D1.3 ASSESSMENT OF INNOVATIVE TECHNOLOGIES OF CLIMATE-KIC

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement no 680511. This document does not represent the opinion of the European Union, and the European Union is not responsible for any use that might be made of its content.

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PROJECT INFORMATION	
Project acronym	DREEAM
Grant agreement number	680511
Project title	Demonstration of an integrated Renovation approach for Energy Efficiency At the Multi building scale

DOCUMENT INFORMATION	
Title	D1.3 Assessment of innovative technologies of Climate-KIC
Version	1.1
Release date	29.03.2017
Work package	WP1
Dissemination level	P

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EXECUTIVE SUMMARY

This deliverable represents a scan of innovative technologies relevant for the residential building sector and so potentially for renovation projects performed within DREEAM.

The document has two parts:

- **PART I** - Market scan of innovations in the residential building sector
  The scan was done beyond Climate-KIC, in order to provide a wider overview of options (page 9-85).

- **PART II** - Examination of specific technologies (solar panels) indicated as being of interest for the renovation projects to be performed within DREEAM (from page 85)

- **PART III** – Innovations developed in other EU-funded projects (from page 177)

PART I – INNOVATION MARKET SCAN

BUILDING ELEMENTS COVERED

- Opaque Components
- Windows
- Heating System
- Ventilation
- Cooling
- Lighting
- Shading
- Solar Thermal
- Storage Tank
- PV
- Control Systems
- Battery
- Alternative Energy Generation

METHODOLOGY

In order to gather the most innovative technologies within energy efficiency in buildings a thorough online research was done through the most relevant institutions in the field.

- Climate – KIC - http://www.climate-kic.org/
- Fraunhofer - https://www.fraunhofer.de/
- BPA Energy Efficiency- https://www.bpa.gov/EE/Pages/default.aspx
- National Renewable Energy Laboratory - http://www.nrel.gov/
- Northwest Energy Efficiency Alliance - http://neea.org/about-neea
- ARPA-E - https://arpa-e.energy.gov/
- Office of Energy Efficiency and Renewable Energy- http://energy.gov/
- International Energy Agency - https://www.iea.org/

The statements done regarding the different technologies are obtained from the suppliers and not tested by DREEAM

TRL

In order to classify the different innovations the Technology Readiness Level (TRL) is mentioned, estimating the maturity of each technology.

Please note that the TRL estimation refers to the time of the writing and might have changed in the meantime.

- TRL 5: Component and/or breadboard validation in laboratory environment
- TRL 6: System model or prototype demonstration in relevant environment
- TRL 7: System prototype demonstration in an operational environment
- TRL 8: Actual System complete and qualified through test and demonstration

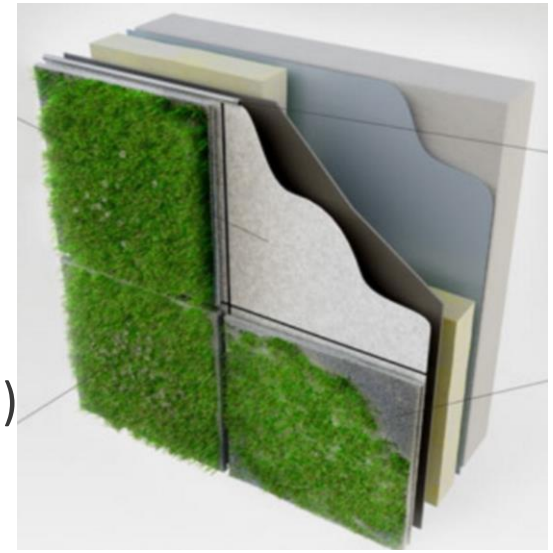
OPAQUE ELEMENTS

GREEN WALL

TRL = 6-8

Wall system with an exterior vegetal layer that can be integrated in the façade or attached to it and acts as a waterproofing layer.

- Key Points
  - Air quality improvement (up to 30%*)
  - Humidity absorption
- Application – building type
  - New buildings (Residential, Commercial)
- Application process
  - Disruptive (if applied as part of an integrated façade)
  - Non-disruptive (if attached to the existing façade)



*reduction in the concentration of NO2 7% and particle matter 30%

http://www.ambius.com/green-walls/panel-systems/index.html

CONVERTIBLE FAÇADES

TRL = 5

Convertible façade element that allows for a transformation of an interior space into an exterior one and vice versa, providing solar gains in winter and shading in summer.

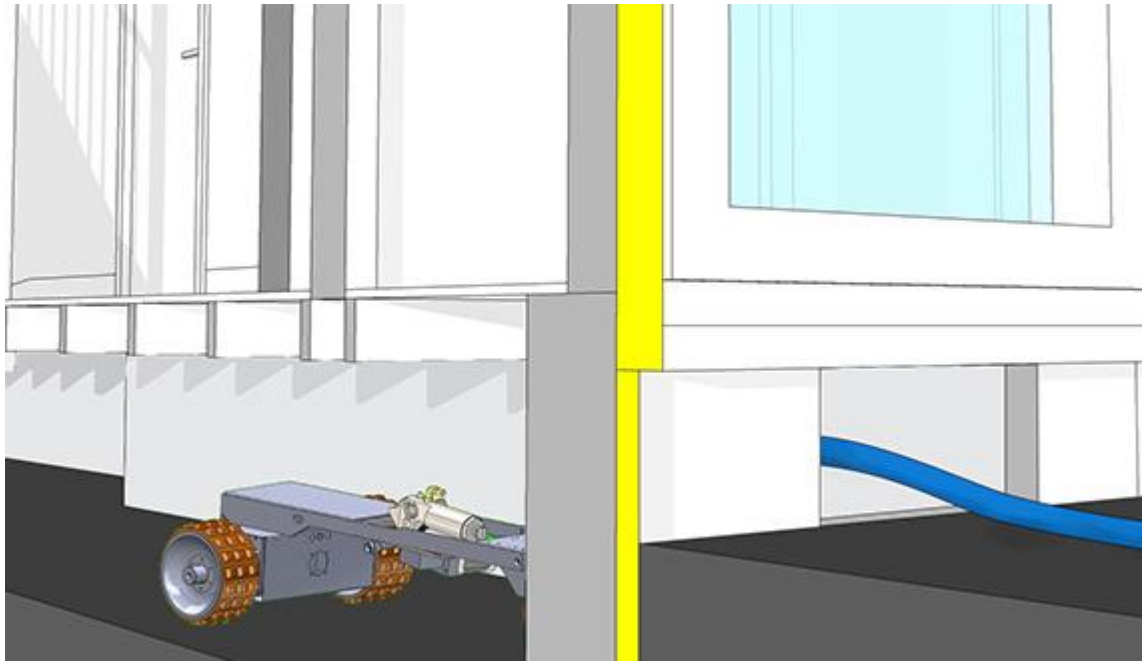
- Key Points
  - Flexibility (on space usage and according to seasonality)
- Application – building type
  - New buildings (Residential, Commercial)
  - Refurbishment (Residential, Commercial)
- Application – process
  - Non-Disruptive

FLOOR INSULATION ROBOTS

TRL = 6

Insulation technology (applied with a robot) to access otherwise inaccessible zones allowing for floor insulation. q-bot also provides a surveying service that maps hard to reach areas, identifies and locates services and provides information on the condition of the building.

- Key Points
  - Potentially faster
  - Potentially cheaper
- Application – building type
  - Refurbishment (Residential, Commercial)
- Application – process
  - Non-Disruptive

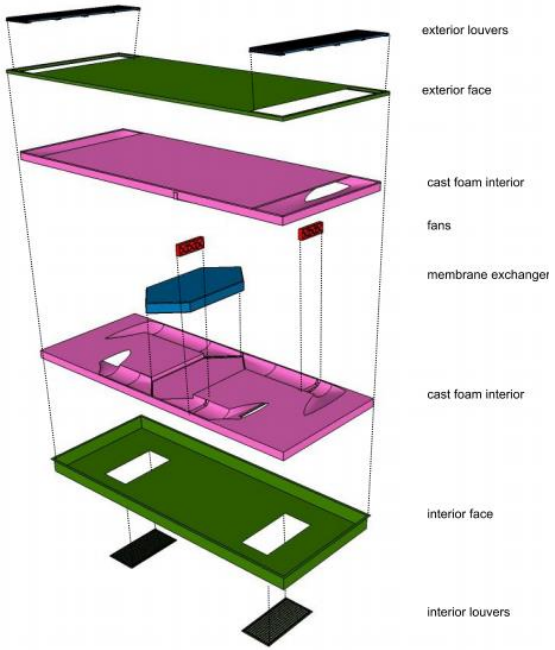


BI HEAT AND MOISTURE EXCHANGE

TRL = 6

Decentralized hybrid HVAC/Building envelope technology.

- Key Points
  - Flexibility (of design and applicability)
  - Potentially energy saving (25 to 50% of HVAC related energy)
  - Integrated technology (envelope + ventilation)
- Application – building type
  - Refurbishment (Residential, Commercial)
- Application – process
  - Non-Disruptive



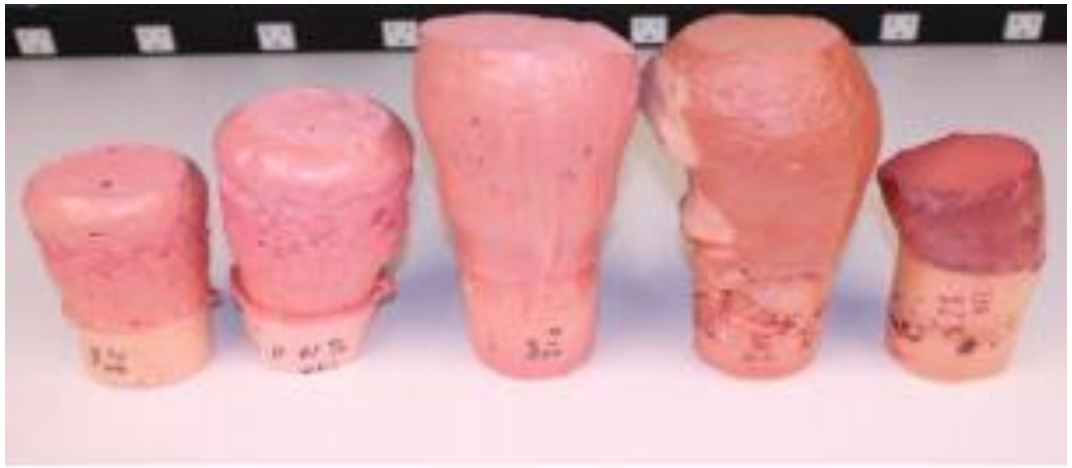
http://energy.gov/sites/prod/files/2016/04/f30/30004_Breshears_040716-1015.pdf

BIO-BASED INSULATION

TRL = 5

Phenolic foam derived from biomass lignocelluloses, obtained from common low cost bio-based waste products with low acidity with improved mechanical characteristics through micro reinforcement.

- Key Points
  - High insulation (R=8 per inch)
  - Compressive strength (20% better than PIR foams)
- Application – building type
  - New building (Residential, Commercial)
- Application – process
  - Disruptive



http://energy.gov/sites/prod/files/2016/04/f30/31397_Kosny_040616-1135.pdf

SELF CLEANING PAINT

TRL = 7

Exterior painting for vertical surfaces with hydrophobic properties and a microstructure that reduces the surface in contact with water.

- Key Points
  - Weather resistant
  - Self-Cleaning
- Application – building type
  - New building (Residential, Commercial)
  - Refurbishment (Residential, Commercial)
- Application – process
  - Non-Disruptive

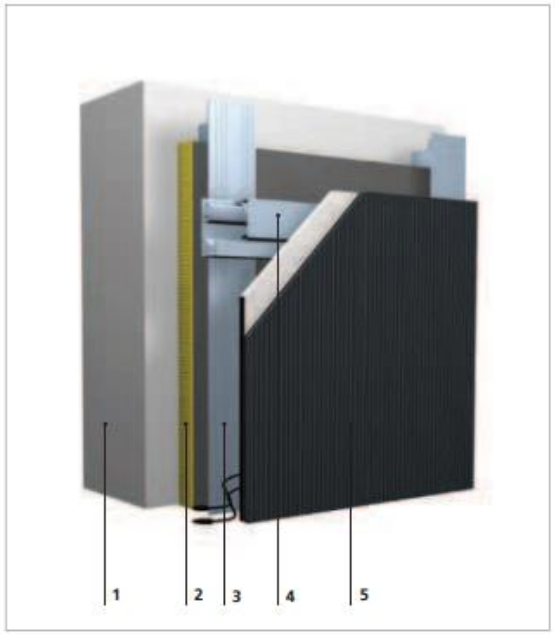
http://www.sto.se/sv/produkter_system/produkter/produkt_161210962.html

BIPV FAÇADE

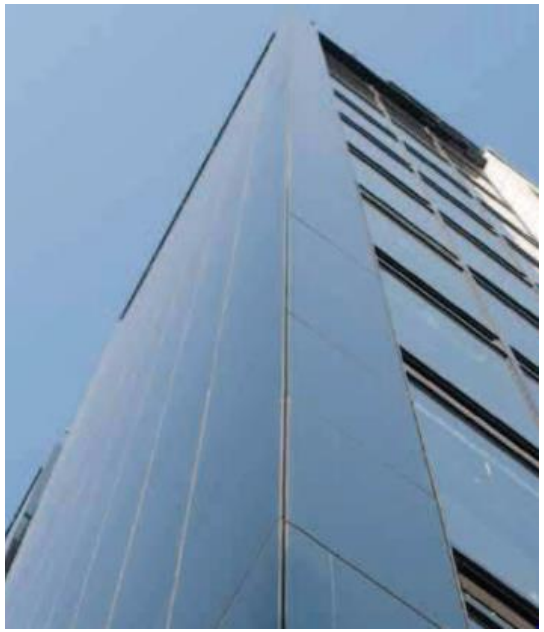
TRL = 7

Ventilated façade with integrated photovoltaics for electricity generation.

- Key Points
  - Electricity production (12 kWp/m2*)
  - Weather resistant
  - Prefabricated (faster installation time/customized)
  - Integrated technology (envelope + PV)
- Application – building type
  - New building (Residential, Commercial)
  - Refurbishment (Residential, Commercial)
- Application – process
  - Disruptive



1 Anchorage substrate
2 Thermal insulation (fleece-laminated)
3 Sub-construction
4 Agraffe profiles
5 StoVentec ARTline Invisible Panel



*in Helsinki, integrated on façade to South

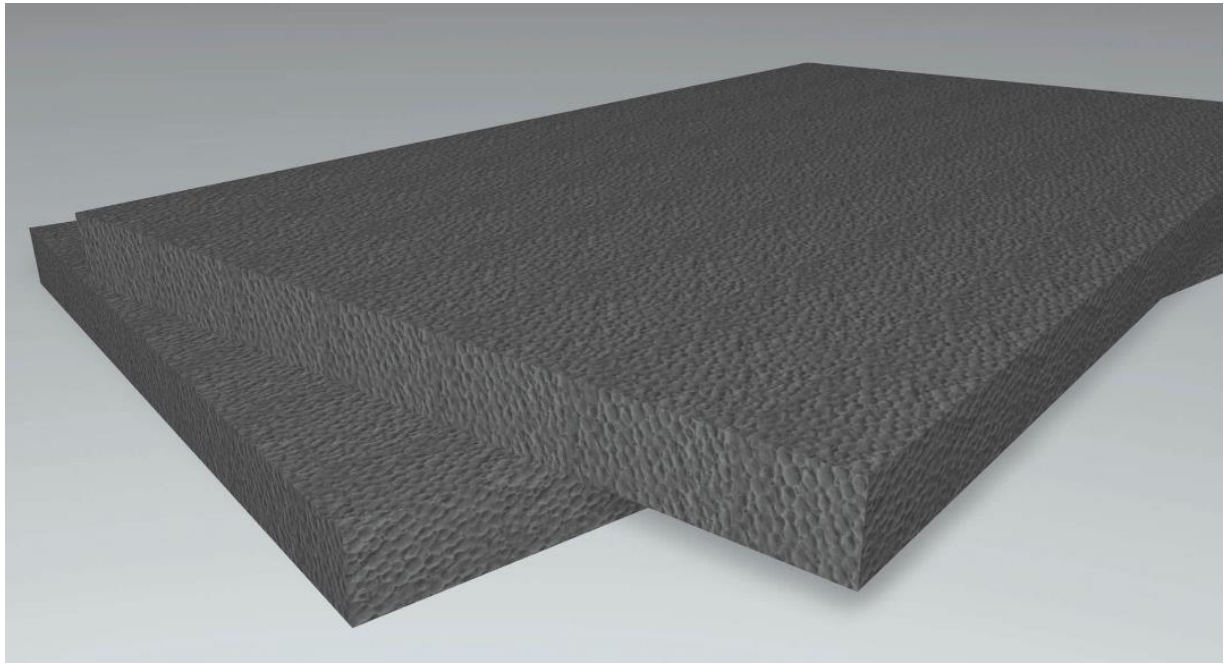
https://www.schueco.com/web2/de-en/architects/products/facades/ventilated_facades/ventilated_facade_bipv/

ENHANCED FOAM INSULATION

TRL = 7

Graphite enhanced polystyrene foam for insulation boards with hydrophobic properties.

