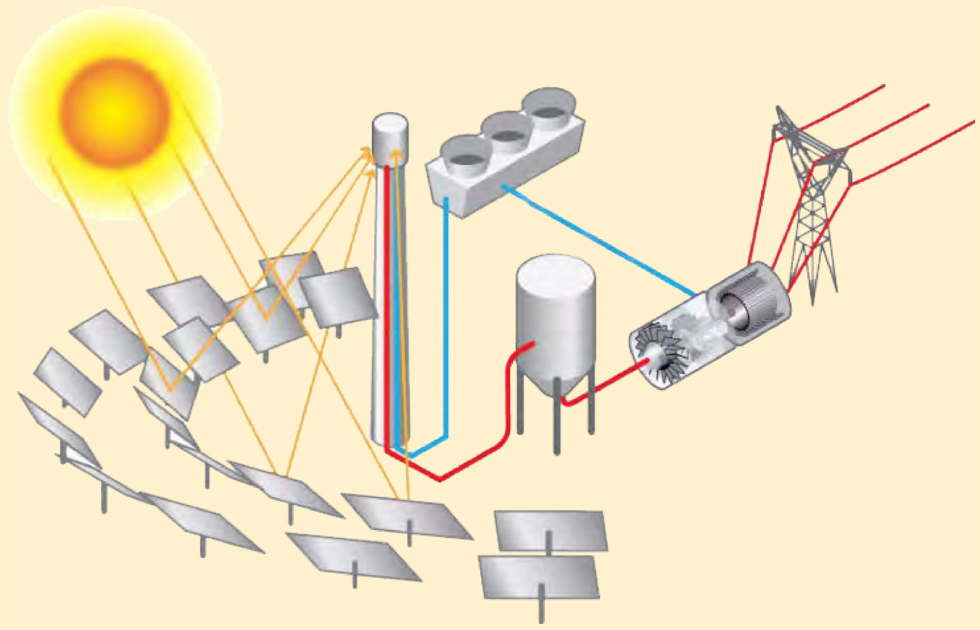
Solar thermal energy can be integrated directly as process heat or indirectly as supply heat, with most facilities using produced energy directly. In contrast, others could utilize storage volumes that could be molten salt and other phase change material, allowing thermal energy storage for prolonged periods.

CONCENTRATED SOLAR ELECTRICITY

At the utility-scale level, concentrated solar power is used for electricity generation, whereby concentrated radiations lead to extremely high temperatures that could be used to spin a turbine or power an engine to produce electricity.

This could be done in a decentralized manner using Stirling engines such as that of solar dishes, but most commonly running larger turbines that mimic the conventional electricity generation process but with a cleaner and less costly approach.

Concentrated Solar Power for Power Generation Configuration



Electricity can be generated and injected directly into the grid or used for onsite consumption in energy-intensive facilities, including public and private facilities. This approach is the most common application for concentrated solar power, creating practical value resulting from enhanced energy security and improved power supply diversification.

FEASIBILITY & APPLICABILITY

Iraq is rich in direct normal irradiance, the type of irradiance needed for concentrated solar power (CSP), making an investment worthy of it. CSP solutions can be utilized by local authorities as well as municipalities through grid-tied or mini-grid applications.

ENERGY CONSIDERATIONS

A large-scale CSP powerplant in Iraq would require a capital investment of $7,540 per kW with storage and $3,690 per kW without storage, with estimated annual operation and maintenance costs of $107 and $60 per kW, respectively.

This allows energy production at $0.39 per kWh with storage and $0.23 per kWh without storage.

Such plants would pay back the investment in 7 to 10 years.

WATER CONSIDERATIONS

Water is a significant concern when utilizing CSP powerplants as it may affect several factors and indicators, especially in areas with water scarcity, as in the case of several regions of Iraq.

Water is heavily used for cooling the steam turbine condenser and cooling towers. Yet, some systems consume less water, especially dry cooling, which usually consumes ten times less water.

Water is also used in the process and servicing cooling equipment and reflectors or mirrors cleaning.

On average, a concentrated solar power system would consume 550 liters of water per MWh generated using dry cooling and 10 to 20 times more for wet cooling.

Morocco's Ouarzazate Solar Power Station (Nour 1) recorded water consumption of 4,600 liters per MWh, using wet-cooling.

RAM PHARMA'S CONCENTRATED SOLAR POWER WINS INTERSOLAR AWARD 2017

RAM Pharma, an industrial facility based in Sahab, Jordan, invested in solar to produce steam for its process use in 2015, to later win Inter Solar's prestigious global award in 2017.

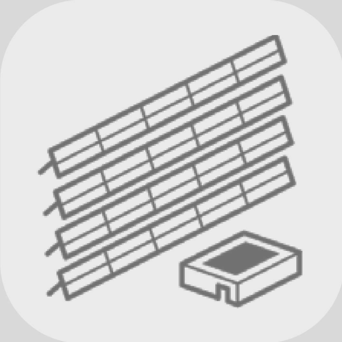
The CSP plant included Linear Fresnel collectors for direct steam generation, comprising 18 LF-11 Fresnel collectors with a total aperture area of 396 m^2 and a peak capacity of 223 kW_{th}.

The system produces steam at 160°C and operates in parallel with the existing boiler for the production process, having an annual specific yield of 860 kWh/m^2 with an annual direct normal irradiance of around 2,500 kWh/m^2.

The project's estimated budget is €360,000, paying back the investment in less than seven years. It was realized within a project between GIZ and ISG to support the market development for solar process heat in the Kingdom of Jordan

This application has proven feasible in industrial applications but could also be used in public facilities to generate electricity.

SOLAR PHOTOVOLTAICS



THE WORKING PRINCIPLE

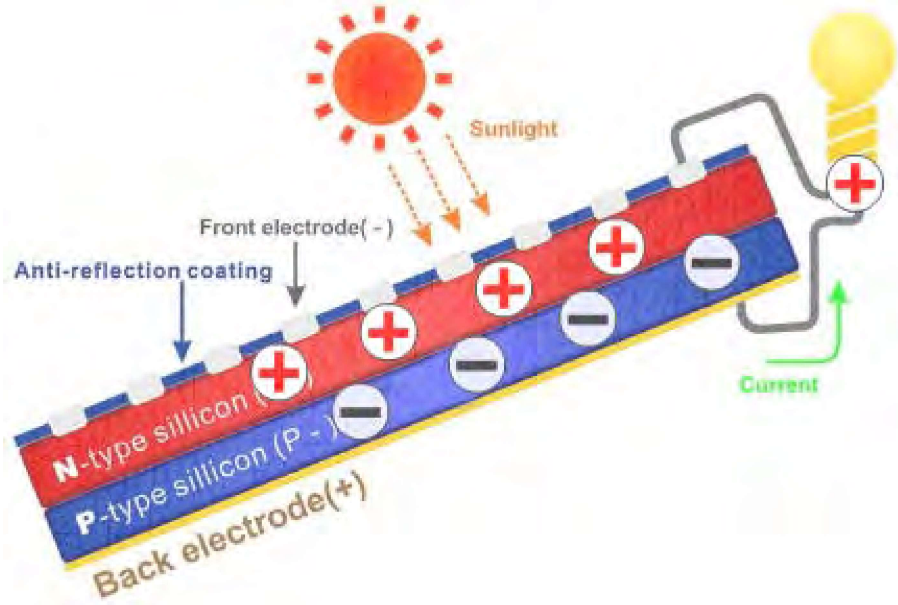
Electricity is generated from solar energy through the photovoltaic effect. The word Photovoltaic (PV) is of Greek origins, with Photo meaning light and Voltaic meaning voltage.

PV cells convert sunlight directly into electricity using semiconductor material, silicon, the earth's second most abundant element after oxygen.

The solar cell has a silicon P-N junction, where positive charges from the P junction are attracted by the N junction, creating a flow of charges back and forth and an electrical field or potential barrier in the depletion region.

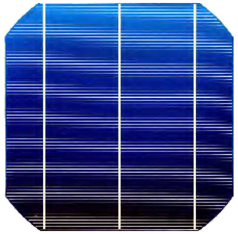
When light hits the P-N junction, electrons gain energy from the N to the P-junction and become free electrons; in the case of a closed circuit, we have an electrical current.

Solar modules are created by combining several solar cells, currently in the range of 72 to 96 cells.



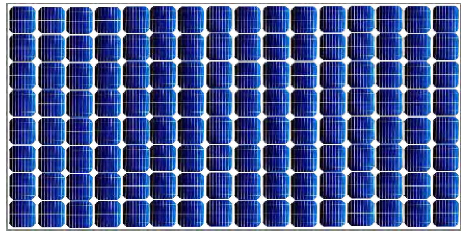
CELL

The cell is the smallest and main component of a solar panel.



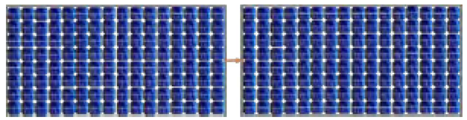
MODULE

A set of cells connected in series and/or parallel form a module.



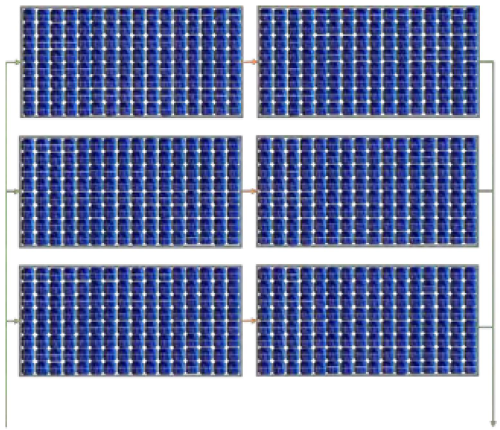
STRING

A set of modules connected in series form a string.



ARRAY

Strings connected in series and/or parallel form a solar array.



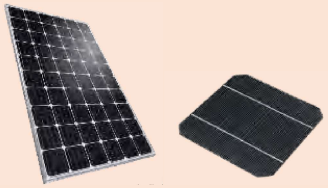
SOLAR PHOTOVOLTAIC COMPONENTS

1 SOLAR MODULE

Solar modules contain semiconductors of different types that convert sunlight to electrons.