- Key Points
  - High insulation (20% better performance than expanded polystyrene)
  - Low thermal conductivity
- Application – building type
  - New building (Residential)
  - Refurbishment (Residential)
- Application – process
  - Disruptive



Thermal Conductivity= 0,030-0,031 W/m.K

http://www.plasticsportal.net/wa/plasticsEU~en_GB/function/conversions:/publish/common/upload/foams/Neopor_Thermal_insulation.pdf

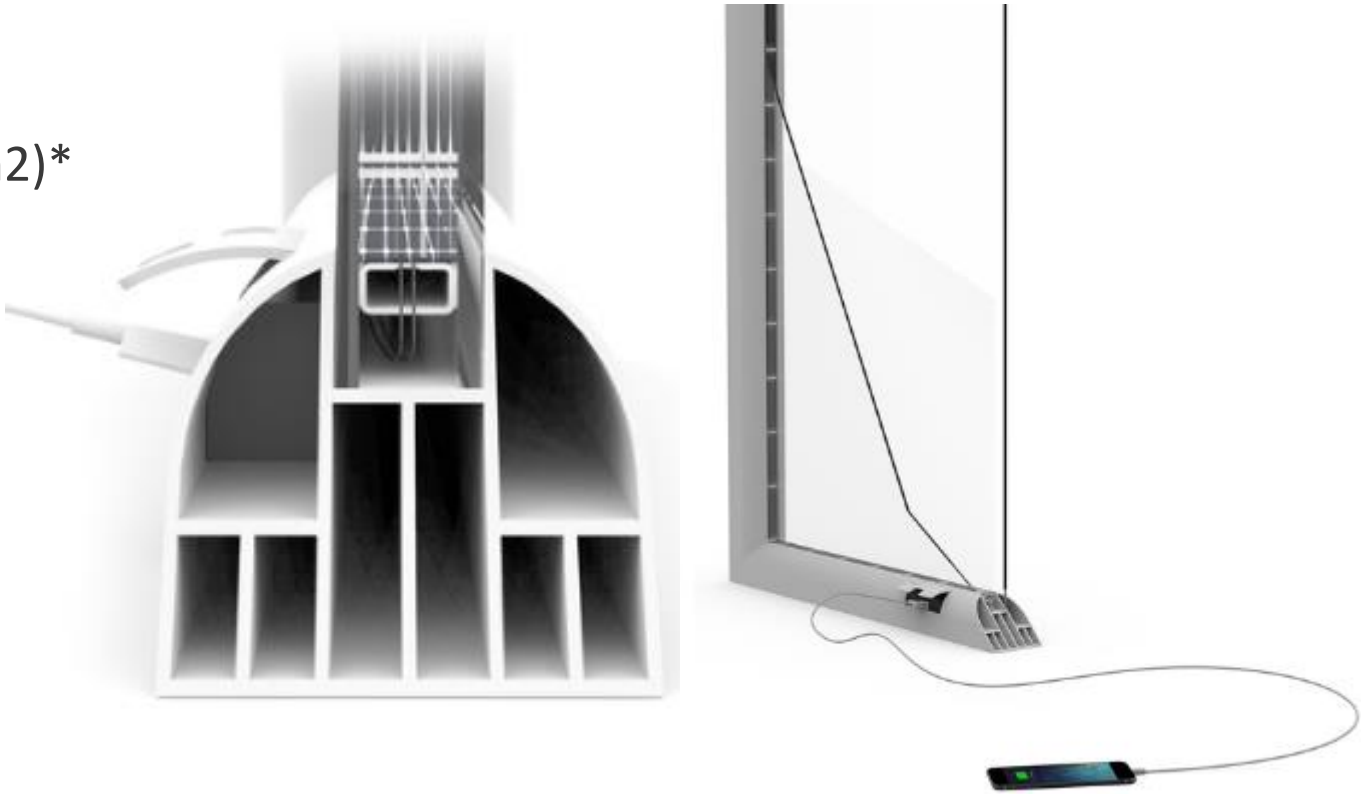
WINDOWS

LSC INTEGRATED WINDOWS

TRL = 6

Transparent double-paned windows with luminescent solar concentrators for energy production, covered with a sputtered thin-film coating.

- Key Points
  - Estimated electricity production (20 W/m2)*
- Application – building type
  - New building (Residential, Commercial)



*in Netherlands

http://www.physee.eu/powerwindow/

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AEROGEL INSULATED GLAZING

TRL = 6

Double glazed windows with aerogel filling, providing light diffusion without glare and a translucent solution for windows.

- Key Points
  - Estimated high insulation(U= 0.64W/m²K)
  - Humidity barrier
- Application – building type
  - New building (Residential ,Commercial)
  - Refurbishment (Residential, Commercial)

http://www.advancedglazings.com/product-overview/what-is-lumira-aerogel/

THERMOCHROMIC GLAZING

TRL = 7

Dynamic window technology that uses the heat form direct sunlight to tint the windows when necessary, passive functioning.

- Key Points
  - Smart window (adapts to external light conditions)
  - Higher user comfort
- Application – building type
  - New building (Commercial)
  - Refurbishment (Commercial)

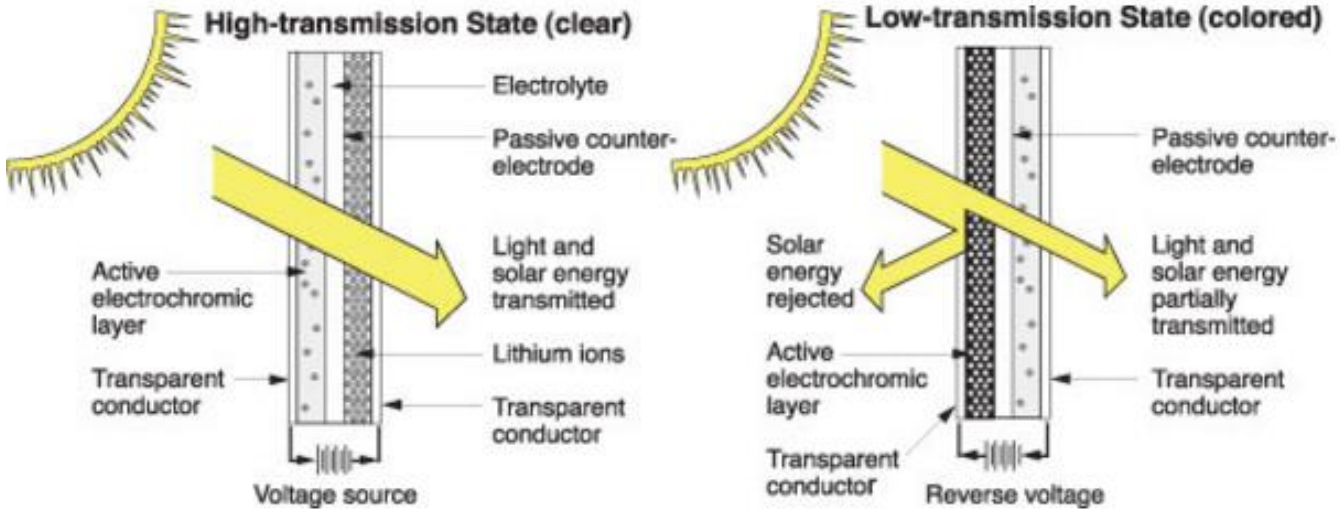
http://www.commercialwindows.org/thermochromic.php

ELECTROCHROMIC GLAZING

TRL = 7

Electricity activated thin layer that switches between clear and transparent blue-gray tinted state with no degradation in the view.

- Key Points
  - Smart window (adapts to external light conditions)
- Application – building type
  - New building (Residential, Commercial)
  - Refurbishment (Residential, Commercial)

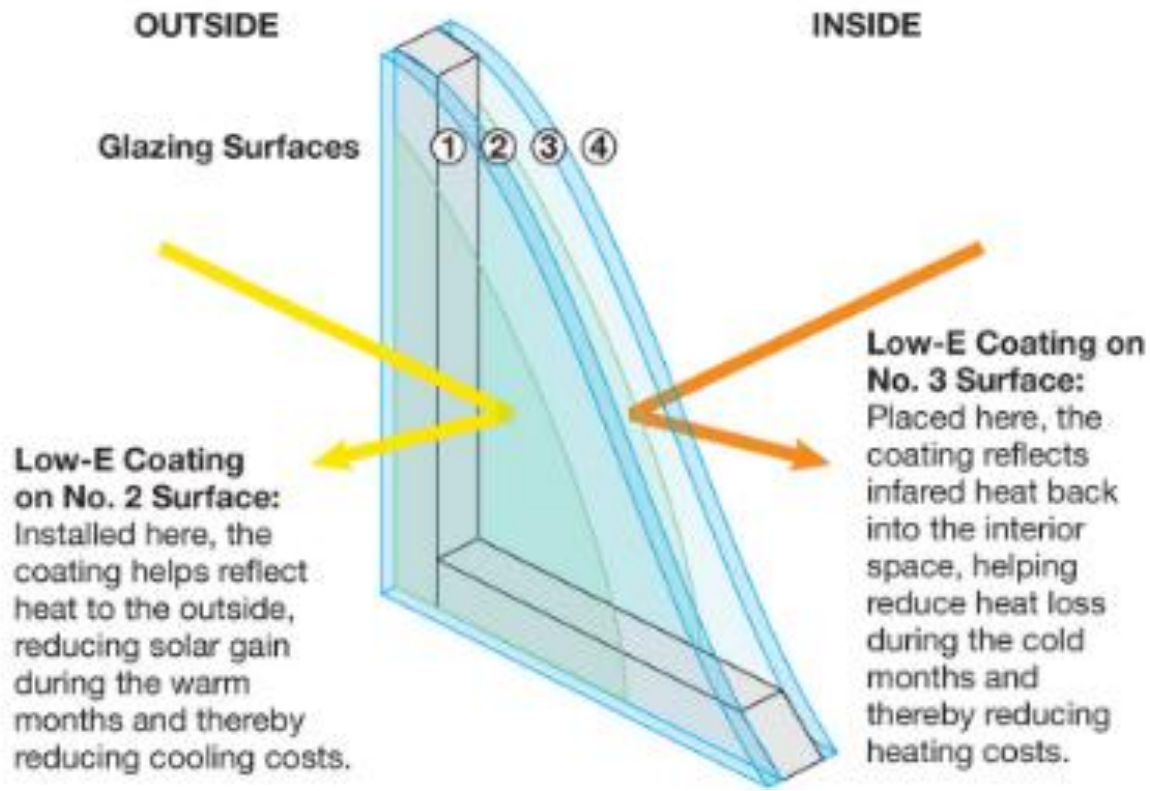


WINDOW WITH LOW EMISSIVITY COATINGS

TRL = 7

Window with thin film coatings applied through sputtering to the different layers that reduce the emission of radiant infrared energy.

- Key Points
  - Lowered emittance (E=0.04, standard glass E=0.84)
- Application – building type
  - New building (Residential, Commercial)
  - Refurbishment (Residential, Commercial)



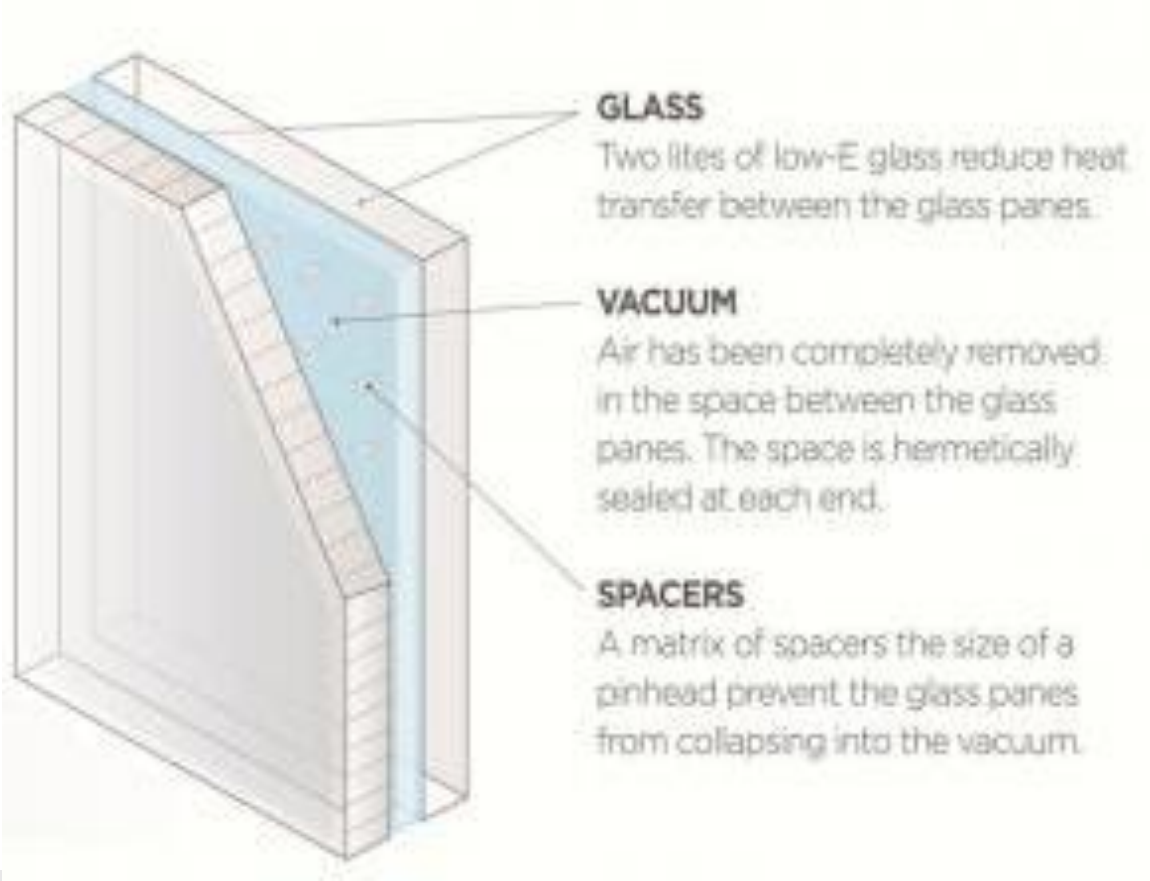
http://www.efficientwindows.org/lowe.php

VACUUM INSULATED WINDOWS

TRL = 6

Window with evacuated intermediate layer (vacuum) eliminating heat transport due to convection and conduction. Glazing is prevented from collapsing by using a matrix of spacers.