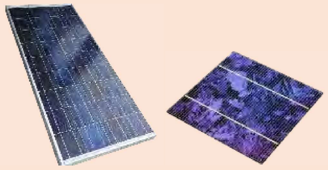
Monocrystalline Modules

Monocrystalline are becoming widely used, characterized by a single, uniform silicon crystal wafer leading to high efficiency, and identified by their blackish color.



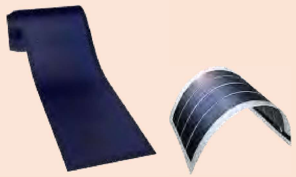
Multi-crystalline Modules

Multi-crystalline, also known as polycrystalline, has been common for years. They can be identified by their blueish color. The cells are less uniform resulting in less efficiency.



Thin Film Modules

Thin-film cells include a range of semiconductors, including Copper Indium Gallium Selenide, Copper Indium Selenide, and amorphous silicon. It is the least efficient and most flexible.



2 BALANCE OF SYSTEM

Balance of System (BOS) components include most of the pieces, which comprise roughly 20%-40% of solar purchasing and installation costs.

Includes cables, meters, circuit breakers, protection components, junction boxes, AC and DC disconnects, monitoring devices, and other components.

3 BATTERY

The sun is not always available whenever electricity is needed, which requires storage, mainly in the form of batteries.

Batteries are rated in kWh, or Ah. Their performance depends on their type, working conditions, and usage patterns.

The market's most common batteries are lead acid, gel, and lithium-ion.

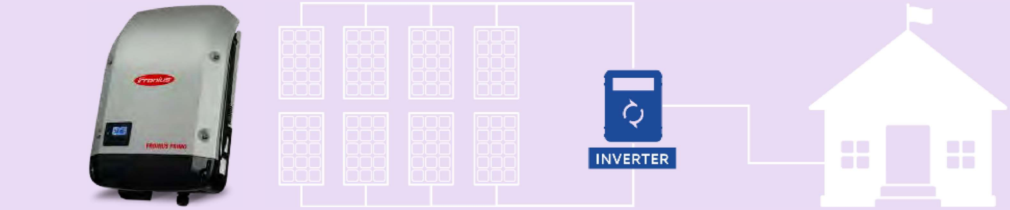
Type		Life Cycles	Cost ($/kWh)	DOD	Maintenance	Installation
	Flooded Lead Acid	1,500 (3-5 years)	$100-150	50%	Terminal corrosion Heavy maintenance	Large space Ventilated space
	Gel Batteries	1,500 (3-5 years)	$120-180	50%	Spill-proof No gassing Low maintenance	Large space Ventilated space
	Lithium Ion	5,000 (8-10 years)	$250-500	90%	Spill-proof No gassing Low maintenance	Small space

4 INVERTER

Solar modules produce direct current (DC), which needs a solar inverter to convert to the utility frequency alternating current. Solar inverters have been evolving for years and now have embedded charge controllers to charge batteries from solar, utility, and backup generator. They come in different types based on the application.

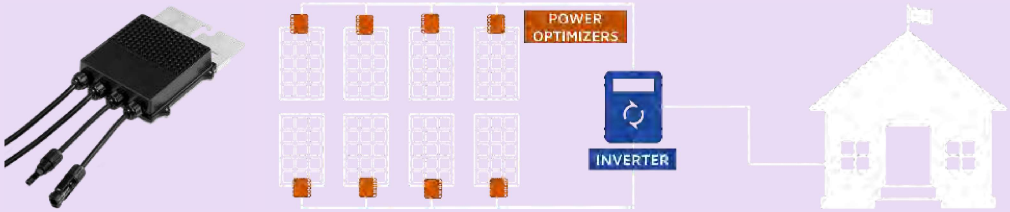
String or Central Inverter

PV string is connected to one or multiple central inverters.



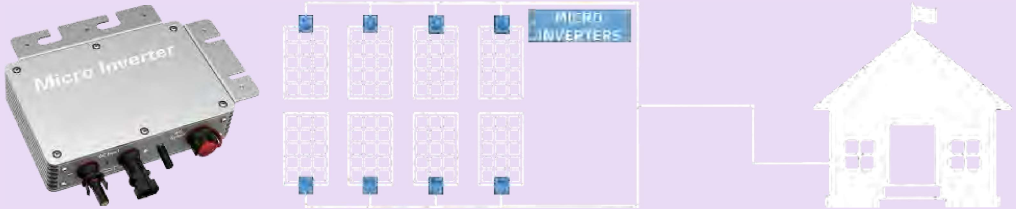
Power Optimizer

Located on the back of the panels to work with the central inverter.



Micro Inverter

Located on the back of the panels to convert to AC directly.



5 MOUNTING

PV panels can be mounted in different ways to accommodate site conditions and requirements, which could be done on flat roofs, inclined roofs, ground areas, facades...

Integral Roof Mounting

Stand-off Roof Mounting

Rooftop Ground Rack

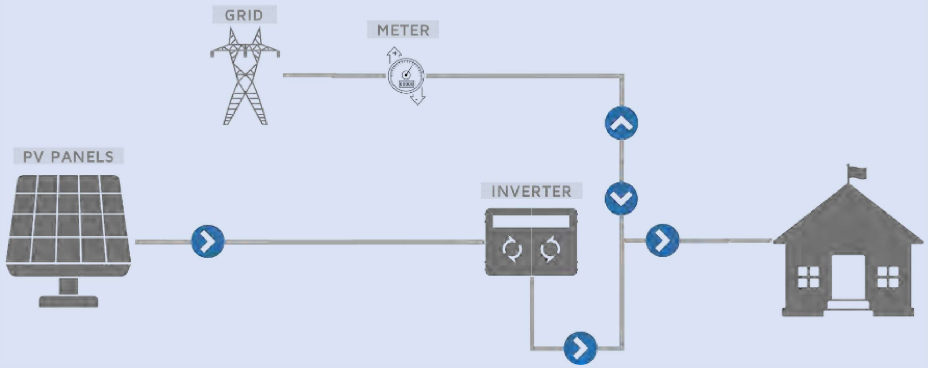
Ground-based Mounting

Façade and Building Integrated

System architecture depends on the application and could be connected to the grid, off the grid with batteries, or hybrid combining both.

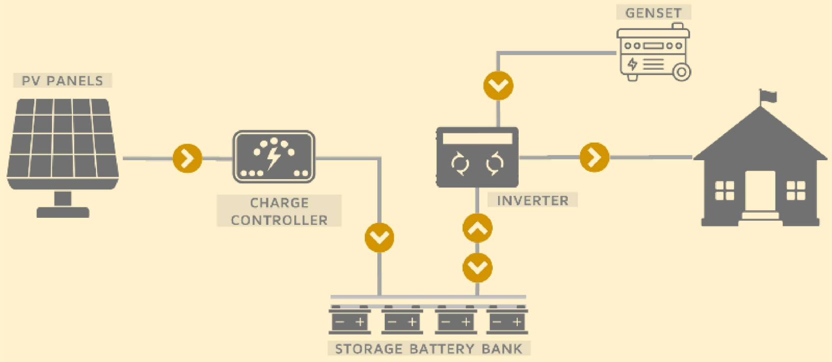
GRID-INTERACTIVE (ON-GRID)

The most practical PV architecture is connected to the grid, interacting with the utility sometimes with a bidirectional meter. This architecture usually does not have batteries.



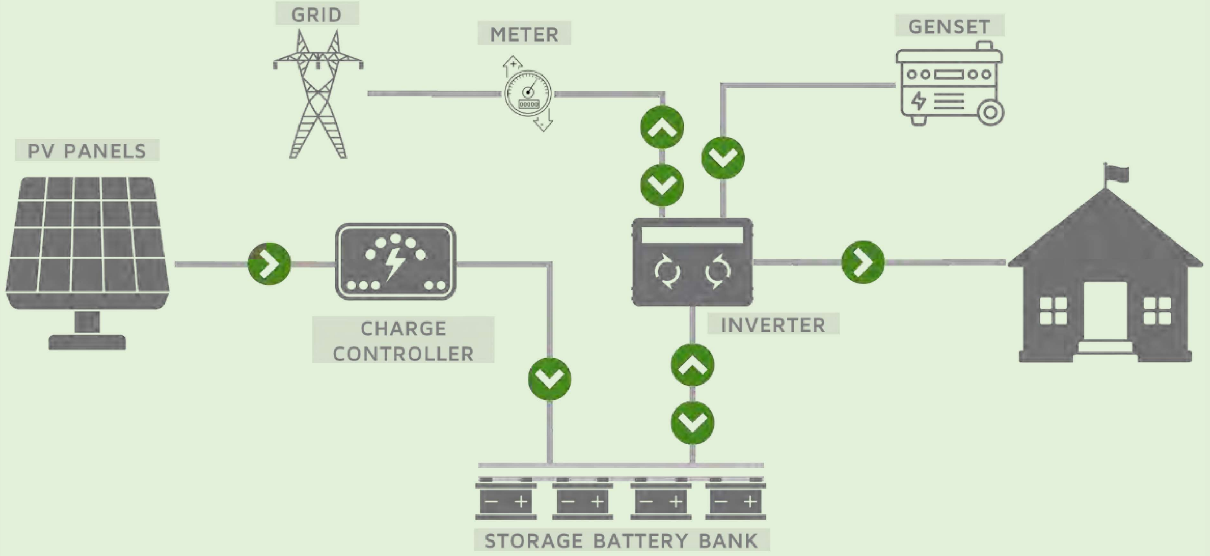
OFF-GRID

PV systems could operate autonomously when utilizing storage batteries. They would be used with off-grid inverters and storage batteries and be designed for certain days of autonomy.



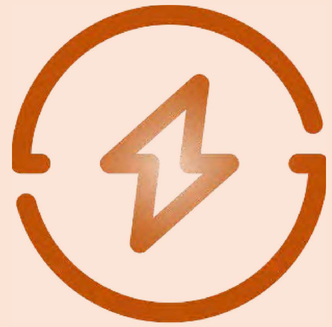
HYBRID SYSTEM

A hybrid system allows integration with the grid but also with storage. This system works best in areas with utility supply shortage



SOLAR PHOTOVOLTAIC IMPACT & BENEFITS

Among affordable decentralized renewable energy solutions for electricity, solar photovoltaics certainly ranks high. That is due to the recent technology development, scalability, and unsophisticated implementation approach.



CHEAP ELECTRICITY

Photovoltaic systems cost more upfront but offer massive electricity savings and lower operational expenses.

PV systems offer a lower Levelized Cost of Energy than many other applications, making them among the most feasible and practical options.

LEVELIZED COST OF ENERGY FOR RESIDENTIAL ELECTRICITY GENERATION (USD/KWH)	
UTILITY (CCGT)	$0.110
DIESEL GENERATOR	$0.220
ON-GRID PV SYSTEM	$0.100
OFF-GRID PV SYSTEM	$0.150

DROPPING COSTS

Solar Photovoltaics prices and costs are dropping rapidly. The prices of solar panels, batteries, inverters, and other components keep falling.

Solar Photovoltaic applications are modular; it is easy to expand them or even, if required, relocate them.

LEVELIZED COST OF ENERGY FOR ON-GRID SMALL PV EVOLUTION AND FORECAST (USD/KWH)	
2015 HISTORY	$0.150
2021 HISTORY	$0.100
2030 FORECAST	$0.075
2040 FORECAST	$0.065

LOW OPERATING EXPENSE

Installed PV system requires minimal maintenance and low running expenses, except for battery replacement in the case of storage systems.

Battery replacement requires costs between 30% and 50% of the initial investment, but not included below.

OPERATIONAL EXPENSES FOR ELECTRICITY GENERATION		
	USD/KW	USD/KWH
CCGT	22	0.003
WIND	22	0.009
PV <1 MW_P	24	0.000
PV >1 MW_P	15	0.000

GHG REDUCTION

Solar photovoltaics are emission-free, producing and storing electricity with no greenhouse gas emitted compared to other sources.

Greenhouse gases are only emitted when used as backup electricity supply during low solar levels.

GREENHOUSE GAS EMISSIONS PER KWH OF ELECTRICITY GENERATED IN IRAQ (KG $CO_{2\text{-EQ}}$)	
DIESEL GENERATOR	1.1
UTILITY GRID	0.8
SOLAR PV	0
WIND	0

SOLAR PHOTOVOLTAIC APPLICATIONS

DISTRIBUTED SOLAR PV

THE TECHNICALITIES

Solar photovoltaics have the advantage of flexibility and ease of installation, allowing almost every user to become an electricity producer and sometimes seller.

ROOFTOP PHOTOVOLTAICS

Roofs are the best places to install decentralized and distributed solar PV systems. All it takes is an exposed roof area, preferably facing south, with sufficient space to fit the solar modules.

This concept allows any user with an exposed roof to generate their own electricity precisely at the point of use.

Roof Mounted PV Installations

Solar modules are installed on the roof, and DC electricity is driven into the inverter and other components, typically installed indoors.

Configurations of Rooftop PV Installations

BUILDING-INTEGRATED PHOTOVOLTAICS

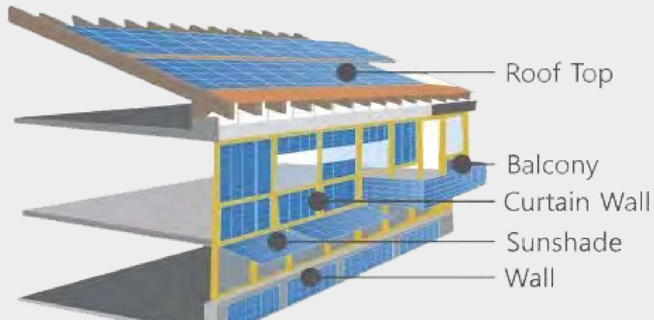
Building integrated PV (BIPV) uses building facades to install solar PV modules, usually done aesthetically.

PV modules used in BIPV are usually thin film or bifacial modules.

Forced Circulation Collective Solar Water Heaters

BIPV could be utilized as a rooftop, balcony, curtain wall, sunshade, or complete building façade, to offer coherent integration with the existing building and available structure.

Configurations of Collective Solar Water Heaters



FEASIBILITY & APPLICABILITY

Solar insolation levels all over Iraq are relatively high, offering wide availability of solar energy and allowing for the practical implementation of solar solutions at decentralized levels.

Decentralized photovoltaic applications can achieve impressive results at both end-user and country levels. Through decentralized solutions, governmental facilities and organizations can invest in self-consumption applications that would meet their energy demand or cover part of the demand while avoiding putting a lot of pressure on the grid. Such applications could be grid-connected, or remain entirely off the grid, an option more feasible for remote and emergency applications.

GRID-INTERACTIVE SYSTEMS

Where the grid permits, PV systems can be connected to the grid, feeding in to avoid the usage of batteries. These systems generate income during surplus production when connected to the grid using feed-in-policy or net metering. This option is financially feasible as it eliminates an additional 66% cost to cater to battery banks.

If net metering is utilized, Erbil's adequately sized grid-interactive system will pay back the investment in less than five years.

OFF-GRID SYSTEMS

With the lack of grid supply and a feed-in policy, off-grid systems have become more common, with storage batteries to store electricity for off-sun hours. Batteries are costly, making on average 40% of the cost of off-grid PV systems, while also requiring replacement after 4 years for lead acid and 8 years for lithium-ion.

An off-grid system utilizing lithium-ion batteries in Erbil would pay back in less than ten years.

EGYPT-PV: THE UNDP PROJECT WINNING BRITISH ENERGY INSTITUTE AWARD 2020

Funded by GEF and implemented by UNDP and the Industrial Modernization Centre, the EGYPT-PV project aims to develop decentralized grid-connected small-scale PV and installation at factories, hotels, commercial, public and residential buildings.

General Authority for Educational Buildings PV Plant


The 15 kWp on-grid plant produces 27 MWh/year, covers 31% of the building's demand, and pays back a $12,000 investment in 7 years.

Housing & Building National Research Center PV Plant


A 93 kWp on-grid plant produces 144 MWh/year, covers 17% of the building's demand, and pays back a $55,000 investment in 7 years.

Egyptian Engineering Syndicate PV Plant


The ten kWp on-grid plant produces 18 MWh/year to cover nearly 100% of demand, paying back the $8,200 investment in 7 years.

WANT TO IMPLEMENT A ROOFTOP SOLAR PV SYSTEM?

CONSIDER THIS

1. Start with what exists. Built on the existing structure and design the PV system to be appropriately integrated with the power supply sources already in place. Consider going hybrid for flexibility and enhanced security.

2. Electrical safety and protection are essential in rooftop systems. Solar cables shall be well-sized, protection devices (surge protection, disconnects, fuses, etc.) adequately installed, and earthling applied to protect against overload.

3. Regarding batteries, one could go for shorter-life lead acid or double the cost and go for longer-life Lithium Ion, which also offers the benefit of faster charging, lighter weight, smaller volumes, and better overall performance.

4. Communication in the PV system is vital. Battery banks need proper communication with the inverters, and inverters must be adequate to work with the selected batteries. Inverter manufacturers publish a list of adequate batteries to use.

5. Consider including a maintenance contract with the contractor's scope, offering support to the user over at least one year. Also, consider purchasing additional spare panels that could be used to replace any damaged ones over the lifetime of the system

SOLAR PV PARKS

THE TECHNICALITIES

Centralized PV power plants, also known as community solar, utilize large areas to erect solar farms at mega-scale levels, to replace or alternate with conventional power plants.

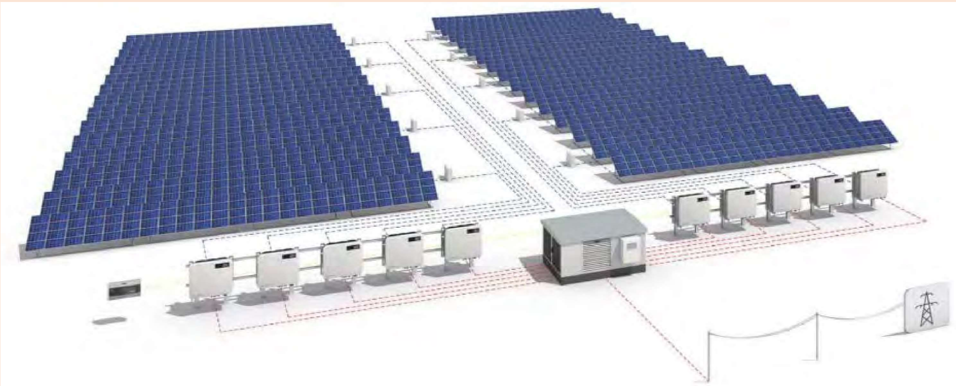
UTILITY-SCALE SOLAR PHOTOVOLTAIC FARMS

Utility-scale solar farms are power plants utilizing large solar modules to produce and inject electricity into the grid.

Solar farms are usually developed through public and private partnerships or solely by the private sector, mainly through power purchase agreements, whereby agreements are signed with the utility grid to purchase energy at a fixed price per kWh.

The primary consumer for utility-scale is the electric utility company. The plant size ranges between 1 MW and 2,000 MW.