- Key Points
  - Estimated high insulation (U=0.4W/m²K)
- Application – building type
  - New building (Residential, Commercial)
  - Refurbishment (Residential, Commercial)

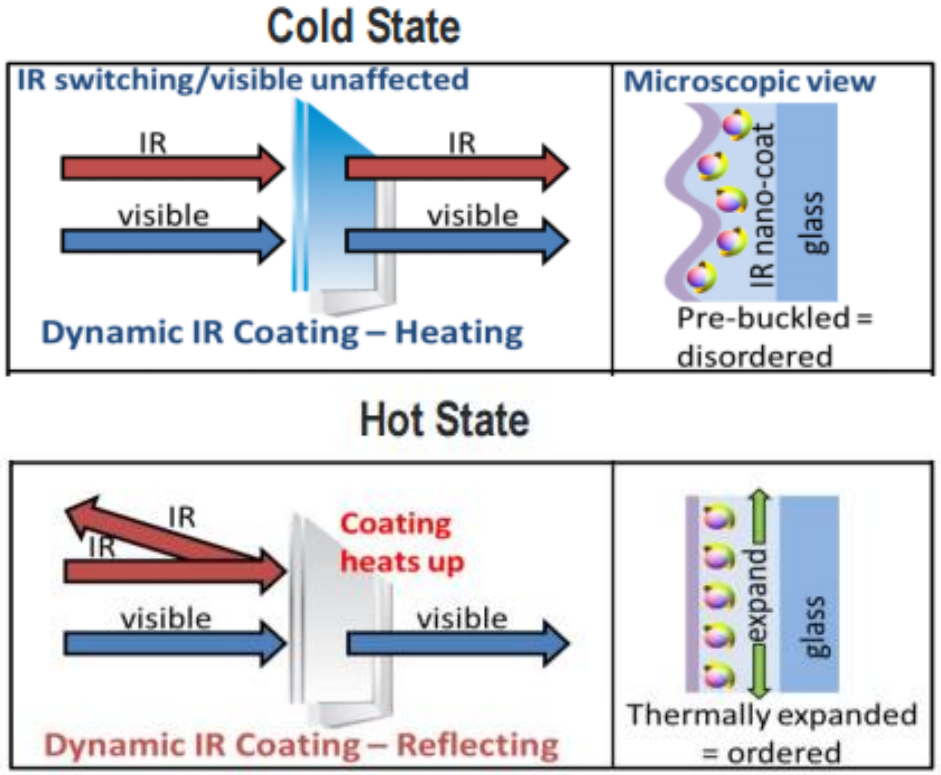


http://www.bine.info/fileadmin/content/Publikationen/Projekt-Infos/2008/Projekt-Info_01-2008/Vacuum_Insulation_Glass.pdf

WINDOWS WITH DYNAMICALLY RESPONSIVE IR COATINGS TRL = 5

Window with infrared reflective sub-wavelength nanostructures integrated in a buckling layer for passive thermal switching.

- Key Points
  - Potential energy saving (20 to 30% of primary cooling)
  - Smart window (adapts to external light conditions)
- Application – building type
  - New building (Residential, Commercial)
  - Refurbishment (Residential, Commercial)



http://energy.gov/sites/prod/files/2015/05/f22/emt42_Alvine_041515.pdf

HIERARCHICAL POROUS SILICA INSULATED WINDOW

TRL = 4

Windows insulated with a layer of a newly produced material, hierarchical porous silica that has high R value. It is also haziness free and has improved mechanical strengths.

- Key Points
  - Potentially high insulation (U = 0.3 W/m^2K)
  - Cheaper (compared to aerogel, $6/$ft^2$)
  - Transparent (compared to aerogel*)
- Application – building type
  - New building (Residential, Commercial)
  - Refurbishment (Residential, Commercial)

*80% visible transmittance

http://energy.gov/sites/prod/files/2016/04/f30/31396_Sharma_040616-1105.pdf

HEATING SYSTEM

SERVER BASED HEATING

TRL = 6

Server center de-centralization to be used as heating system in buildings. Employs otherwise wasted heat and eliminates the need for cooling of servers as well as specific spaces and infrastructure for them.

- Key Points
  - Estimated heat production (1kw)
  - Estimated energy saving (3 tons of CO2 /house/year)
- Application – building type
  - New buildings (Residential)
  - Refurbishment (Residential)
- Application – process
  - Non-disruptive

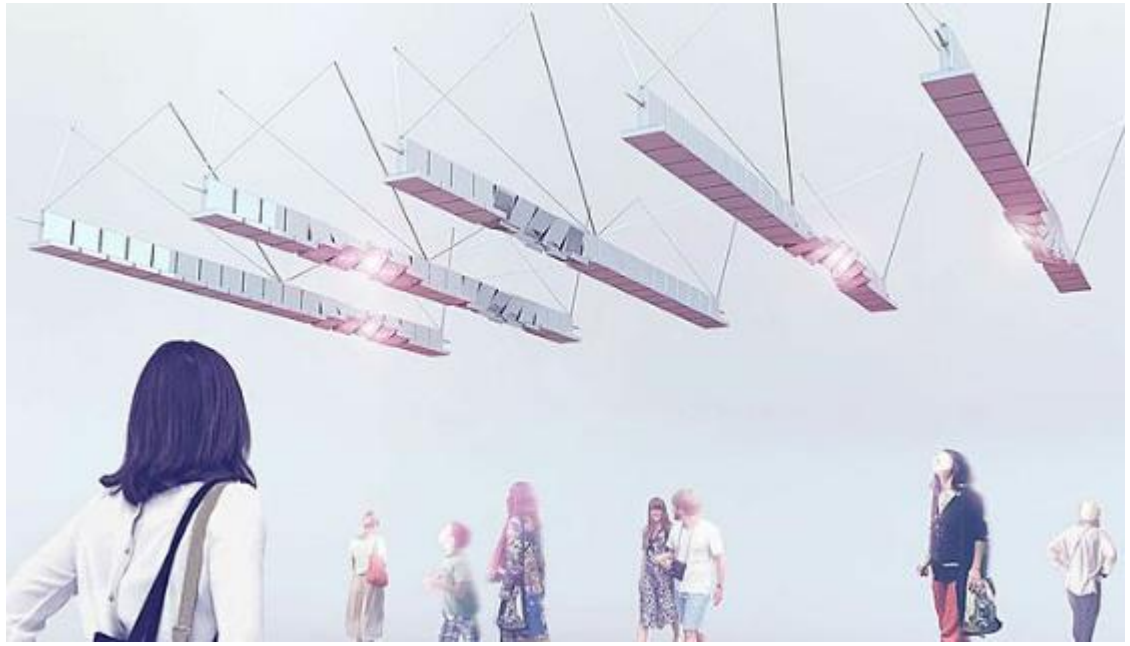
Heating System

LOCAL WARMING

TRL = 5

Wi-fi based motion tracking to provide on demand heating and cooling through the usage of a collimated infrared energy beam that follow the user and that can be controlled by it.

- Key Points
  - Personal climate
- Application – building type
  - New buildings (Commercial)
- Application – process
  - Non-Disruptive



http://senseable.mit.edu/localwarming2014/

MICRO CHP

TRL = 5 - 7

Simultaneous production of heat and power in an individual building based on small conversion units . Depending on the technology used they can be based on reciprocating engine (7), stirling engine (6) or fuel cell(5).

- Key Points
  - Heat production (12,5 kW)*
  - Electricity production (4,7 kW_{el})*
  - High energy efficiency (95%)
- Application - building type
  - New buildings (Residential)
  - Refurbishment (Residential)
- Application - process
  - Disruptive

http://www.tips-project.org/DOWNLOAD/Graz_Innovation_Micro_CHP.pdf

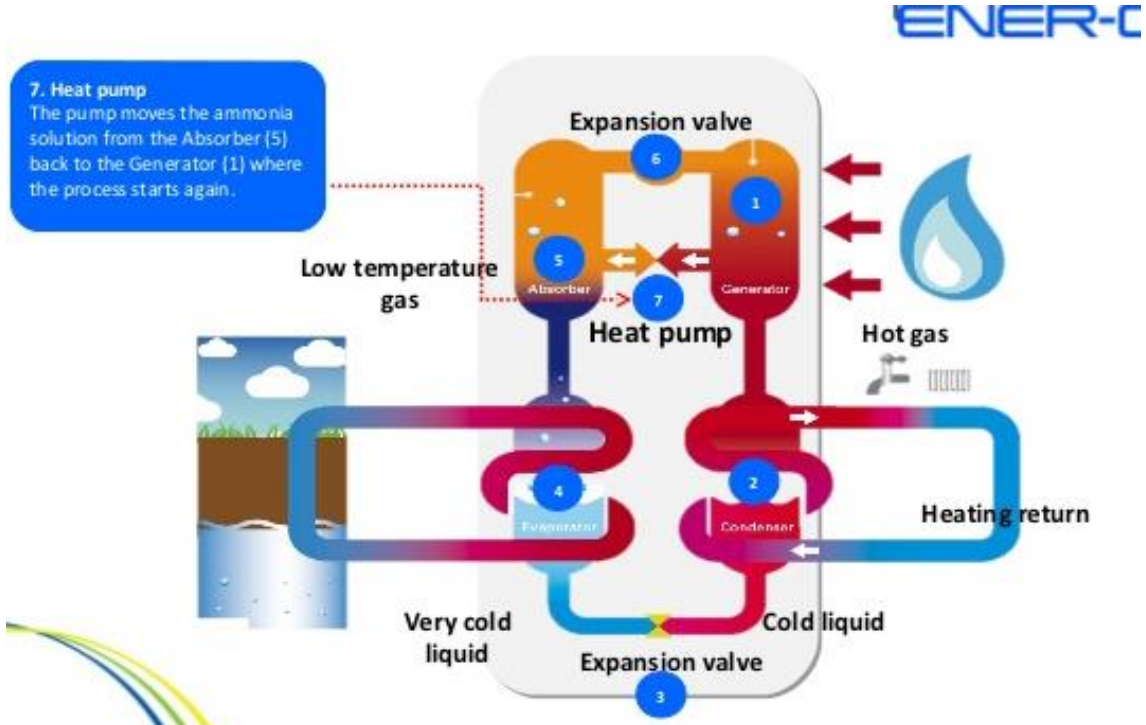
* For a CHP 3-6 kW, with λ=1, maximum efficiency

AIR SOURCED HEAT PUMPS

TRL = 7

Heating system that provides both heating and cooling through a refrigerant cycle that can be inverted, transferring heat from the inside of the building to the outside or vice versa.

- Key Points
  - High energy efficiency (COP =3-3.5)
  - Long life span
- Application – building type
  - New buildings (Residential, Commercial)
  - Refurbishment (Residential)
- Application – building type
  - Disruptive

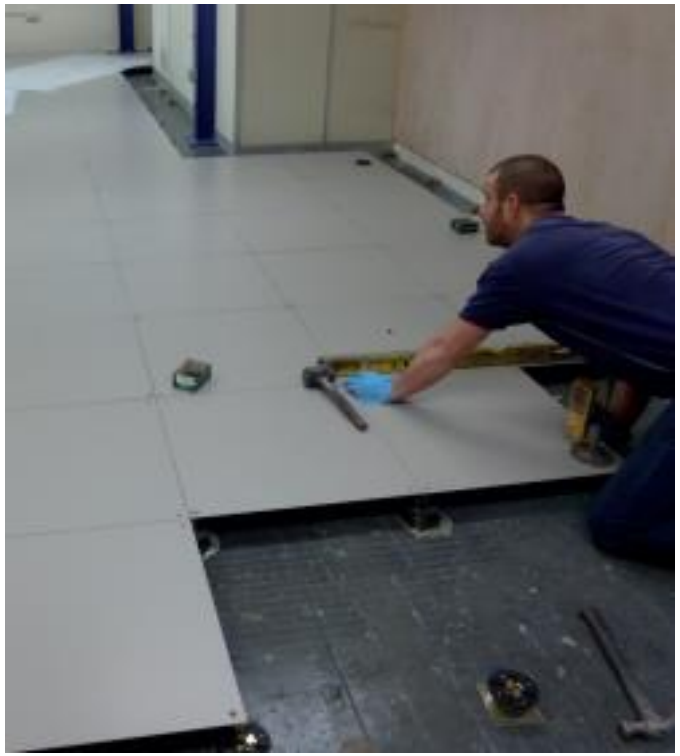


HEATED RAISED ACCESS FLOOR SYSTEM

TRL = 6

Electrically heated raised access floor, with a heated coating and the usage of resistive electrical heating. That is applied to a steel substrate and fitted to the surface of a standard raised access floor.

- Key Points
  - Space saving
  - Fast installation
- Application – building type
  - Refurbishment (Commercial)
- Application – process
  - Disruptive



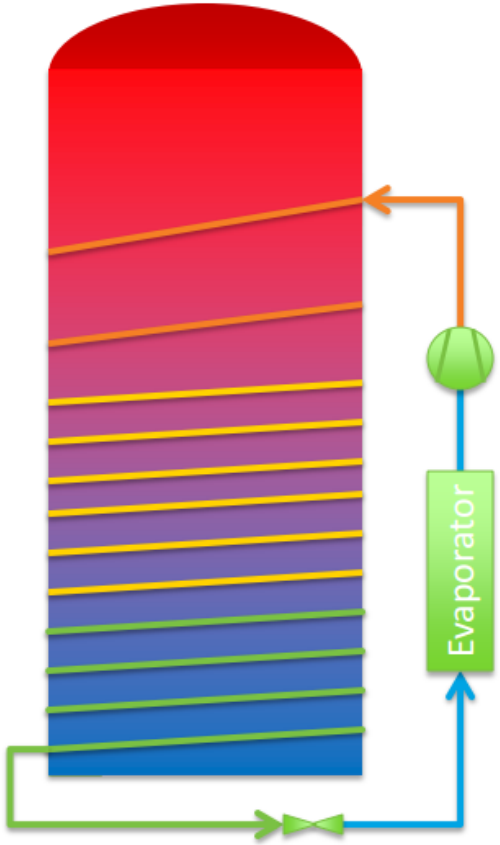
Heating System

CO2 HEAT PUMP

TRL = 7

Heat pump using C02 as a natural refrigerant for water heating , as an alternative to move away from HFC refrigerants

- Key Points
  - High energy efficiency (potentially up to COP=8)
  - Low GWP (CO2 gwp =1, R407c gwp = 1652.5)
- Application – building type
  - New building (Residential, Commercial)
- Application – process
  - Disruptive



Coefficient of Performance=4

http://energy.gov/sites/prod/files/2016/04/f30/32218a_Gluesenkamp_040616-1205.pdf

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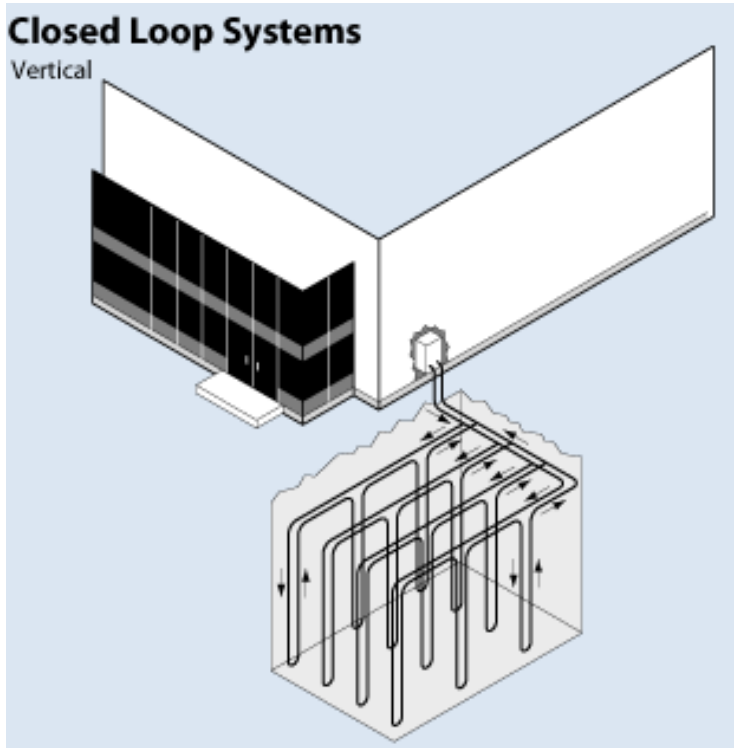
Heating System

GEOTHERMAL HEAT EXCHANGER

TRL = 7

Geothermal Heat Exchanger with heat recovery that uses the constant temperature of the earth for heat recovery and tempering the supply air.

- Key Points
  - Energy saving (30% to 50%)
  - High energy efficiency (A rating)
- Application – building type
  - New Building (Residential, Commercial)
- Application – process
  - Disruptive



Heat Recovery= 92%

http://energy.gov/energysaver/geothermal-heat-pumps/

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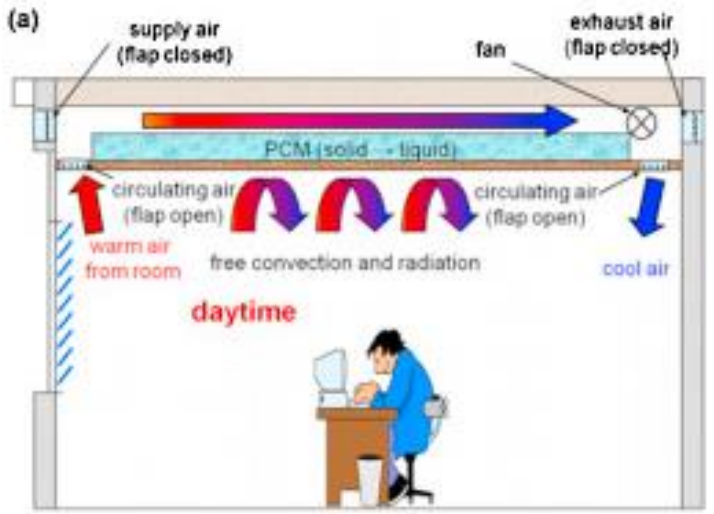
VENTILATION

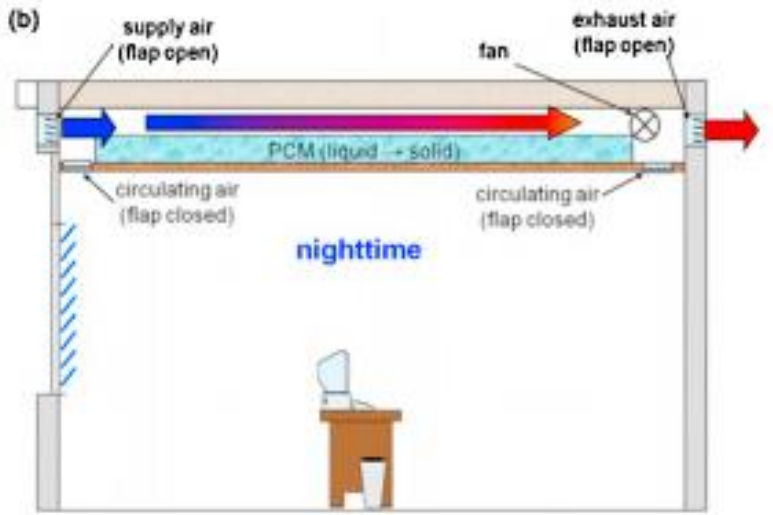
PCM ENHANCED CEILING VENTILATION SYSTEM

TRL = 5

Thermally activated building system incorporated to the ventilation, through the usage of PCM materials to lower the operative room temperature.

- Key Points
  - High energy density
  - Potential high cooling power (30 W /m2)*
- Application – building type
  - New building (Commercial)
  - Refurbishment (Commercial)
- Application – process
  - Disruptive





*Room temperature 28ºC, volume flow rate 300m3/h

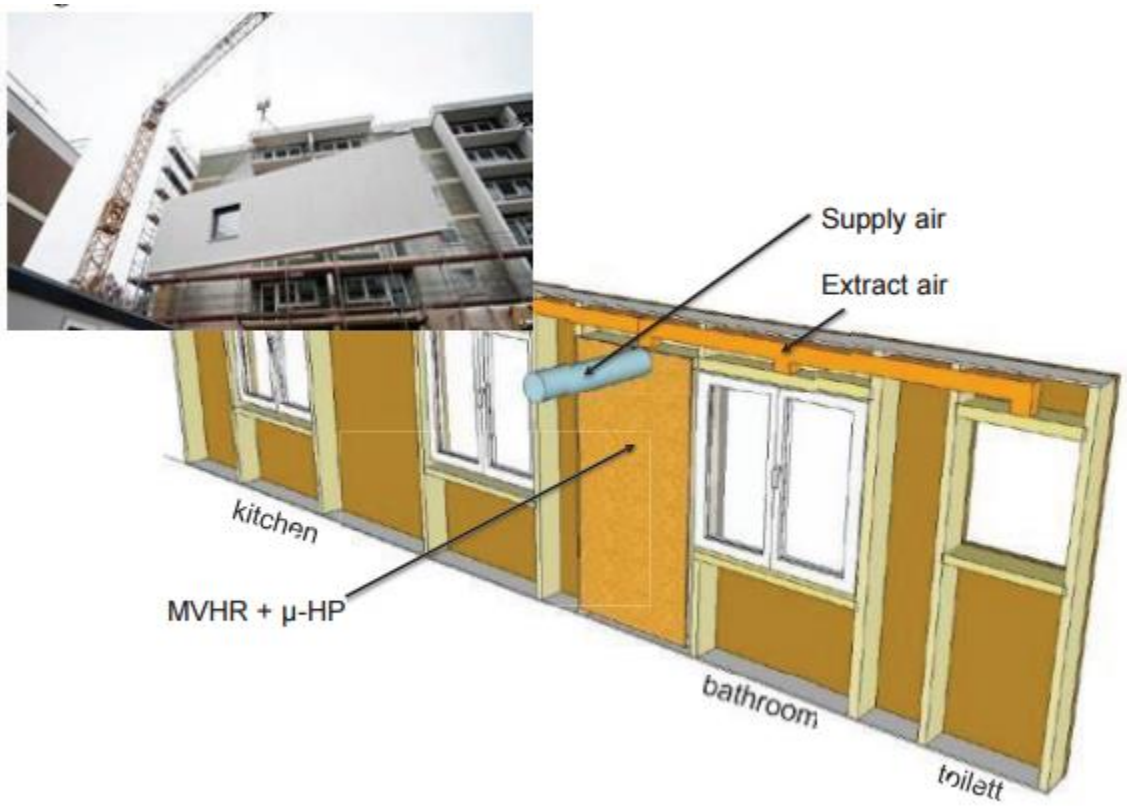
http://ac.els-cdn.com/S0378778814005507/1-s2.0-S0378778814005507-main.pdf?_tid=071dcbd0-83f6-11e6-87f8-00000aacb362&acdnat=1474900518_5d6f90a33f748b0bd321f9011ba2eccd

FAÇADE INTEGRATED VENTILATION

TRL = 5

Prefabricated façade element with an integrated micro heat pump with heat recovery.

- Key Points
  - Integrated technology (envelope + ventilation)
  - Heat production (10W/m2)
  - Prefabricated (faster installation time/customized)
- Application – building type
  - New building (Residential)
  - Refurbishment (Residential)
- Application – process
  - Disruptive



http://ac.els-cdn.com/S1876610215018470/1-s2.0-S1876610215018470-main.pdf?_tid=d4bdd438-848a-11e6-a717-00000aab0f02&acdnat=1474964429_f0cb80ddf666d04756e87b56ac81ad21

COOLING

SURFACE BASED COOLING SYSTEM

TRL = 7

Ceiling, floor or wall panels with chilled surface that operates below the dew point without any condensation.

- Key Points
  - Integrated technology (floor + cooling)
  - High energy efficiency (operates at temperatures close to room temperature)
  - High cooling capacity (60W/m2)*
- Application – building type
  - New building (Commercial, Residential)
  - Refurbishment (Commercial, Residential)
- Application – process
  - Disruptive

* In the ceiling, 35-50 in the wall, 35 in the floor

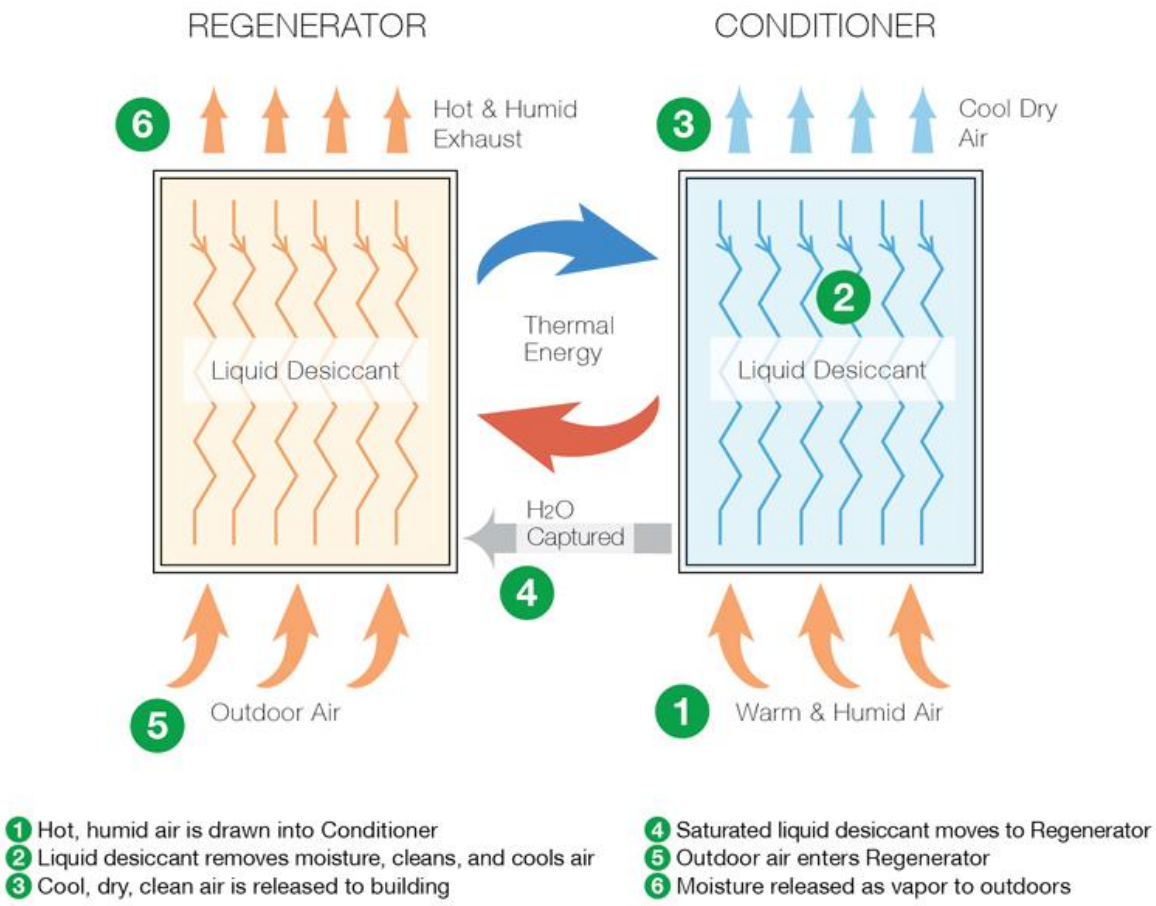
http://www.ehi.eu/article/surface-heating-and-cooling

LIQUID DESICCANT COOLING

TRL = 5

Desiccant cooling system using a liquid water-lithium chloride solution as sorption material.

- Key Points
  - Potentially high air dehumidification (compared to solid desiccant cooling system)
- Application – building type
  - New building (Commercial, Residential)
  - Refurbishment (Commercial, Residential)
- Application – process
  - Disruptive



GREEN REFRIGERANTS

TRL = 5

Non global warming potential (GWP) refrigerants (ammonia, carbon dioxide,...) that are non contaminating and free ozone depleting. Can be found in a number of ventilation systems.

- Key Points
  - High energy efficiency (compared to standard refrigerants)
  - Low GWP
- Application – building type
  - New Building (Commercial, Residential)
  - Refurbishment (Commercial, Residential)

Refrigerant		Molecular weight	Boiling point [℃]	Critical temperature [℃]	Flammability [vol%]	Toxicity [ppm]	ODP (R-11=1)	GWP (CO2=1)
Natural Refrigerant	CO_2	44.0	-78.4	31.1	None	5000	0	1
	Propane	44.1	-42.1	96.7	2.1-9.5	1000	0	3
	Butane	58.1	-11.6	134.7	1.8-8.5	800	0	3
	NH_3	17.0	-33.3	132.3	15-28	25	0	<1

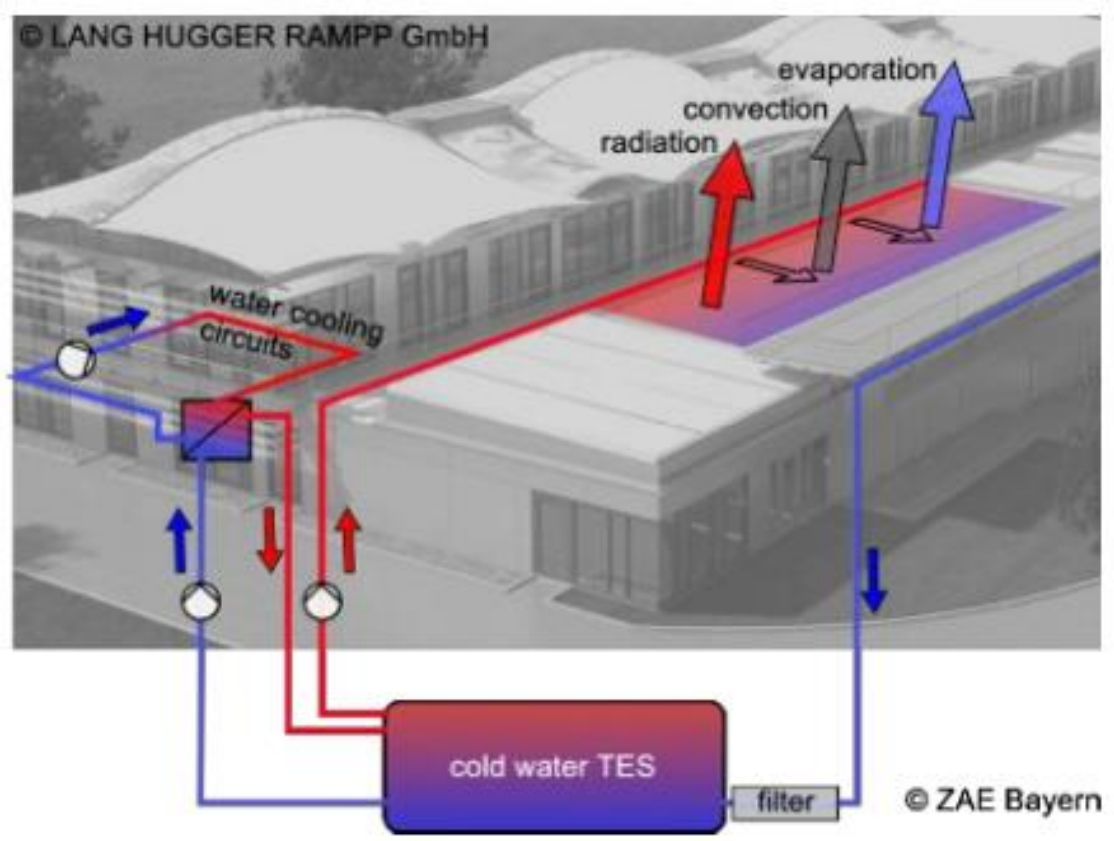
http://www.eurammon.com/sites/default/files/attachments/airconditioning_eur_engl.pdf

PASSIVE INFRARED NIGHT COOLING

TRL = 5

Tank connected to the cooling circuits via heat exchangers. Water is re-cooled in the rooftop at night caused by infrared heat radiation.