A solar PV farm connected to the grid



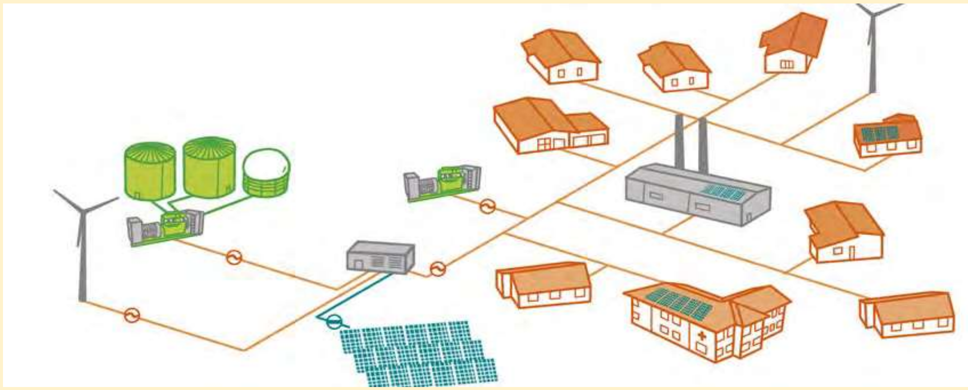
COMMUNITY SOLAR & MINI-GRIDS

Collective efforts by end users or public authorities develop the concept of community solar, also called solar gardens.

Such mini-plants usually have different owners, serving their energy consumption through the concept of shared energy production. These gardens are generally smaller than solar farms and can be developed using mini-grids.

The primary consumers of community solar are end-users. The garden size ranges between 100 kW and 5 MW.

Community solar utilizing mini-grid



FEASIBILITY & APPLICABILITY

Centralized solar plants can provide sufficient energy for communities, municipalities, and large complexes. They take advantage of economies of scale and can enhance energy security and community level.

In most cases, solar farms provide power to the electric grid and are part of the utility's energy mix.

UTILITY-SCALE PV PLANTS

Utility-scale PV power plants can be implemented in different areas with no restriction to be close to end users, allowing for the use of less costly lands, and making use of brownfields.

Local authorities can invest in such plants without the need for storage batteries. Produced electricity would be injected directly into the grid and later distributed to end-use.

MINI-GRID APPLICATIONS

Local municipalities and communities can use mini-grid applications, where different sources of electricity are utilized through either an isolated or connected mini-grid.

Mini-grids utilizing solar PV, diesel generators, and grid power is the most common in recent days. Storage batteries are optional but create added value for local communities when made available.

Mini-grids could also use other sources of electricity, such as wind or geothermal energy.

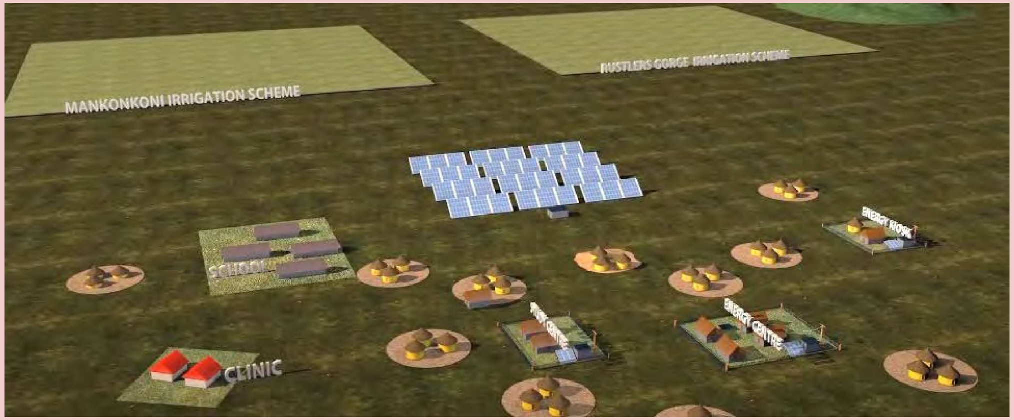
Mini-grids are very feasible to local municipalities, allowing them to provide power to end-users, reduce energy bills, and enhance energy security.

MASHABA COMMUNITY MINI-GRID: ZIMBABWE'S FIRST INCLUSIVE MINI-GRID

The Mashaba Mini-grid project demonstrates a business and financial model of decentralized renewable energy through a partnership between public and private sectors and donors.

The pilot project was implemented in 2017 through funding from the European Union, OPEC Fund for International Development, and the Global Environmental Facility.

The 99 kWp mini-grid powers public and private facilities, serving a public school, a public clinic, a study center, 5 business centers and 3 irrigation schemes, 2,800 households, and an energy center that supports economic activities such as cold rooms, agro-processing, welding applications, and other energy-intensive activities.



SOLAR WATER PUMPING

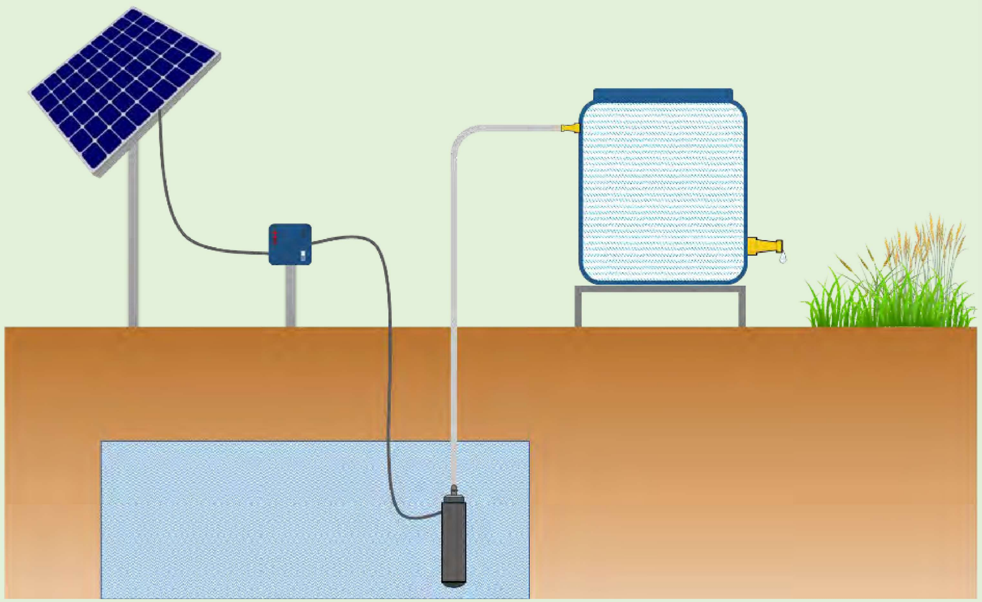
THE TECHNICALITIES

Solar energy could be utilized to run water pumps, providing water from either deep or surface levels to end-use points or storage volumes for later supply to end-use points.

DEEP WATER PUMPING

Deep water pumping utilizes submersible pumps in boreholes at levels exceeding 10 meters to pump water to the surface.

A submersible pump is coupled with the solar PV system, a variable frequency drive, and related components to operate even at lower solar insolation levels.



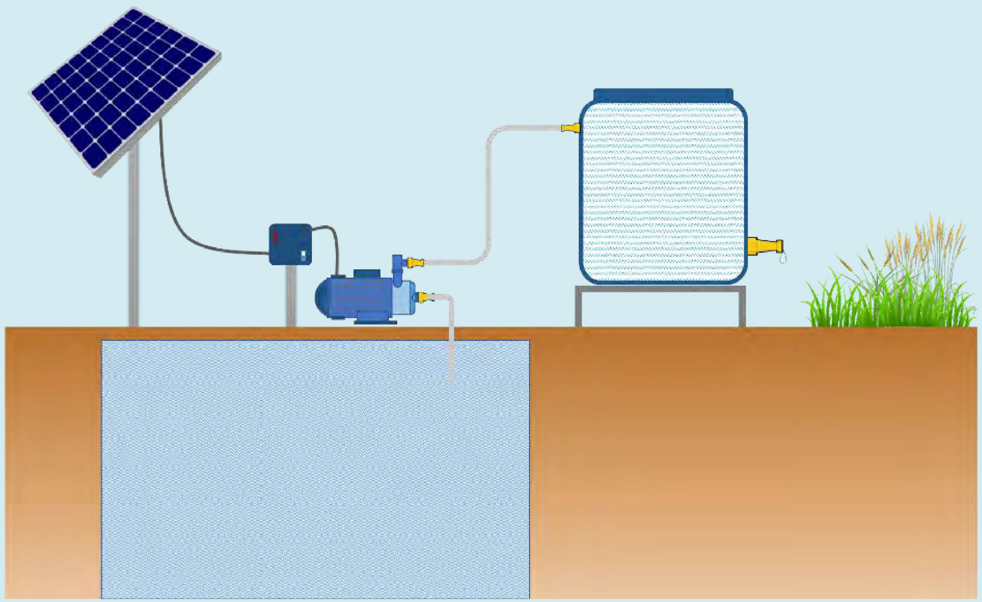
Deep water pumps are mainly used for domestic water, irrigation water, feedstock water supply, and delivery.

Submersible pumps have the advantage of operating at deeper levels and offering higher flow and head, in addition to higher efficiency and a silent operation.

SURFACE WATER PUMPING

Surface water pumping utilizes pumps within 10 meters of the surface to move water to use points or between locations.

A surface pump can be coupled with solar to deliver water from the ground source to storage areas or even between different locations as part of municipal pumping stations.



Shallow water pumps are mainly used for irrigation and feedstock water supply and delivery.

Surface pumps have the advantage of easier maintenance as they are easily accessible while having the disadvantages of lower operating points and less efficiency.

FEASIBILITY & APPLICABILITY

Solar Pumping ranks high on the solar feasibility scale, especially since water is usually required when the sun is there.

Solar pumping applications proliferate for irrigation, domestic water supply, feedstock, and water movement.

IRRIGATION & FEEDSTOCK WATER PUMPING

Borehole submersible pumps to supply water to agricultural areas for crop irrigation or feedstock water supply. The configuration of the solar pumping system would depend on the water demand and requirements. Sometimes water can be pumped directly to end-use without storage as long as the demand is coherent with the solar supply. Such systems have proven to be feasible and effective.

DOMESTIC WATER PUMPING

Solar water pump systems can effectively provide safe and secure water supply solutions for households in remote areas with insufficient water supply due to power shortages. Solar can be used to power submersible pumps as well as moving pumps to deliver water to end-use points.

Solar water pumping for domestic water is by far the most feasible, impactful, and practical solution, allowing for the pumping of water at any time there is sun, even at low levels thanks to variable frequency drives, then storing it at elevated tanks and supplying it whenever it is demanded.