- Key Points
  - Potential high energy efficiency (COP >20)
  - Holistic system
- Application – building type
  - New building (Commercial)
- Application – process
  - Disruptive



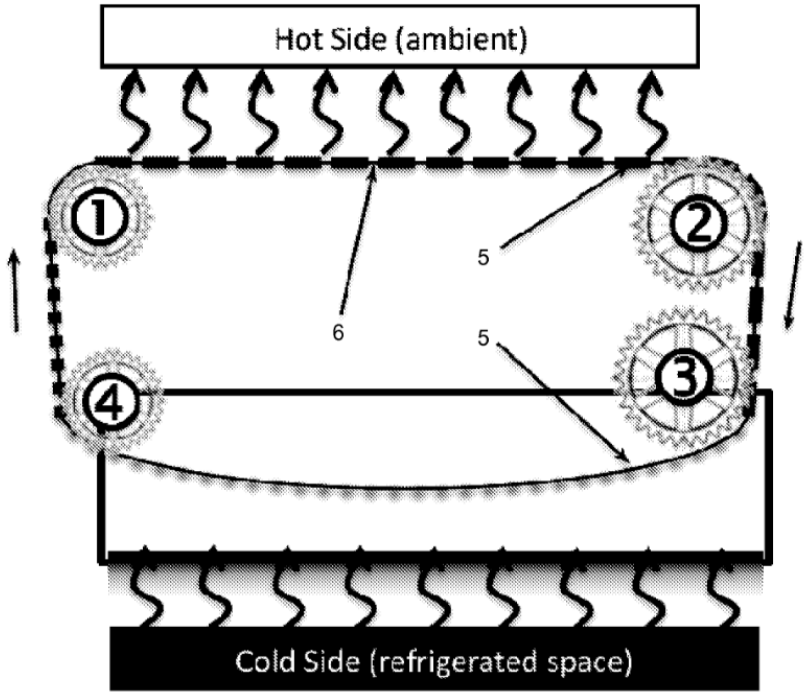
http://www.irbnet.de/daten/iconda/CIB_DC27890.pdf

COMPACT THERMOELASTIC COOLING

TRL = 5

A system with a regenerator that comprises solid thermoelastic refrigerant materials capable of absorbing or releasing heat with a roller-belt design.

- Key Points
  - Long Life Span
  - Potential Energy Saving (up to 40%)
  - Potential High Energy Efficiency (COP >4)
- Application – building type
  - New Building (Commercial, Residential)
- Application – process
  - Disruptive



Coefficient of Performance=11

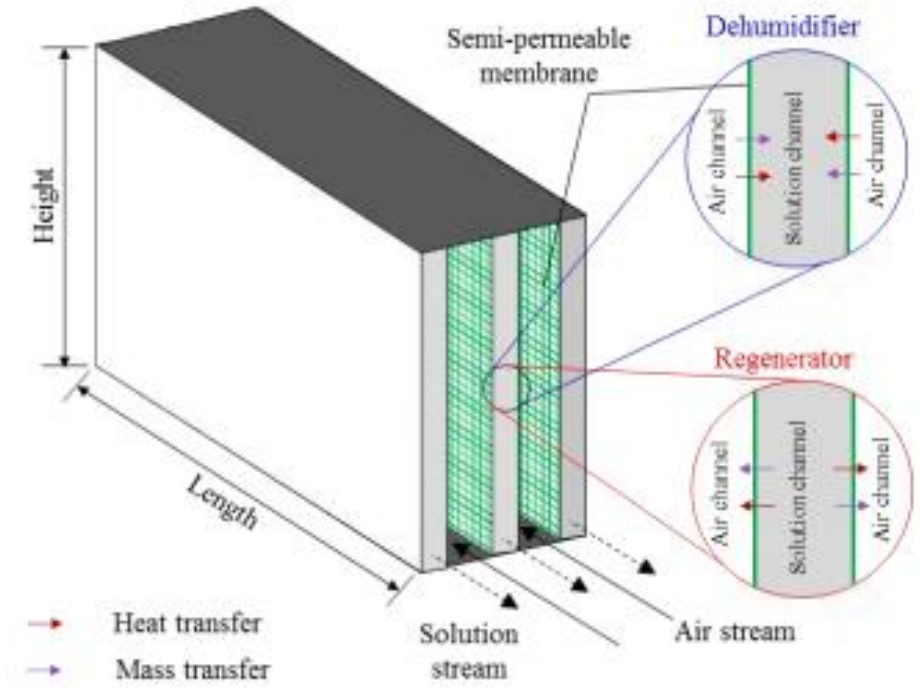
http://energy.gov/sites/prod/files/2016/04/f30/312109_Takeuchi_040616-950.pdf

MEMBRANE HEAT PUMP

TRL = 6

Driven by a vacuum pump, these systems provide cooling/dehumidification and/or heating/dehumidification by transferring moisture across a number of membranes.

- Key Points
  - Estimated energy saving (up to 50%)
- Application – building type
  - New building (Commercial, Residential)
- Application –process
  - Disruptive



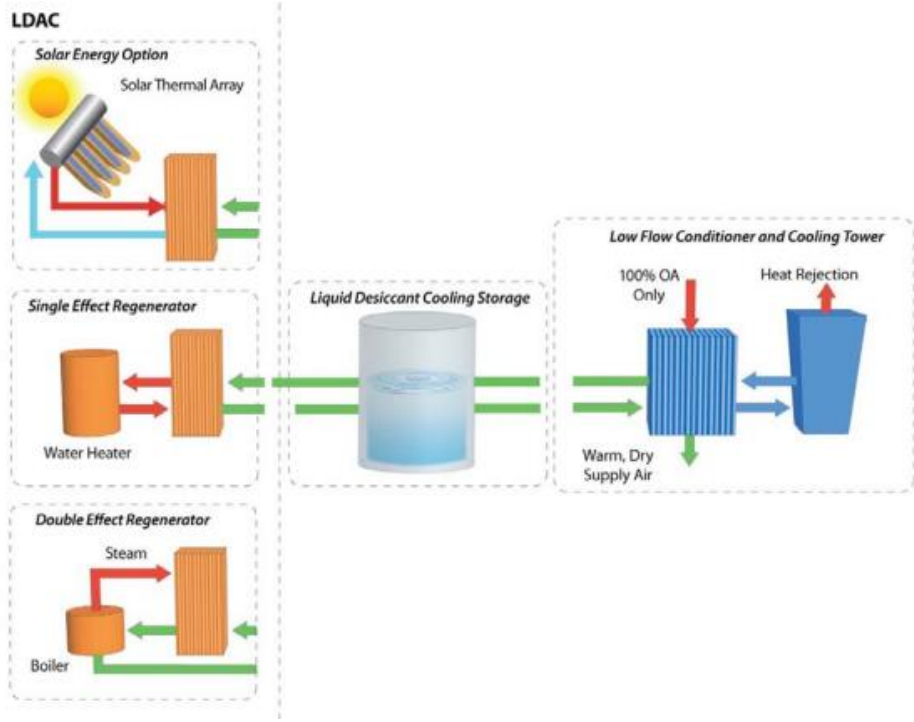
Energy Efficiency Rating=26

EVAPORATIVE LIQUID DESICCANT COOLING

TRL = 5

Ventilation system that consists of a primary channel (dries and cools incoming air using a liquid desiccant stream) and a secondary channel (evaporatively cools a water layer using a portion of the dried air, thereby further cooling the supply air).

- Key Points
  - Potential energy saving (up to 61%)*
  - Air quality Improvement
  - Energy Efficiency (COP =1,2 -1,4)
- Application – building type
  - New building (Commercial, Residential)
- Application – process
  - Disruptive



*Of source energy consumption

http://www.nrel.gov/docs/fy11osti/49722.pdf

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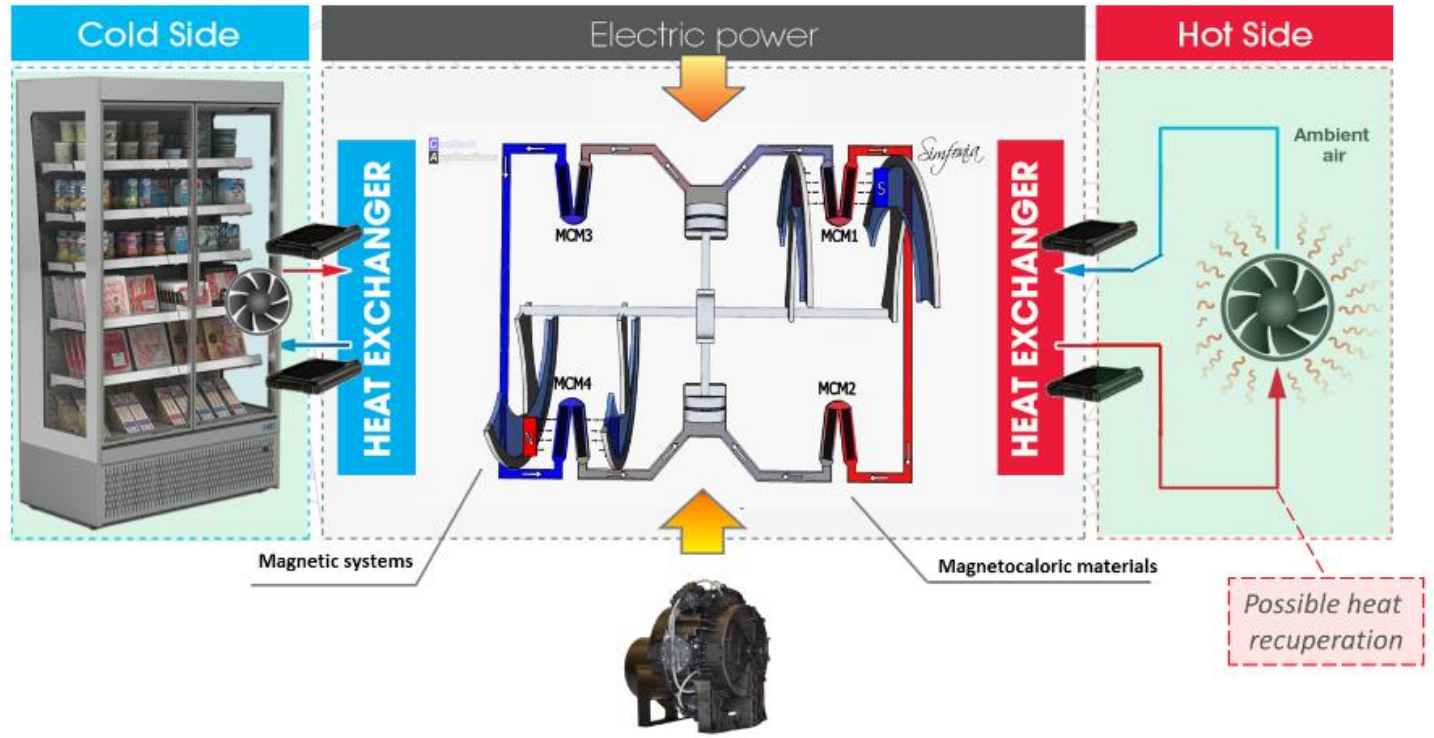
MAGNETOCALORIC COOLING

TRL = 4

Cooling technology that operates on the magnetocaloric effect, a phenomenon in which a paramagnetic material exhibits reversible temperature change when exposed to a changing magnetic field.

- Key Points
  - Potential energy saving (up to 20%)
  - Potential energy efficiency (COP =2-4)
  - Noiseless
- Application – building type
  - New building (Commercial)
  - Refurbishment (Commercial)
- Application – process
  - Non-Disruptive



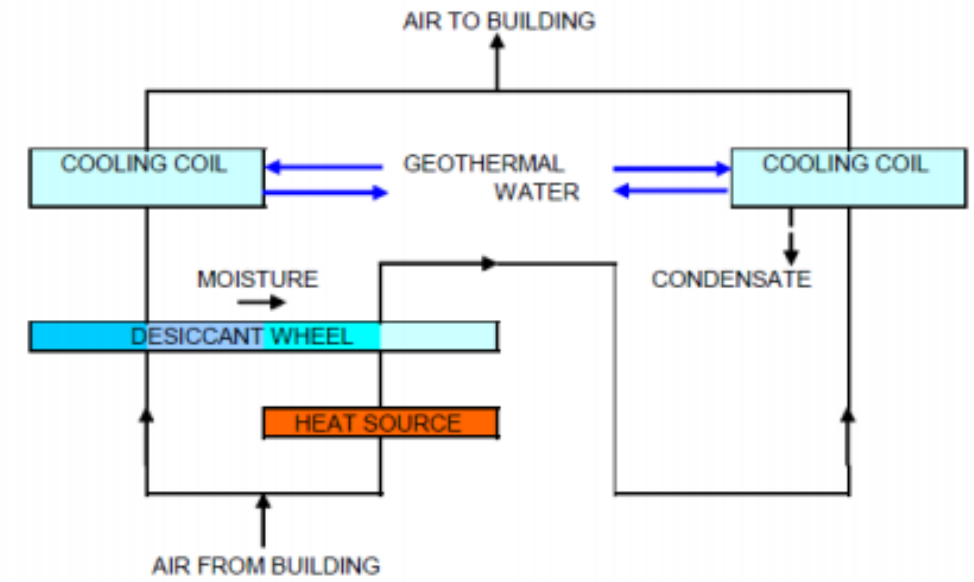
http://www.cooltech-applications.com/magnetic-refrigeration-system.html

GROUND COUPLED SOLID DESICCANT COOLING

TRL = 5

Cooling technology that combines two technologies: ground-coupled fluid systems and solid desiccants. The primary stage first dries the supply air using a solid desiccant wheel and the secondary stage sensibly cools the air using a ground-coupled fluid loop.

- Key Points
  - Potential energy saving (up to 43%)
  - Potential energy efficiency (COP =1,85)
  - Noiseless
- Application – building type
  - New building (Commercial, Residential)
  - Refurbishment (Commercial, Residential)
- Application – process
  - Disruptive



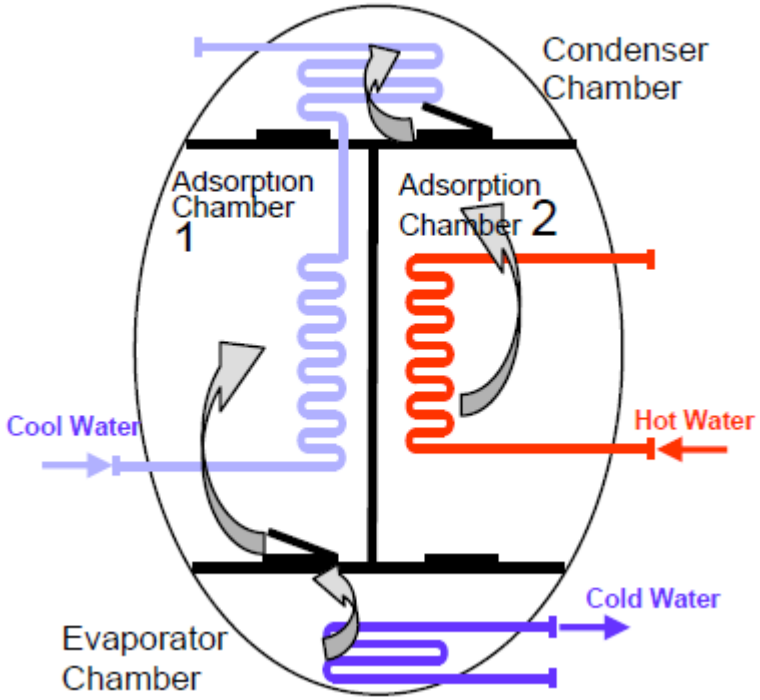
http://www.aertc.org/conference2011/Speaker%202011/2011%20AEC%20Session%204/4C%20Building%20Efficiency/Crista%20Shopis/shopis%20presentation.pdf

ADSORPTION COOLING

TRL = 5

Thermal compressor based on metal organic frameworks, a metallic cluster that together with organic linkers form a three-dimensional porous structure.