When solarized, a 50-hp submersible pump in Erbil would save as much as 180 MWh a year, paying back the investment in less than six years when considering the existing infrastructure and excluding any related costs.

11 VILLAGES IN DOHUK GOVERNORATE ENJOY SUSTAINABLE DRINKING WATER

Barav, Rabanka, Kani Gerke, Pase, Zewa Sheikh Pirmus are a few of the 11 villages now enjoying having drinking water delivered to their households with the help of solar energy.

Funded by German Cooperation Agency, managed by GIZ, and supervised by KURDS NGO, the 11 solar pumping systems provide more than 494 families with drinking water with zero dependence on the electricity utility, delivering water from deep wells with the head from 84 and 180 meters and flow from 27 and 160 m^3/day.

A total of 331 PV modules were installed all over the 11 municipalities, with a cumulative capacity of 119 kWp and dedicated submersible pumps using Lorentz products.

The systems are all designed with a new pump and not used to run existing pumps, which dictates the design parameters and flow requirements in this case.

Zewa Sheikh Pirmus Solar Pumping Station

One of the largest pumps is a 19.44 kWp pump installed at Zewa Sheikh Pirmus in Sarsang, with 54 solar modules installed to operate a Lorentz submersible pump delivering water to villagers.

The solar pumping station delivers water with a daily flow rate of 160 cubic meters per day with a wellhead of 84 meters.

WANT TO IMPLEMENT A SOLAR WATER PUMPING SYSTEM?

CONSIDER THIS

1 Solar water pumping works best when utilizing variable frequency drive, allowing the pump to operate even at lower solar insolation levels, and thus starting from early morning hours with low flow, to achieve peak flow during mid-day.

2 A rule of thumb for Iraq is to size the PV plant peak power in kWp to be 1.5 to 2 times the power rating of the pump in kW, which means that for a 50 hp pump (36 kW), the PV plant capacity would be between 55 and 72 kWp.

3 Water storage is very effective and beneficial in solar pumping applications. Sizing the storage tank for domestic use would be to maintain ten days autonomy (i.e., ten times the daily demand), while it is 3 to 5 times for irrigation.

4 Calculating daily water demand is essential for proper pump sizing, storage volume estimation, and solar PV plant design. International references can be used to estimate the daily consumption and simulate it over the months of the year.

Person (Basic)	50 lit/person	**Potatoes**	30 lit/ha
Person (Average)	100 lit/bed	**Wheat**	80 lit/ha
Milking Cow	130 lit/head	**Citrus**	30 lit/ha
Sheep	7.5 lit/head	**Olive**	35 lit/ha
Chicken	1 lit/head	**Deep root**	50 lit/ha

STANDALONE PV SYSTEMS

THE TECHNICALITIES

Solar can be effectively used in remote areas for standalone applications, whereby an independent application unit is solarized with backup batteries and autonomous operation.

SOLAR STREET LIGHTING

Solar street lighting can be applied at both centralized and decentralized levels, with decentralized, also known as standalone, having a more comprehensive range of benefits, including continuous lighting, improved road safety and fewer accidents, and enhanced security levels.

Split-type SSL Lamp

All-in-one SSL Lamp

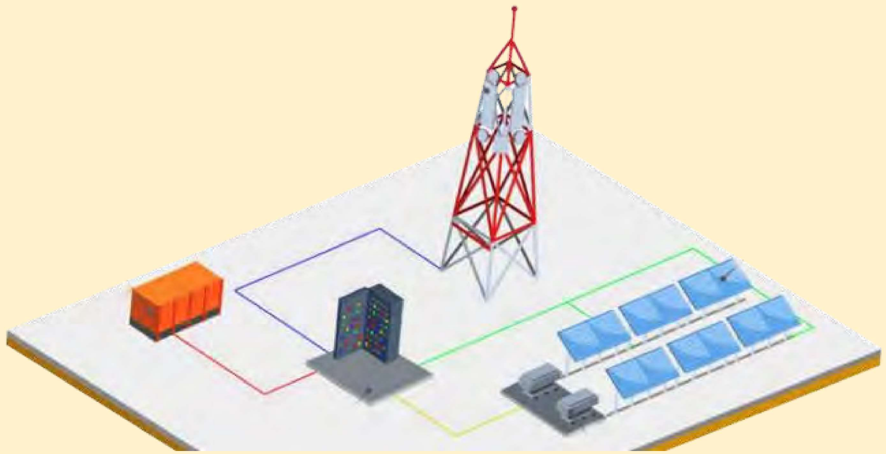
Standalone solar street lamps could be applied to existing fixtures by switching to LED and adding a solar panel with batteries and charge controllers to existing lighting poles. This is referred to as Split-type solar street lighting.

An all-in-one solar streetlighting solution offers the LED lamp, the PV modules, storage batteries, and the charge controller as one package. This solution is easy to install but has some limitations related to its performance and meeting application requirements.

SOLAR REMOTE SUBSTATIONS

Several technology applications require autonomous operation and are usually installed in remote areas with limited access to electricity and other resources. These applications are telecom towers and surveillance units, which need a continuous electricity supply for reliable operation.

Telecom towers standalone PV supply



Telecom towers are usually installed in remote areas to secure good network coverage, where there isn't always access to electricity, similarly for remote surveillance units that operate cameras and related equipment to maintain security on site.

The presence of these units in remote areas makes diesel generators essential. Solar PV would solve this issue by providing a continuous electricity supply and reducing the diesel refill and generator maintenance trips and their high costs.

FEASIBILITY & APPLICABILITY

Standalone solar applications are interesting in the Iraqi context, with feasibility and applicability in rural and urban areas.

STREETLIGHTING APPLICATIONS

Solarizing streetlights enhances visibility, security, and versatility. For existing streetlighting poles, solarization is best done

A typical 120-Watt High-Pressure Sodium streetlight used for a typical pedestrian area in Ebril would cost more than $80 to run from dusk to dawn over one year. When replaced by 70-Watt LED fixtures utilizing solar PV, running costs would be minimized with less than seven years to pay back the investment.

When replacing equivalent 250-Watt mercury vapor, annual savings would exceed $150, paying back in less than four years.

REMOTE TELECOM APPLICAITONS

There are more than three million telecom towers worldwide, mostly in remote areas, with only 26% of them utilizing renewables energy, with solar being the primary source, according to IRENA, which also reports that no more than 7% of overall telecom power supply is coming from renewable resources.

Telecom towers are energy intensive, with power demand determined by the number of base transceiver stations (BTS) housed. A typical 3-BTS telecom tower would have an average power demand of 2.5 kW, with an annual energy bill exceeding $3,500 in Iraq. Such a telecom tower would also incur operating expenses related to refill costs, maintenance costs, oil changes, and other fees reaching $400 a year.

Utilizing solar saves on energy bills and reduces operating expenses, achieving a payback period of fewer than six years.

SOLAR STREETLIGHTS IN JINJA SELL ADVERTISEMENTS AND SAVE LIVES

Following the footsteps of its neighboring city, Kampala, the capital city of Uganda, Jinja, the second largest city, decided to leave the dark and switch to solar, starting in 2016 to install more than 100 solar streetlights over three years to light a 2.5-kilometer stretch of the main street and some priority streets near a hospital and a market square.

The $45,000 project implemented by the local authorities saved the city tens of thousands of dollars if it was to install conventional non-solar-powered streetlights and improved the safety levels, visibility on the streets, and businesses revenues by allowing them to operate for more extended periods, in addition to reducing installation costs by 25% and maintenance costs by 60% as reported by city officials.

The city can now raise funds by selling advertising space on the new solar-powered light poles and has raised awareness among the central government that is now committed to solar lighting and an additional stretch of 54 of Jinja's 380-kilometer roadways.

WANT TO BRING LIGHT TO THE STREETS WITH SOLAR?

CONSIDER THIS

1 It goes without saying; before applying solar, switch to LED. Converting to LED lamps reduces power demand but should be done appropriately to maintain the required color temperature, uniformity, and light distribution.

2 Use adaptive lighting that utilizes daylight and motion sensors and dusk-to-dawn programmable timers to operate the lamps based on occupancy, traffic volume, available daylight, and user's requirement through remote control.

3 Avoid lamps with a radiant output of wavelengths below 500 nanometres (no blue light or ultraviolet). This is essential to avoid insects and living creatures causing damage and to avoid reducing the biodiversity of natural environments.

4 Theft is a significant threat related to solar street lighting. To avoid the risks of theft, batteries could be installed at the highest points, buried with access gates, or integrated into an all-in-one solar streetlighting solution.

5 Proper luminaire distribution design is key to ensuring safety.

One-side distribution	Road width < luminaire height
Staggered distribution	Road width < 1.5 x luminaire height
Opposite Pairing	Road width > 1.5 x luminaire height
Mid-road Suspension	Where side installation is not possible

THE WAY FORWARD

FEASIBILITY OF SOLAR SOLUTIONS

How much sense do solar solutions make?

That question can only be answered when developing a detailed lifecycle cost analysis to compute the Levelized Cost of Energy (LCOE), similar to the Levelized Cost of Heat (LCOH) for thermal applications.

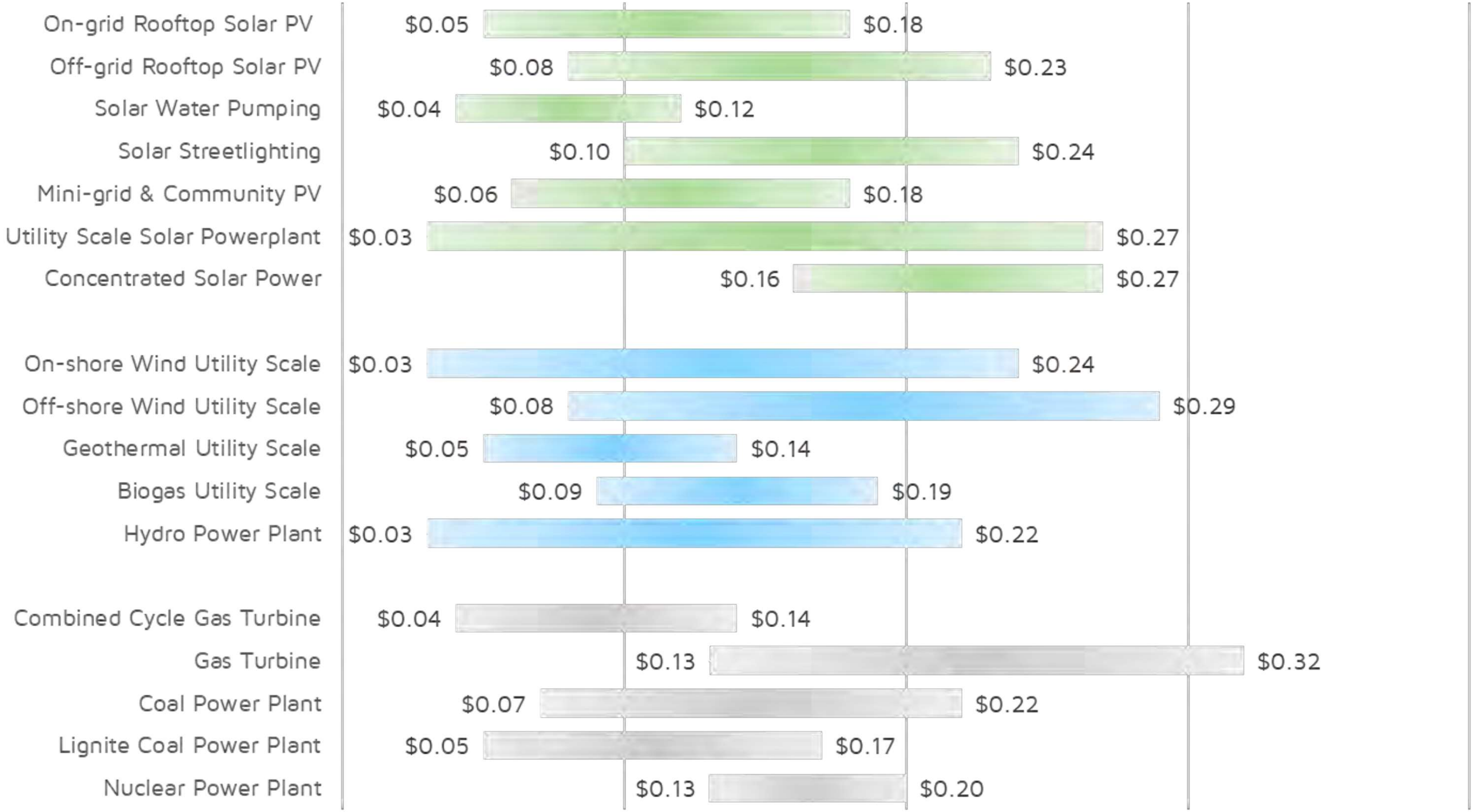
The concepts of LCOE and LCOH assess different solutions over an extended period to evaluate and compare the costs of energy produced and present a clear and comprehensive approach, presented in US dollars per kWh.

SOLAR THERMAL FEASIBILITY

LEVELIZED COST OF HEAT FOR SOLAR THERMAL VS CONVENTIONAL APPLICATIONS

SOLAR PHOTOVOLTAICS FEASIBILITY

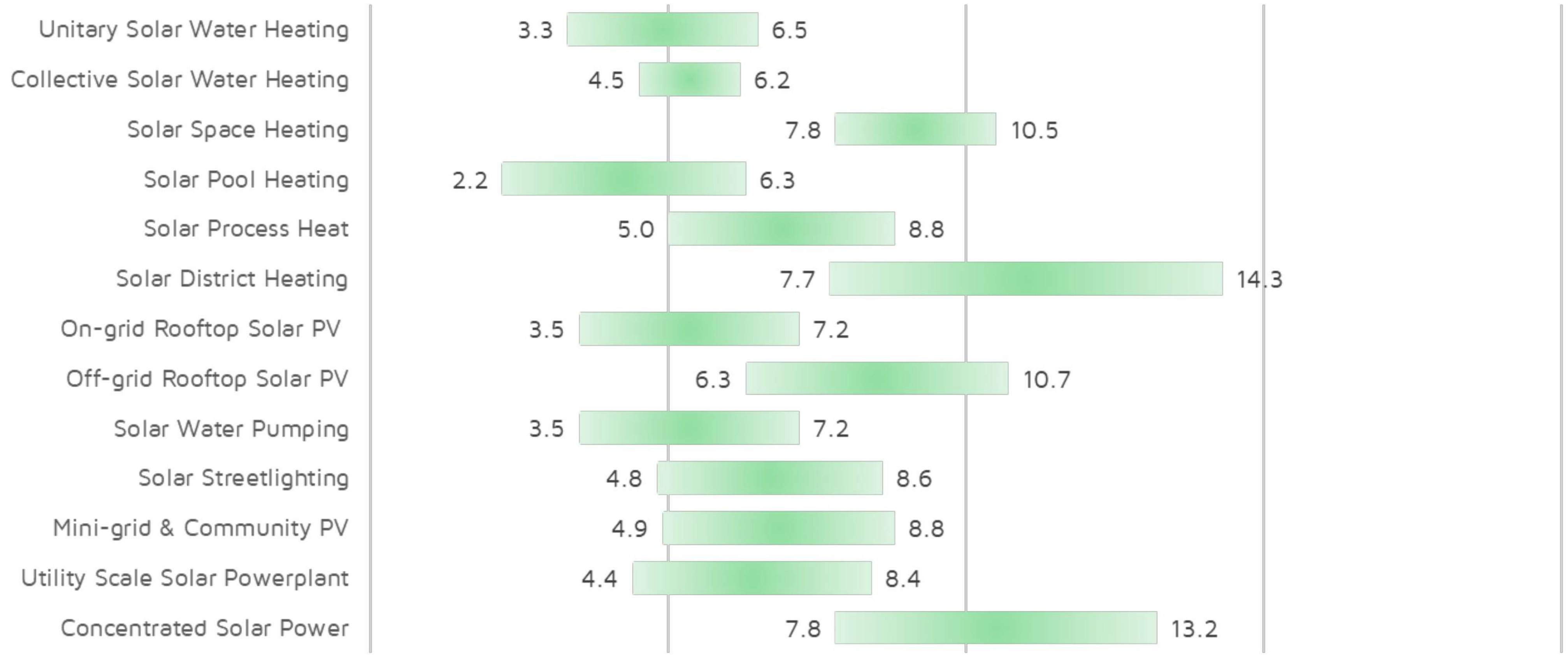
LEVELIZED COST OF ELECTRICITY FOR SOLAR PV VS CONVENTIONAL APPLICATIONS



SOLAR APPLICATIONS PAYBACK ASSESSMENT

A simple payback period is a very trivial concept to evaluate the return on investment without considering operational expenses, the value of money, or inflation factors. It is not the most accurate of all. Still, it offers a simplified and easy way to understand approach to compare the period expected to return the investment for different solutions.

PAYBACK PERIOD COMPARISON FOR DIFFERENT SOLAR SOLUTIONS



PLANNING FOR SOLAR DEVELOPMENT

A comprehensive, inclusive approach is made at different stages to enhance and promote solar development.

COMMUNITY ENGAGEMENT

Local communities are the first stakeholder in any strategic plan and development consideration. It is essential to work closely with representatives of local communities to develop solutions that cater to their needs and keep them involved in the solution development process.

Commonly, local communities have misperceptions about solar solutions, especially in newer technologies like solar PV, which requires valuable efforts to overcome these misperceptions, raising awareness of the value of solar solutions, and engaging local communities through education, training, and job creation.

MASTERPLAN DEVELOPMENT

It is only logical to start by developing a national plan, laying out targets and objectives in the context of the broader local policy framework. A Masterplan shall be created with the clear intention to support solar development and encourage and facilitate both private and public solar energy systems to benefit the local authorities, municipalities, communities, and citizens. When coupled with sustainability planning such as UNDP’s SDGs, SEEAPs, and SECAPs, a master plan would have a holistic approach that covers a broader scope of sustainable development.

A local strategy and master plan should be tailored to the community’s needs and conditions. Small dense communities, for example, may need to ask different questions about where and how to best place solar than sprawling suburban or rural municipalities. Cities with large numbers of flat-roofed commercial buildings should investigate their potential for solar installation. Agricultural communities need to decide on how to integrate agri-Voltaics effectively.

SUPPORT SCHEMES & MECHANISMS

Incentives, support schemes, policy instruments, and financial aid are essential to support the solar market's development. Such schemes and mechanisms are usually enforced by the federal government but can also be promoted and encouraged by local authorities.

Local authorities, municipalities, and communities should self-analyze when considering how to formulate the policy on solar energy. While solar energy is beneficial, the local authority should consider its particular character when studying how to gain the most significant benefit from solar installations.

SOLAR PROJECT ROADMAP

THE SOLAR PROJECT DEVELOPMENT ROADMAP

The roadmap to successful solar project execution lies in good handling of the different aspects of the project, starting at the planning stage and ending in proper operation.

PROJECT DEVELOPMENT PLAN

Starting with a project development plan that outlines the organization's specific targets and circumstances paves the way for project success.

SITE & NEED ASSESSMENT

Assessing specific beneficiary needs, evaluating site conditions, and developing site-specific solutions ensure feasibility: practicality, and best value for money.

PRODUCT SOLICITATION

Sourcing is critical. A well-developed RFP with detailed technical specifications and tailored design lays down the ingredients for successful project execution.

IMPLEMENTATION

The implementation stage must be monitored and controlled by specialists, ensuring good work meets safety and technical requirements.

TESTING AND COMMISSIONING

Project handover can only be done after proper testing and commissioning through onsite measurement, online monitoring, and performance control.

OPERATION & MAINTENANCE

Developing a proper O&M plan ensures sufficient operation over the solution's lifetime. Preventive maintenance and regular testing save a lot.