- Key Points
  - High water vapor absorption (1.4 against 0.4 of standard systems)
  - High refrigerant capacity (3 times higher than standard chillers)
- Application – building type
  - New building (Commercial, Residential)
  - Refurbishment (Commercial, Residential)
- Application – process
  - Disruptive



https://www.fraunhofer.de/en/press/research-news/2014/june/efficient-thermal-cooling-and-heating.html

LIGHTING

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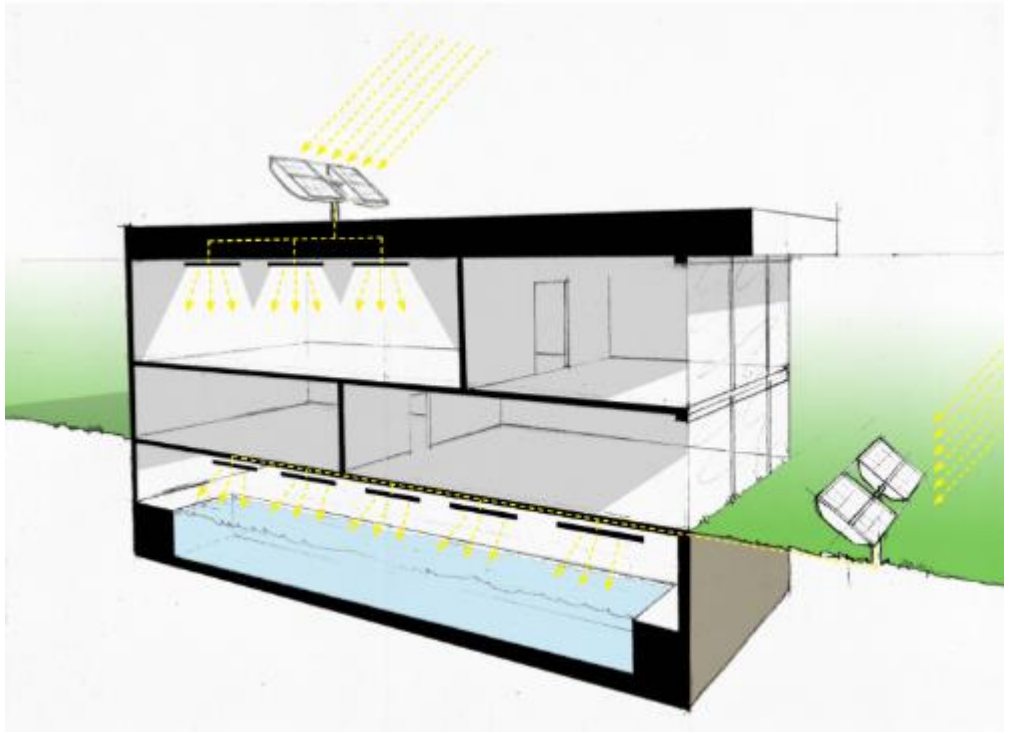
SOLAR LIGHTING WITH FIBER OPTICS

TRL = 7

Light capture through Fresnel lenses that are fixed in a sun tracker and then fed into the building through fiber optic cables with no ultraviolet rays transmitted and minimal heat emission.

- Key Points
  - Natural light
  - Green technology (sun as light source)
- Application – building type
  - New building (Commercial, Residential)
- Application – process
  - Disruptive



http://www.greenbuildingadvisor.com/blogs/dept/energy-solutions/fiber-optics-daylighting

ARTIFICIAL SKYLIGHT

TRL = 6

Solid nanoparticles layer that produce Rayleigh scattering simulating blue sky in a way of modifying artificial light, and allowing for a sensation of external lighting in otherwise dark places.

- Key Points
  - Natural light feeling
- Application – building type
  - New building (Commercial, Residential)
  - Refurbishment (Commercial, Residential)
- Application – process
  - Non-Disruptive

http://www.coelux.com/en/products/index

RESPONSIVE LIGHTS

TRL = 7

Lights that adapt to you and learn from your preferences over time,through a sensor system integrated in the bulb.

- Key Points
  - Smart lighting (capable of adapting to user habits)
  - Energy saving (40% to 60%)
- Application – building type
  - New building (Commercial, Residential)
  - Refurbishment (Commercial, Residential)
- Application – process
  - Non-disruptive

https://stacklighting.com/

SHADING

PV INTEGRATED SHADING

TRL = 6

Transparent photovoltaics integrated in the façade or window for shading and energy generation, allowing natural light through diffusion.

- Key Points
  - Estimated electricity production (5,3 kWh/m2)*
  - Integrated technology (shading + PV)
  - Smart shading (adapts to position of sun)
- Application – building type
  - New building (Commercial)
  - Refurbishment (Commercial)
- Application – process
  - Disruptive

http://pvdatabase.org/pdf/Renovatie_ECN-laboratorium_English.pdf

*South façade, 100 Wp

RESPONSIVE DYNAMIC SHADING

TRL = 7

Engineered envelope shading layer adaptable according to exterior and interior conditions for a more energy efficient usage of exterior lighting.

- Key Points
  - Smart shading (adapts to external lighting conditions and internal comfort needs)
- Application - building type
  - New building (Commercial, Residential)
- Application - process
  - Disruptive

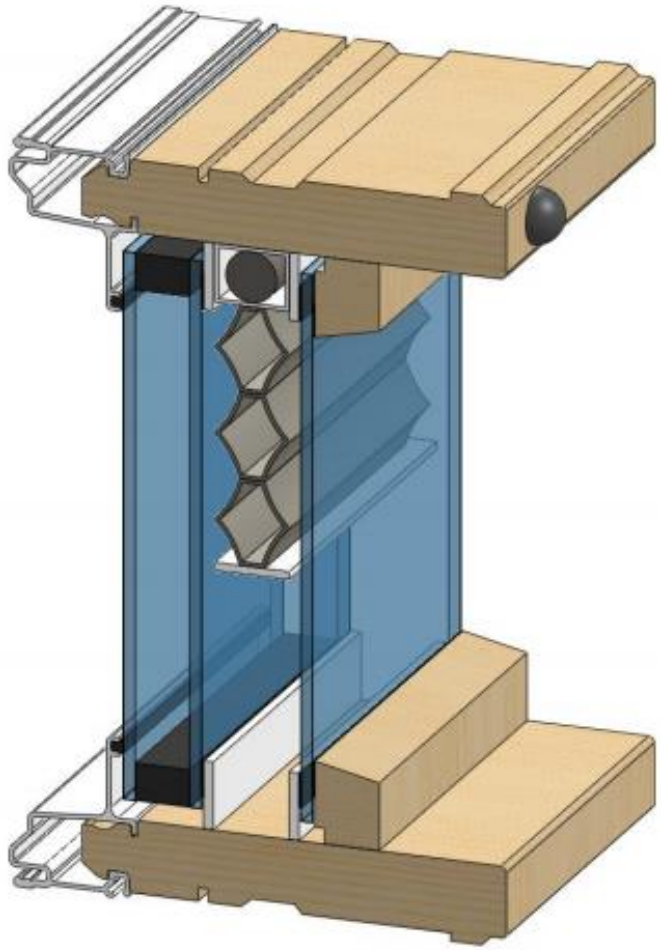
http://aercnet.org/wp-content/uploads/2015/12/ES-SO-Study-2015.pdf

WINDOW WITH SMART AUTOMATED SHADING

TRL = 5

Window integrated shading connected to sensors with an automated functioning with programmed and networked intelligence.

- Key Points
  - Potential high insulation (U = 0,13 - 0,35 btu/h-ft2)
  - Integrated technology (Shading + Glazing)
  - Smart shading (adapts to external lighting conditions and internal comfort needs)
- Application – building type
  - New building (Commercial, Residential)
- Application – process
  - Disruptive



http://energy.gov/sites/prod/files/2015/05/f22/emt37_Hart_041515.pdf

SOLAR THERMAL

Solar Thermal

INTEGRATED SOLAR THERMAL ROOF

TRL = 7

Composite roof integrated solar collector where heat improves the PV output by actively cooling the cells.

- Key Points
  - Electricity production (5.814 kWh/year)*
  - Heat production (25.290kWh/year)*
  - Energy saving (20.186 kg CO2 /year)*
  - Integrated technology (Roof + Solar thermal)
  - Good aesthetics
- Application – building type
  - New building (Residential)
  - Refurbishment (Residential)
- Application – process
  - Disruptive

*South orientation, 25ª tilt, 4,14kWp

http://ecomesh.es/pdf/brochure-ecomesh.pdf

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SOLAR THERMAL BALCONY RAILINGS

TRL = 7

Integrated evacuated tubular vacuum collectors as balcony railings.

- Key Points
  - Integrated technology (railings + solar thermal)
  - Good aesthetics
  - Heat production
- Application – building type
  - New building (Commercial, Residential)
  - Refurbishment (Commercial, Residential)
- Application – process
  - Non-Disruptive

https://www.ntnu.no/wiki/download/attachments/48431699/Master-Basnet.pdf?version=1&modificationDate=1339765553175

Solar Thermal

THERMO-ELECTRIC FAÇADE

TRL = 7

A façade system that combines wood louvers and back-vented glazing together with integrated PV panels.

- Key Points
  - Heat production
  - Electricity production
  - High insulation (U=0.2 W/m2K)
  - Integrated technology (envelope + solar thermal + PV)
- Application – building type
  - New building (Commercial, Residential)
  - Refurbishment (Commercial, Residential)
- Application – process
  - Disruptive

http://www.nelson-solar.ch/en/solar-facade/

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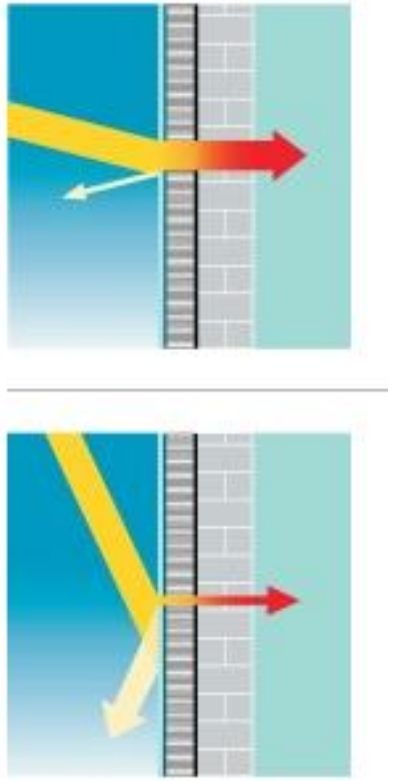
SMART INSULATION

TRL = 7

A façade system that stores heat during winter and reflects it along the summer.

- Key Points
  - Smart insulation (capable of modifying the R value according to interior needs and exterior lighting)
- Application – building type
  - New building (Residential)
  - Refurbishment (Residential)
- Application – process
  - Disruptive



http://www.sto.de/webdocs/0000/SDB/T_02667-002_0101_DE_01_03.PDF/

STORAGE TANK (ENERGY STORAGE)

PCM BASED STORAGE TANK

TRL = 7

Chilled storage water tank with integrated PCM materials which increase energy density and improve performance of storage systems.

- Key Points
  - Water pre heating
  - Higher heat storage capacity (compared to standard storage)
- Application – building type
  - New building (Commercial, Residential)
- Application – process
  - Disruptive

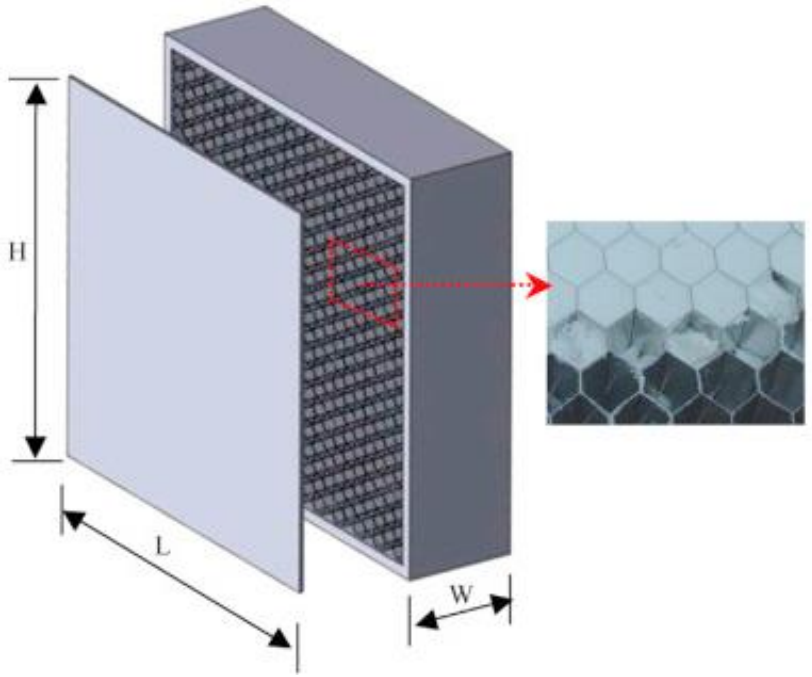
Storage Tank

MICROENCAPSUALTED PCM WALLS

TRL = 7

Wallboards supported by graphite nano sheets to improve its thermal conductivity and take advantage of the characteristics of PCM for thermal storage and energy distribution.

- Key Points
  - Higher thermal mass
  - Simple installation (like regular gypsum boards)
  - Higher heat storage capacity (69,4 W /m2)
- Application – building type
  - New building (Residential)
  - Refurbishment (Residential)
- Application – process
  - Disruptive

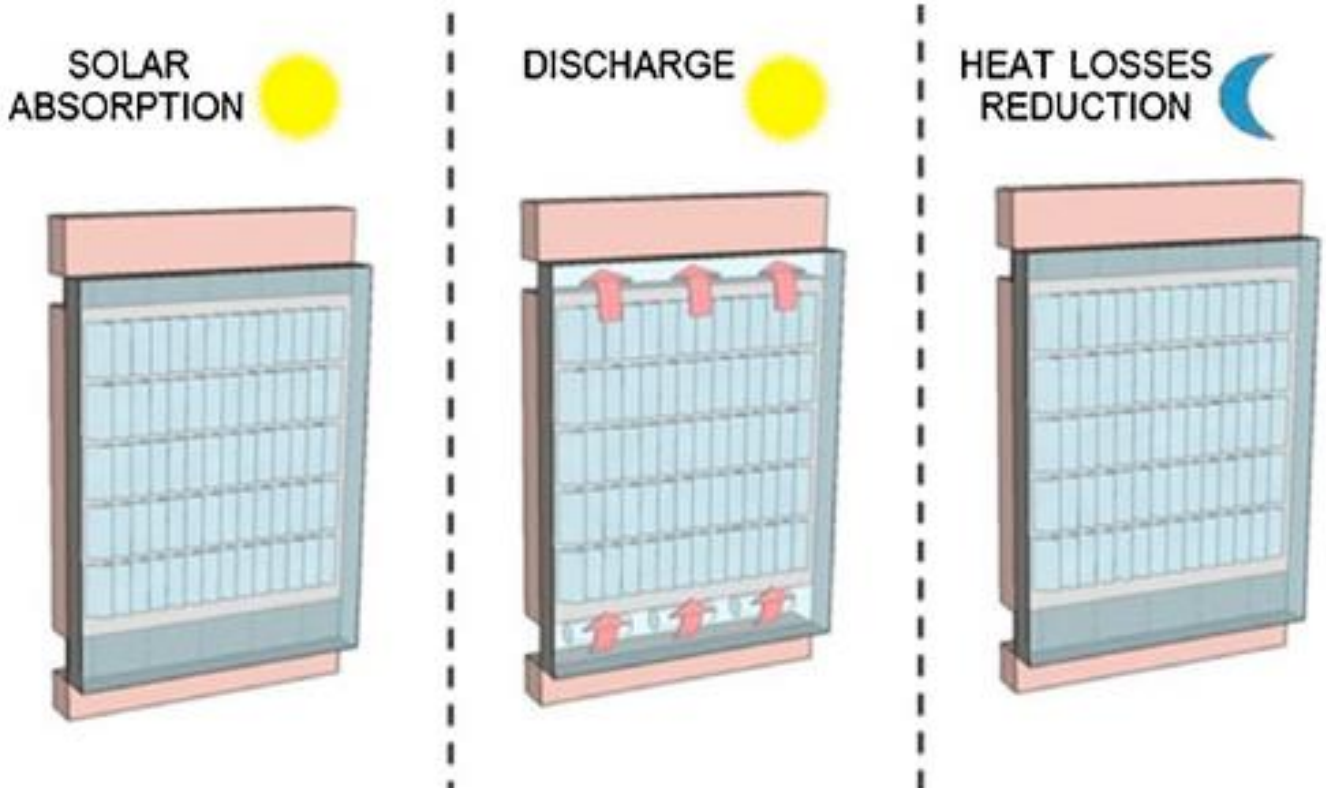


PCM VENTILATED FAÇADES

TRL = 7

Ventilated Façade with integration of a solar collector and a blister-PCM panel.