SUPPORTIVE & ENABLING ACTIONS

Federal policies and support initiatives play a significant role in transforming the solar market. As national governments commit to energy targets and a sustainability action plan, the solar market grows steadily through a well-rounded development approach, including commitments, capacity building, support initiatives, and enabling financing schemes. With the different potential ownership models, authorities and organizations could skip severe bottlenecks and advance toward effective solar project implementation.

SUPPORTING POLICIES

SOLAR ORDINANCE

When enforced by local authorities, simple and direct solar ordinances can best enable citizens and developers to install solar systems and provide fair treatment to all.

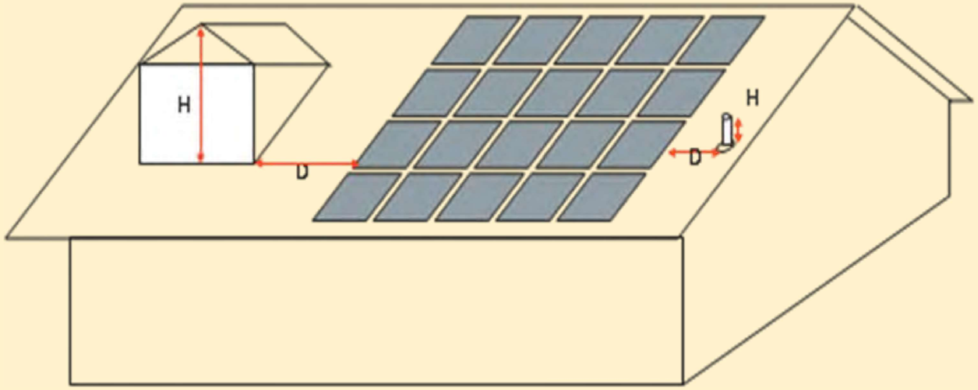
SOLAR ACCESS ORDINANCE

Localities have the authority to protect end-users and homeowners by enforcing solar access ordinances, allowing homeowners to have the right to access a reasonable amount of sunlight. This is done by enforcing schemes that protect against shading caused by vegetation, building structures, or other factors affecting the roofs.

Solar access ordinance might be voluntary, encouraging dialogue among neighbors to give all homeowners the right to have a good solar installation location, mainly on the roof.

SOLAR READY ORDINANCE

Developing and implementing solar-ready codes encourage developers to design and build buildings ready for solar installations, whether solar water heaters or solar photovoltaic systems. This would include requirements like south orientation, space sufficiency, roof readiness and adequacy, pre-installed connections, wiring readiness, and many others.



Local authorities and municipalities could mandate solar-ready codes by enforcing and providing supporting schemes such as registration fees and tax reductions.

GRID INTERACTIVITY

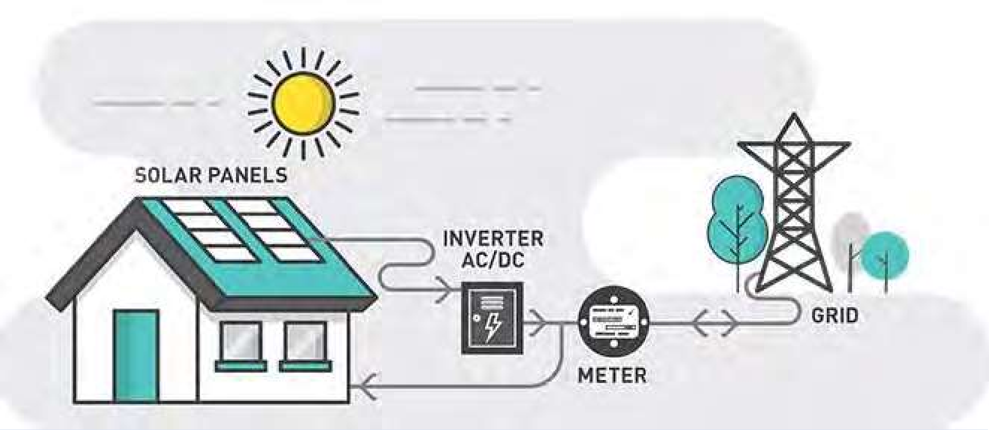
FEED-IN POLICIES

Feed-in policy and allowing users to connect PV systems to the grid and inject surplus power is a game changer, reducing investment costs and improving profitability.

FEED-IN AND NET-METERING

The feed-in policy allows users to connect their renewable energy electricity systems to the grid and interact with the public utility. This would be done by installing a bidirectional meter that counts electricity flow in both ways.

This policy allows users to utilize the grid and use it as a storage point. Still, it requires a continuous grid power supply, reliable grid connections, and performance to be adequate.



A feed-in policy could be done in one of two typical schemes, the first being a feed-in tariff and the second being net-metering.

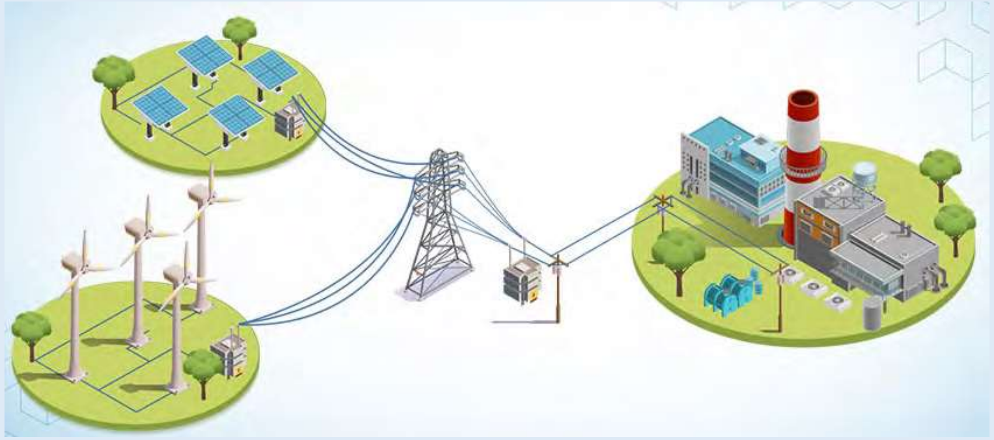
With feed-in tariffs, users get paid for the electricity injected into the grid. The bidirectional meter counts the fed-in electricity and compensates the user using a pre-fixed rate. This policy requires legislative work since there is a monetary transaction.

Net metering has no monetary transaction; it bills users for the difference in electricity use without paying for excess energy.

POWER WHEELING

In many cases, especially in urban areas, large energy consumers cannot have sufficient solar photovoltaic systems to have a considerable solar supply. That is very common in highly dense areas like Erbil and similar cities.

Power wheeling allows users to install larger solar plants outside the facility's footprint, inject the output into the grid, and use it at the point of use.



Power wheeling needs an implementation of a grid connection or feed-in policy to be effective.

When appropriately executed, power wheeling would save on the investment cost when using less expensive lands but would incur additional expenses related to electricity transmission from the generation site to the use site.

Power wheeling uses the existing grid infrastructure and can only be implemented in coordination with the grid operator.

FINANCING MODELS

FINANCING INCENTIVES & SUPPORT SCHEMES

Investing in solar might be financially challenging for some. This is where federal governments develop and offer financial incentives to overcome this burden.

SOFT LOANS

Subsidized and soft loans are offered to finance the purchase of solar solutions. These loans are usually below-market rates to provide incentives and support to users and homeowners.

Loans are usually offered by the central bank through the typical credit scheme and have the exact credit requirements for eligibility. This sometimes provides a bottleneck that needs intensive work to start considering renewable energy investments as income-generating options rather than debt options

An example of a soft loan would be financing the purchase of suitable solar solutions over ten years at an interest rate of 10 years, with a 2-year grace period.

REBATE SCHEMES

Rebates are offered to users and entities investing in solar energy. This could come from cash payments through local authorities or utility bill rebates through the electricity company.

Rebates could be provided based on the solar system's performance if it is solar PV. These rebates can be offered as an upfront payment or at a later stage following installation and satisfactory performance. In contrast, others provide one-time subsidies to install a solar solution for water heating or electricity.

An example of a rebate scheme would be a $200 rebate on solar water heater purchases from a listed company. The rebate would be dedicated to the invoice and paid directly to service providers.

INVESTMENT SUBSIDIES

Federal governments may offer investment subsidies for selected solar solutions under a managed and controlled support scheme through which products and service providers are prequalified

Investment subsidies are simpler to administer than long-term schemes. The subsidy could be done with the buyer or through direct contracts with service providers listed and prequalified.

In the second case, the service provider would be offering the solar solutions at the subsidized rate, having to report the sales to be eligible to collect the subsidy from the government.

Subsidies could be paid out as a function of the system capacity or at a fixed rate per purchase, regardless of the unit's ability. This is independent of the power yield or system performance.

TAX INCENTIVES

Tax incentives are common in tax-dependent economies, with different schemes, including tax exceptions, tax credits, property tax, and sales tax relief.

Tax credits are similar to rebates, with a portion of project cost deducted from the buyer’s tax obligation, which reaches more than 30% in some states in the United States of America.

Property value usually increases by 2% to 5% with solar solutions. Due to this increase, property tax relief is applied to exempt from additional property tax.

Solar sales tax exemptions could be offered to the entire cost of the solar solution to cut down the investment costs and promote the deployment of green and solar solutions.

OWNERSHIP MODELS

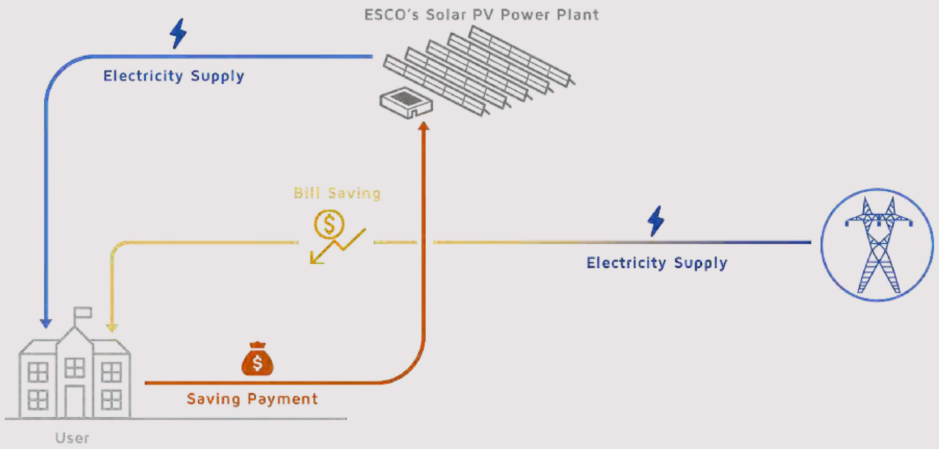
POTENTIAL OWNERSHIP MODELS

Access to finance is not always easy. This is where the private sector's role jumps in, allowing for different ownership and investment models for CAPEX financing.