- Key Points
  - Potential high cooling capacity (1kW)
  - Potential high heating capacity (3kW)
  - Integrated technology (envelope + storage)
- Application – building type
  - New building (Residential, Commercial)
- Application – process
  - Disruptive



http://www.eurogia.com/projects/eurogia2020-projects/90-pcmsf.html

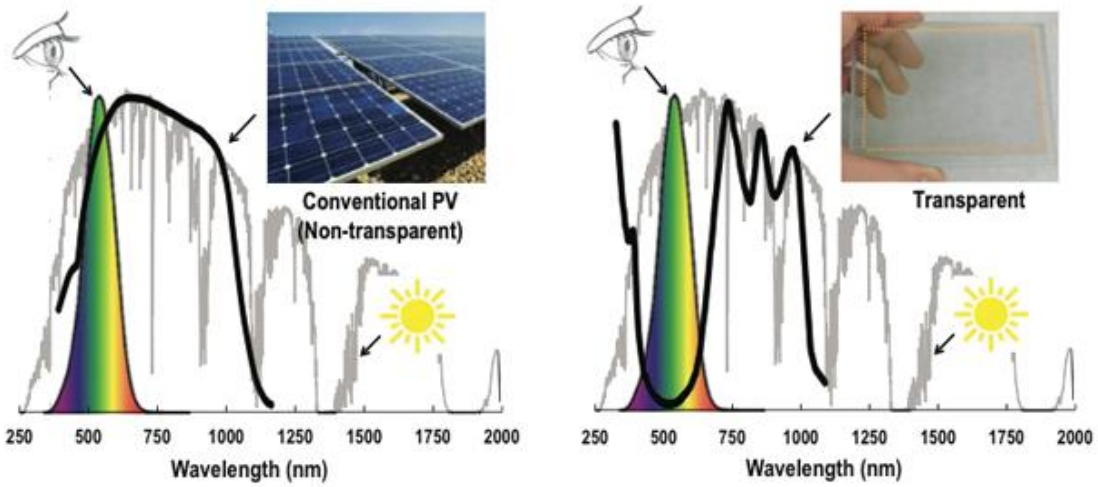
PV

TRANSPARENT SOLAR CELLS

TRL = 5

Thin coating solar cells that absorb light , but avoid the range within visible spectrum.

- Key Points
  - Transparent PV
  - Adaptability (can be installed in variety of surfaces)
  - Potential electricity production (70 to 120 W/ m2)
  - Integrated technology (envelope/glazing + PV)
  - Flexibility
- Application – building type
  - New building (Residential, Commercial)
  - Refurbishment (Residential, Commercial)
- Application – process
  - Non-Disruptive

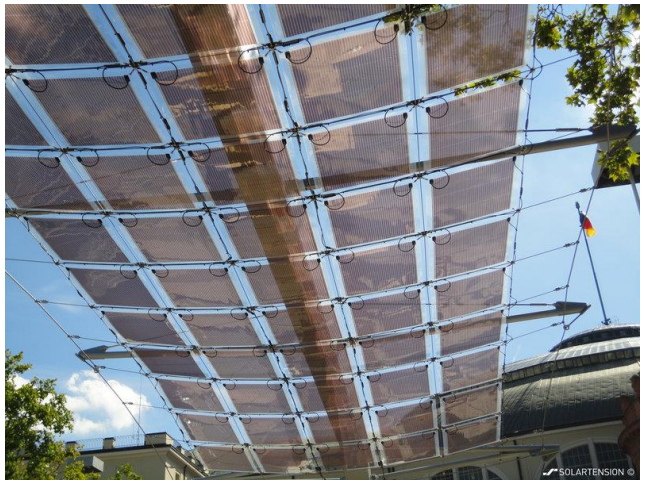


ORGANIC PV (BIOPV)

TRL = 7

PV based on organic electronics, using organic polymers or small organic modules. Third generation of solar technologies.

- Key Points
  - Adaptability
  - Electricity generation (132 W/ m2)
  - Good aesthetics
  - Flexibility
- Application – building type
  - New building (Residential, Commercial)
  - Refurbishment (Residential, Commercial)
- Application – process
  - Non-Disruptive



http://www.heliatek.com/en/heliafilm/technical-data

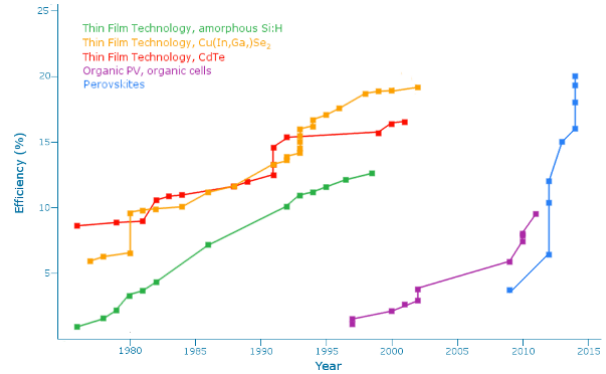
PV

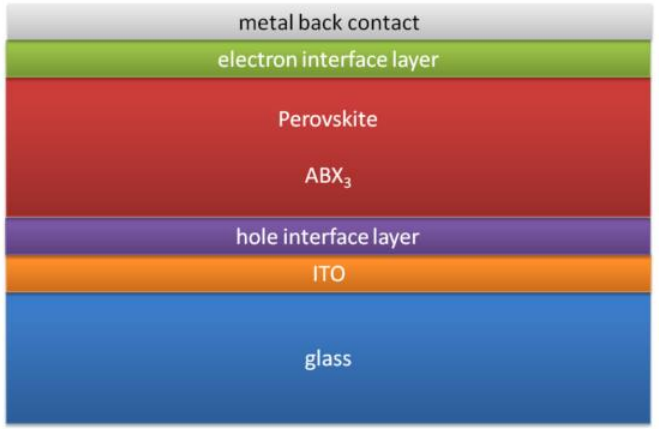
PEROVSKITE SOLAR CELLS

TRL = 6

Thin film technology with a perovskite structured compound.

- Key Points
  - Adaptability
  - Flexibility
  - Estimated electricity production (221 W/m2)
- Application – building type
  - New building (Residential, Commercial)
  - Refurbishment (Residential , Commercial)
- Application – process
  - Non-Disruptive





https://www.ossila.com/pages/perovskites-and-perovskite-solar-cells-an-introduction

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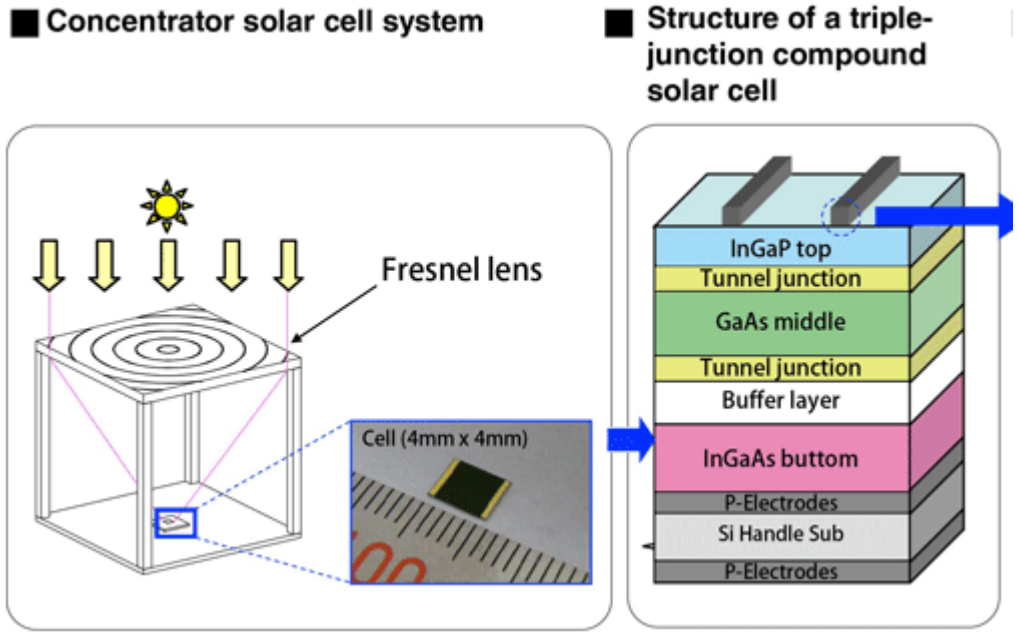
CONCENTRATOR TRIPLE JUNCTION PV

TRL = 6

Triple junction compound solar cell combined with a lens based concentrator system that focuses sunlight on cells to generate electricity.

- Key Points
  - Estimated electricity production (444 W/m2)
  - Highest conversion efficiency achieved
- Application – building type
  - New building (Residential, Commercial)
  - Refurbishment (Residential, Commercial)
- Application – process
  - Non-Disruptive



http://www.sharp-world.com/corporate/news/130614.html

CONTROL SYSTEMS

SMART HEATING CONTROL

TRL = 7

Regulators for heaters based on presence sensors, wifi controlled and connected to the internet. Regulating temperature in every room through sensors and actuators.

- Key Points
  - Smart technology (adapts heating to interior needs)
  - Optimization of energy usage
- Application – building type
  - New Building (Residential, Commercial)
  - Refurbishment (Residential, Commercial)
- Application – process
  - Non-Disruptive

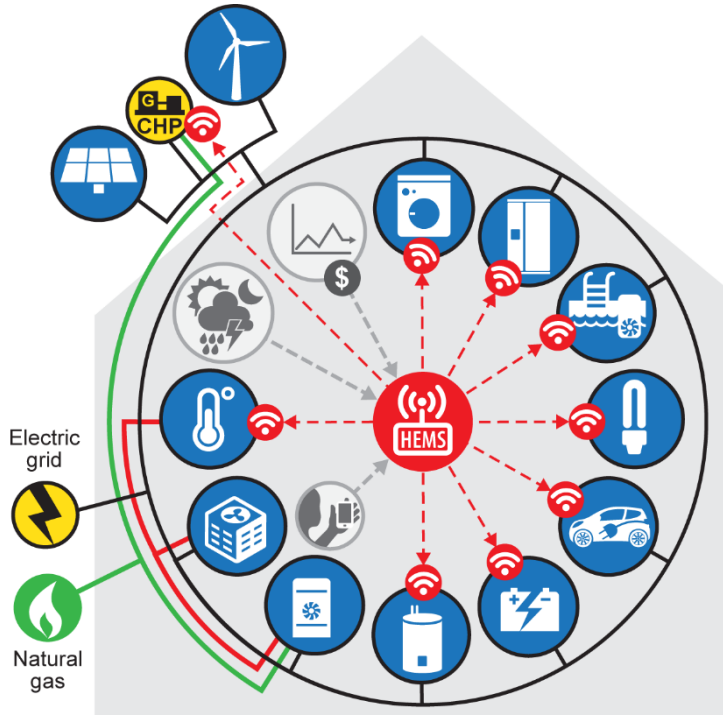
Control Systems

STOCHASTIC OPTIMAL SCHEDULING

TRL = 5

Software based on an algorithm that schedules residential appliance operation to minimize the weighted sum of occupant discomfort, total energy cost, peak electricity consumption and carbon footprint.

- Key Points
  - Smart technology (adapts to consumer habits)
  - Optimization of energy usage
  - Scheduling
- Application – building type
  - New building (Residential, Commercial)
  - Refurbishment (Residential, Commercial)
- Application – building type
  - Non-Disruptive



http://techportal.eere.energy.gov/technology.do/techID=1288

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BATTERY

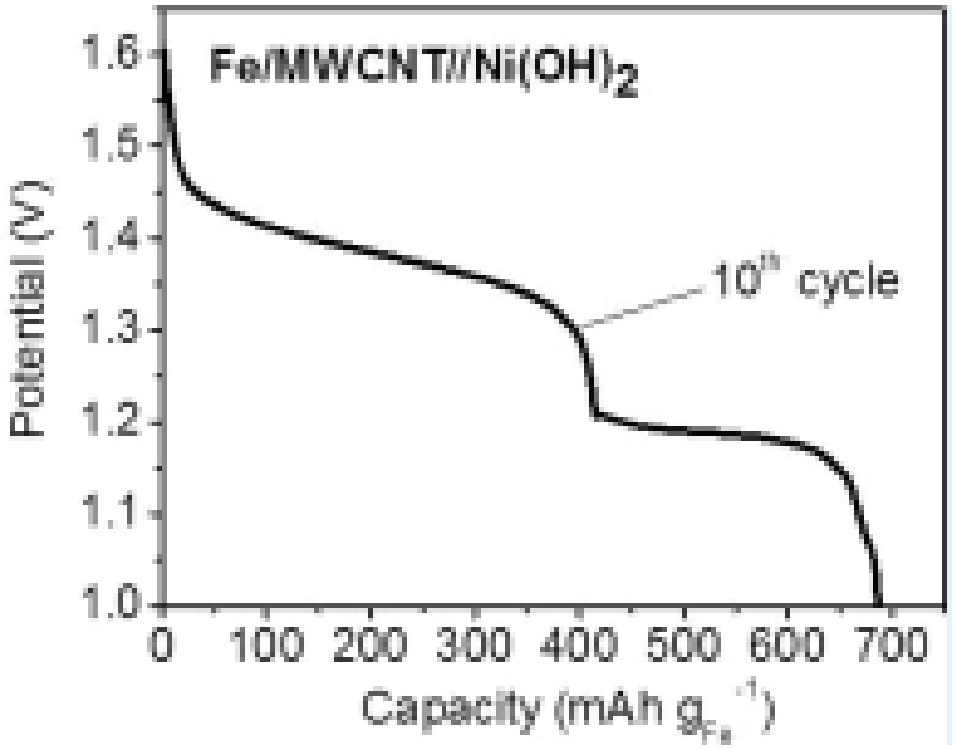
Battery

RENEWABLE ENERGY STORAGE

TRL = 5

Battery made of easily accessible materials (Nickel – Iron) with an electrode based on iron, creating a low cost technology that can survive frequent cycling.

- Key Points
  - Long life span
  - Renewable energy storage
  - Potential energy efficiency (80 - 90 %)
- Application – building type
  - New building (Residential, Commercial)
  - Refurbishment (Residential, Commercial)



http://e-stonebatteries.com/web/

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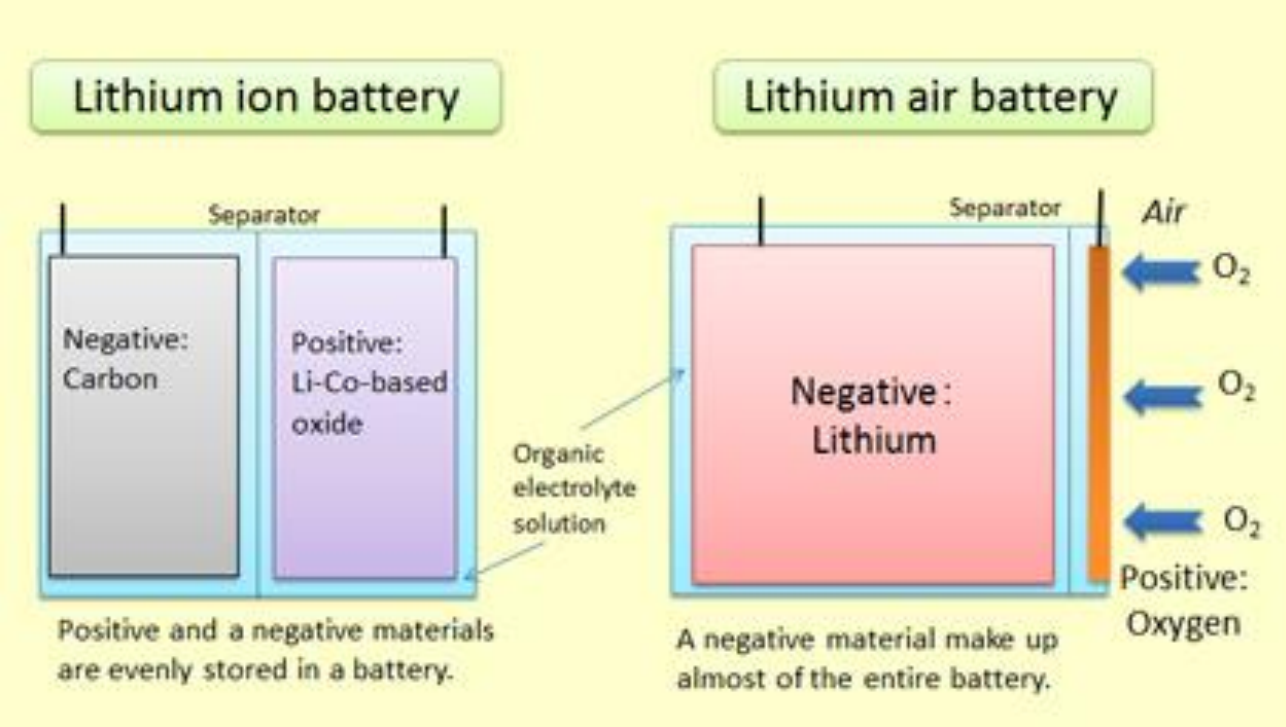
LITHIUM – AIR BATTERY

TRL = 5

Metal-air battery that uses oxidation of lithium at the anode and reduction of oxygen at the cathode.