ENERGY PERFORMANCE CONTRACTING

Energy performance contracting is a form of creative financing for capital improvement which allows funding energy upgrades from cost reductions achieved usually with the involvement of an ESCO.

An ESCO would develop and invest in a solar PV plant and get the savings over an energy performance contract period.



Energy Performance contracting offers peace of mind guaranteeing savings through an energy-saving contract.

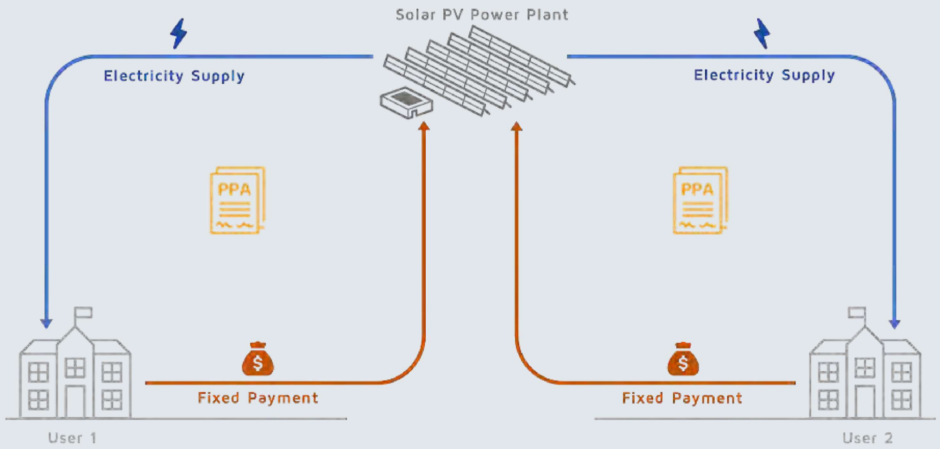
Through a guaranteed saving contract, the owner would agree with the ESCO allowing it to get 100% of the savings achieved over a certain period, after which the contract is over.

Shared saving contracts allow the parties to agree on sharing cost savings in a manner that will enable the ESCO to return its investment while guaranteeing the savings and energy bills reduction for the lifetime of the installed solar system.

THIRD-PARTY OWNERSHIP

Third-party ownership is a popular model for solar project financing, allowing building operators and landowners to implement solar systems with little or no capital outlay.

Third-party companies often have easier access to finance and better financial standing that would use tax incentives if available.



Third-party ownership offers two common structures: Power Purchase Agreements (PPAs) and Operating Leases.

Under PPA agreements, a solar developer builds, owns, and maintains a solar PV system on the local authority's property and sells electricity for a fixed rate and term.

Operating lease structures allow solar developers to install and own a solar PV system installed at the local authority's premises that pays a fixed monthly fee for the use of the equipment over a specified period.

SUPPORT SCHEMES & SUCCESS STORIES

POWER WHEELING: GETTING THINGS MOVING IN JORDAN

In 2013, Jordan issued the first direction regulating the wheeling of electric power generated from renewable energy sources for self-consumption, allowing users to produce power at any location, and consume it at the point of use, using the national electricity grid as a transmission medium.

Power wheeling is subject to losses and charges for the transmission of solar-produced electricity outlined in the relative directive, which lists loss rates and wheeling charges based on the connection of the production plant and end-use point.

Power wheeling monthly physical losses and charges

SITUATION	LOSS RATE	CHARGE/KWH
Solar power plant directly connected into transmission network to feed load connected to the transmission network	2.3%	$0.0064
Solar power plant directly connected to the distribution network to feed load connected to the distribution network	6.0%	$0.0100
Solar power plant directly connected into transmission network to feed load connected to the distribution network	9.3%	$0.0164

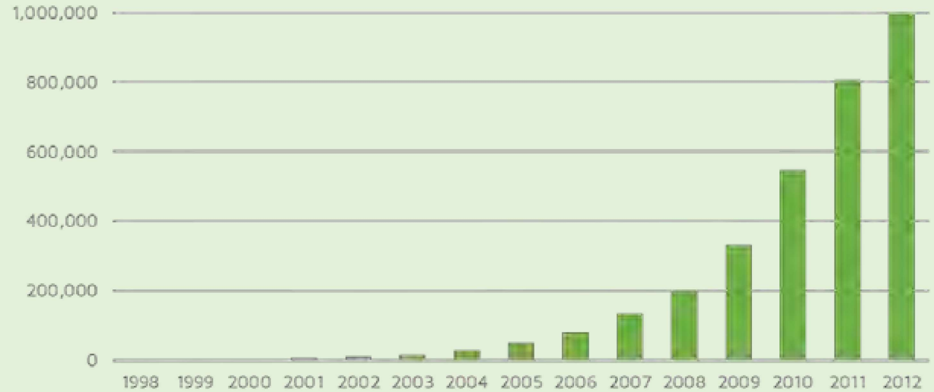
By 2020, more than 362 MW of solar PV installations were benefiting from the power wheeling scheme. These numbers are expected to keep growing over the years.

GRAMEEN SHAKTI AND THE NOBLE PRIZE-WINNING MICROCREDIT GURU

In 1996, a social enterprise established by Muhammad Yunus hit the rural areas of Bangladesh, offering microcredits to rural areas to install solar PV systems at first and then expanding to include biogas, cookers, and others, and overcoming the main financial barrier hindering the growth of solar installation in rural areas.

This private sector-led initiative started by raising $16,700 of funding, which was used to bring three regional companies on board; a Sri Lankan for solar panels, a Nepalese for accessories, and a Bangladeshi for batteries.

Evolution of solar water heaters installation in square meters



Three factors explain the success behind this microfinancing concept and Muhammad Yunus' approach.

1. The solid local involvement of Grameen Bank
2. Government support through its solar power program
3. Yunus's driving force as a leader in social entrepreneurship

NAMIBIA SOLAR REVOLVING FUND (SRF): A GAME CHANGER WITH LIMITS

Namibia's SRF was initiated in 1996 under the Home Power Project to support rural electrification by helping rural communities access credit finance and install off-grid solar solutions.

The revolving fund provides rural end-users with funds to support the purchase of solar energy systems targeting households with the condition to target Namibians between 22 and 55 years old.

SRF's technologies and limits

TECHNOLOGY	LOAN LIMIT	REQ. MONTHLY INCOME
Solar Home System 1	$250-$1,666	$83-$583
Solar Home System 2	$1,750-$5,000	>$583
SME Solar System	$1,750-$7,916	>$583
Solar Pumping	up to $5,000	N/A
Solar Water Heater	up to $2,900	N/A

The revolving fund offers low-interest loans of 5% to eligible users, with initial deposit of 5% and a payback period of 5 years.

The application process goes as follows:

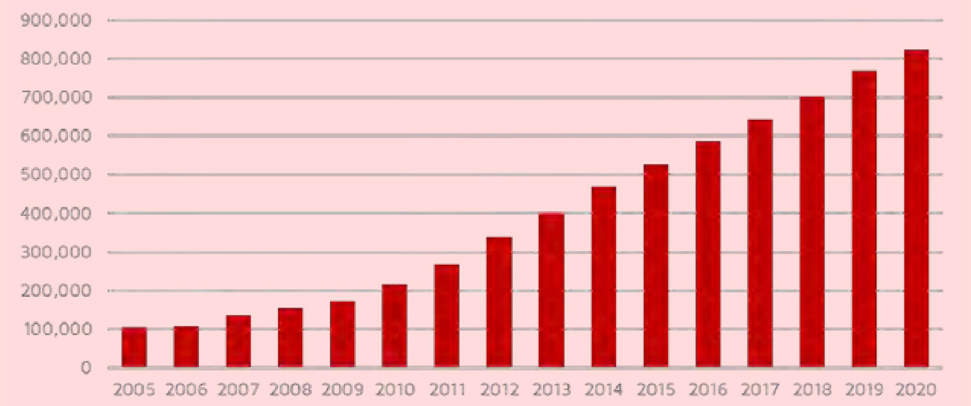
1. Applicant fills an application form with a quotation from a registered installer
2. A committee studies applications at the Ministry of Mining and Energy
3. Technical experts intervene to study the application further and approve technical aspects
4. Approved applications are notified of the approval and advised to pay the 5% deposit
5. Purchase orders are prepared, and installation is completed and then checked for confirmation

LEBANON'S GREEN LOAN: A SWEET FUSION OF SOFT LOAN AND REBATE

Lebanon's solar water heaters support program started in 2010 with the central bank of Lebanon offering subsidized loans for residential users interested in installing solar water heaters.

0% interest loans are offered with a cap of $5,000, coupled with a $200 rebate for the first 7,500 installations, creating a market boom and achieving more than 20,000 installations per year.

Evolution of solar water heaters installation in square meters



The program included qualification and listings of solar solutions providers, allowing only specific suppliers and specific technical specifications (compliant with EN12975 standard) to be eligible for the rebate and financing scheme.

Interested users would apply for a green loan at any commercial bank, submitting the required documents and a quotation from a qualified company. Individuals eligible for a loan are pre-approved and technical documents are reviewed by a technical committee to verify and approve technical eligibility.

The program was the primary market driver, ranking Lebanon 14th among 66 countries studied by the International Energy Agency to study the performance of the solar thermal markets.

Funded by the European Union

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