- Key Points
  - Long life span
  - High energy density (up to 12 kWh/kg)
  - Light weight (compared to standard)
- Application – building type
  - New Building (Residential, Commercial)
  - Refurbishment (Residential, Commercial)



http://www.nature.com/articles/nenergy2016128

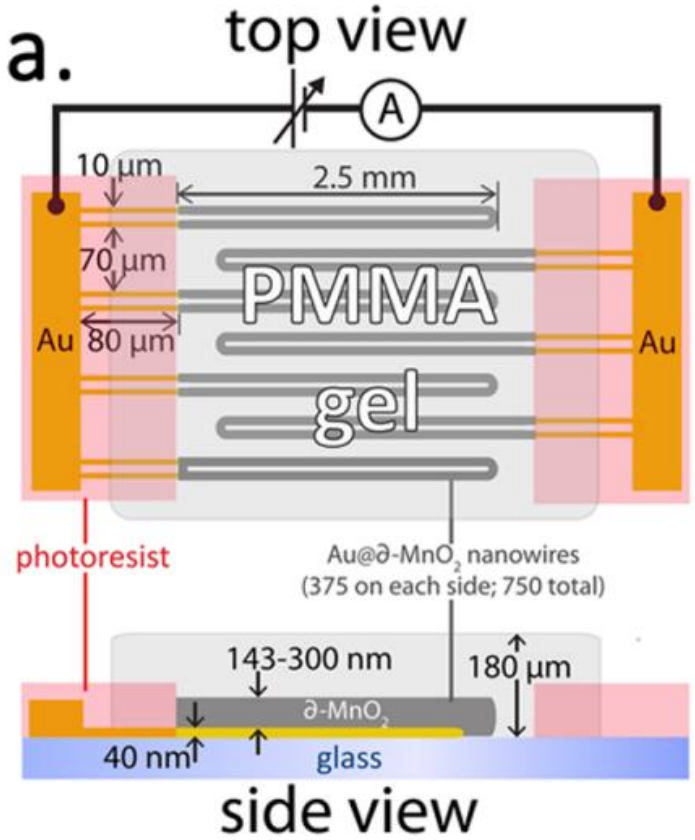
Battery

NANOWIRE LITHIUM-ION BATTERY

TRL = 5

Battery with usage of nanowires to increase the surface area of one or both electrodes.

- Key Points
  - Potentially Long Life Span (up to 200 000 cycles)*
  - Renewable Energy Storage
  - Potentially Energy Efficient (94 – 96%)**
- Application – building type
  - New Building (Residential, Commercial)
  - Refurbishment (Residential, Commercial)



*standard no more than 7 000 cycles
** Coulombic efficiency

http://pubs.acs.org/doi/pdf/10.1021/acsenergylett.6b00029

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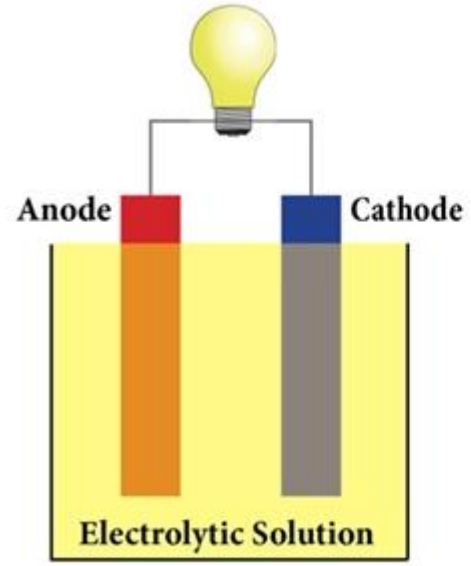
SOLID STATE BATTERY

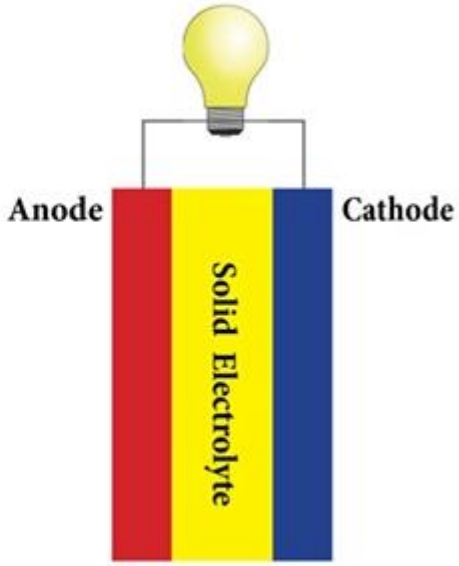
TRL = 5

Battery consisting of solid electrodes and solid electrolytes, that is easy to miniaturize and has an improved life cycle.

- Key Points
  - High energy density
  - Diminished self-discharge rate
  - Long life cycle
- Application – building type
  - New building (Residential, Commercial)
  - Refurbishment (Residential, Commercial)



Conventional Battery



All-Solid-State Battery

http://news.mit.edu/2015/solid-state-rechargeable-batteries-safer-longer-lasting-0817

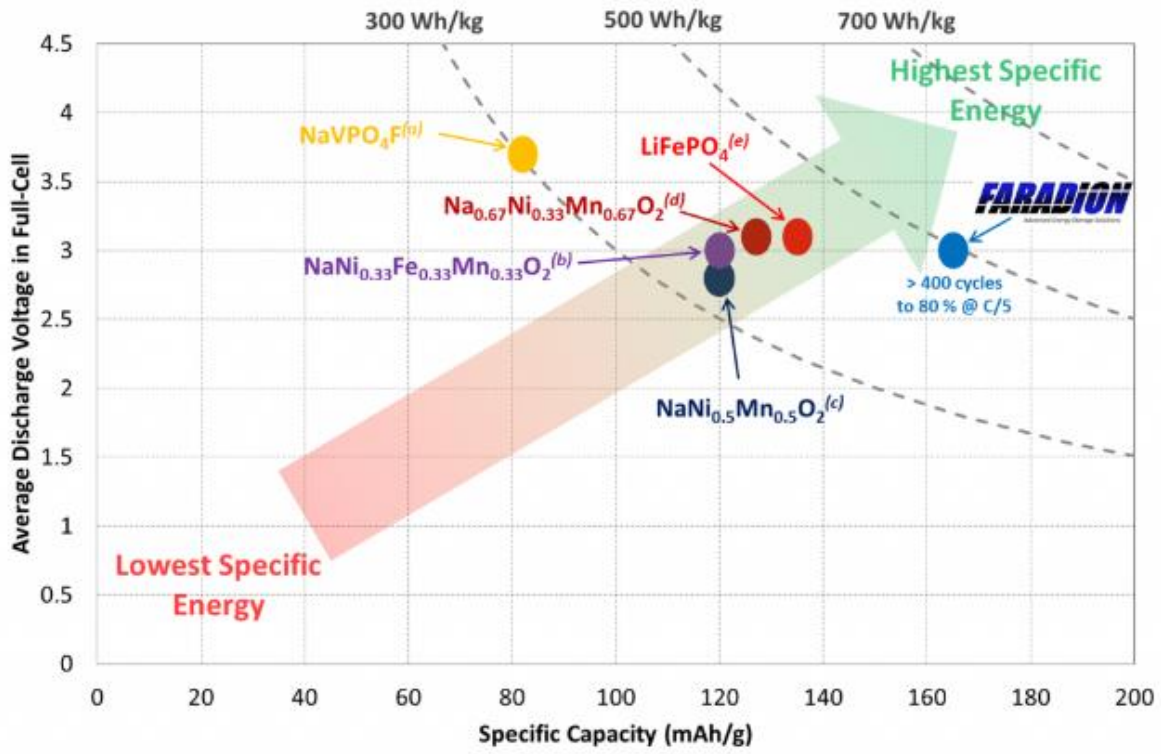
Battery

SODIUM-ION BATTERY

TRL = 7

Rechargeable metal-ion battery that uses sodium ions as charge carriers, using therefore abundant materials for cheap production.

- Key Points
  - Long life span
  - Energy efficient (>90%)*
- Application – building type
  - New building (Residential, Commercial)
  - Refurbishment (Residential, Commercial)



*Round Trip Efficiency

http://www.faradion.co.uk/technology/sodium-ion-technology/

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SMART BATTERIES

TRL = 7

Battery connected to PV system without directly feeding the dwelling and controlled through a smart interface.

- Key Points
  - Smart technology (allows for a programmed electricity consumption)
- Application – building type
  - New building (Residential)
  - Refurbishment (Residential)

https://shkspr.mobi/blog/2016/03/meet-maslow-the-uks-answer-to-teslas-powerwall/

ALTERNATIVE ENERGY GENERATION

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VERTICAL AXIS WINDMILLS

TRL = 6

Small sized vertical axis windmills.

- Key Points
  - Wind direction independent
  - Electricity generation (Estimated 1 kW to 5 kW)
- Application – building type
  - New building (Residential, Commercial)
  - Refurbishment (Residential, Commercial)
- Application – building type
  - Disruptive

Alternative Energy Generation

HYBRID MINI POWER PLANTS

TRL = 7

Eolic and photovoltaic energy station integrated with a battery for decentralized power supply.

- Key Points
  - Integrated system (PV + Battery + Eolic)
  - Electricity production
- Application – building type
  - New building (Residential)
  - Refurbishment (Residential)
- Application – process
  - Non-Disruptive

http://www.newgreentec.com/produkte/power-pyramid

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Alternative Energy Generation

BIOREACTOR FAÇADE

TRL = 5

Façade that generates renewable energy from algal biomass and solar thermal heat.

- Key Points
  - Integrated technology (Envelope + Solar Thermal + Shading)
  - Energy efficient*
  - Smart shading (adaptable to external light conditions)
- Application – building type
  - New building (Residential, Commercial)
- Application – process
  - Disruptive

*10% efficiency light to biomass
38% efficiency light to heat

http://www.arup.com/projects/solarleaf

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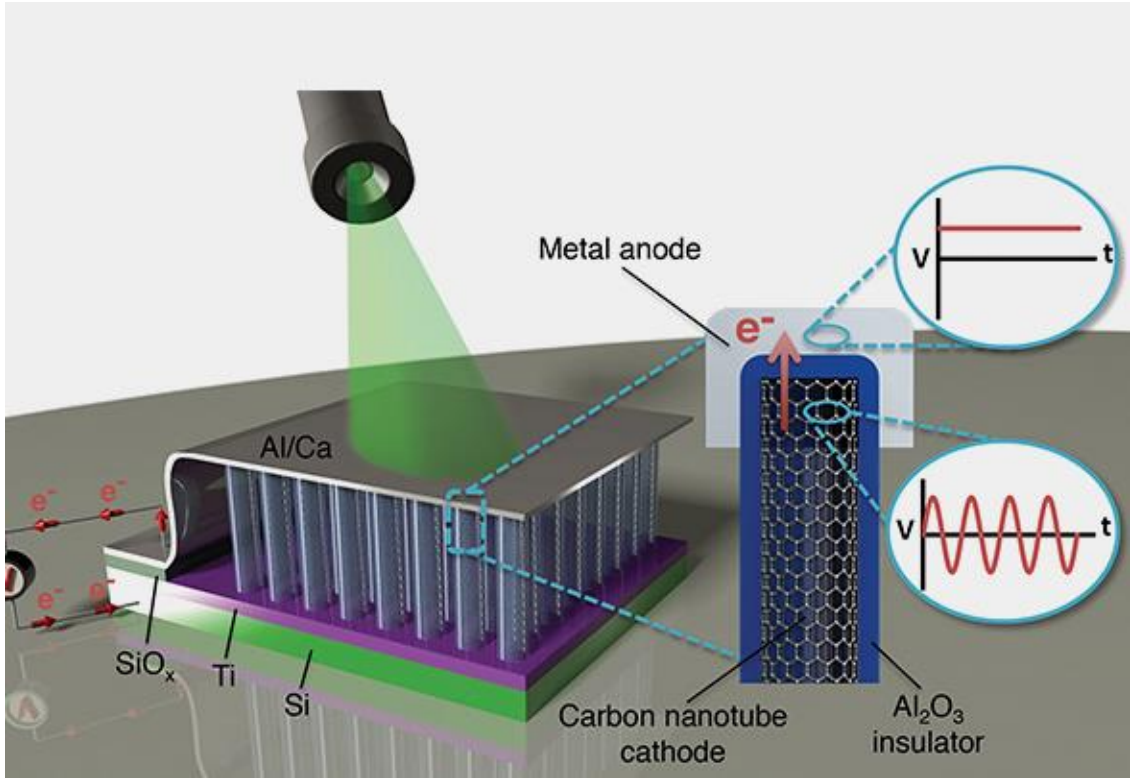
OPTICAL RECTENNA

TRL = 5

Rectifying antenna that works with visible or infrared light. Converts free-propagating optical frequencies into DC current.

- Key Points
  - Energy efficient (>85%)*
  - Electricity production (Potentially 400 W/m2)
- Application – building type
  - New building (Residential, Commercial)
  - Refurbishment (Residential, Commercial)
- Application – process
  - Non-Disruptive



*Carnot´s Theoretical Efficiency

http://www.nature.com/nnano/journal/v10/n12/full/nnano.2015.220.html

POTENTIAL OF GRID-CONNECTED PV SYSTEM AT THE WORKING CONDITIONS OF PADIHAM, UK: COMPARING DIFFERENT PV MODULE TYPES AND BRANDS/MODELS

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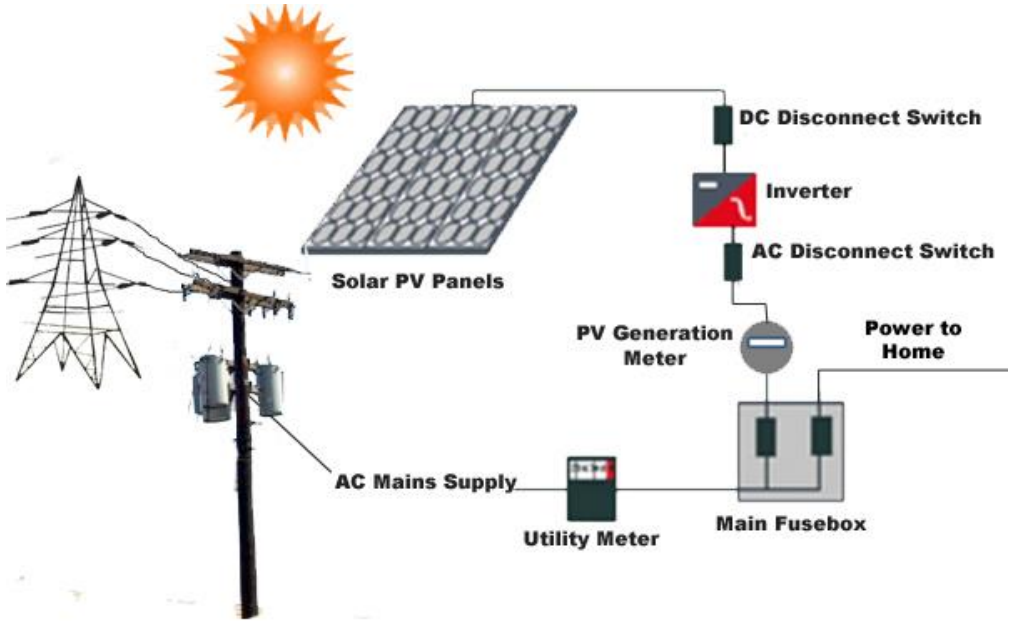
PART II – EXAMINATION OF IMPLEMENTATION POTENTIAL OF CONCRETE TECHNOLOGIES FOR DREEAM PILOTS

OBJECTIVE

- This work studies the potential of utilizing PV system for electricity generation at current ***conditions*** of Padiham, UK.
- In addition, the energy and economic performance of different PV module brands and technologies are compared.



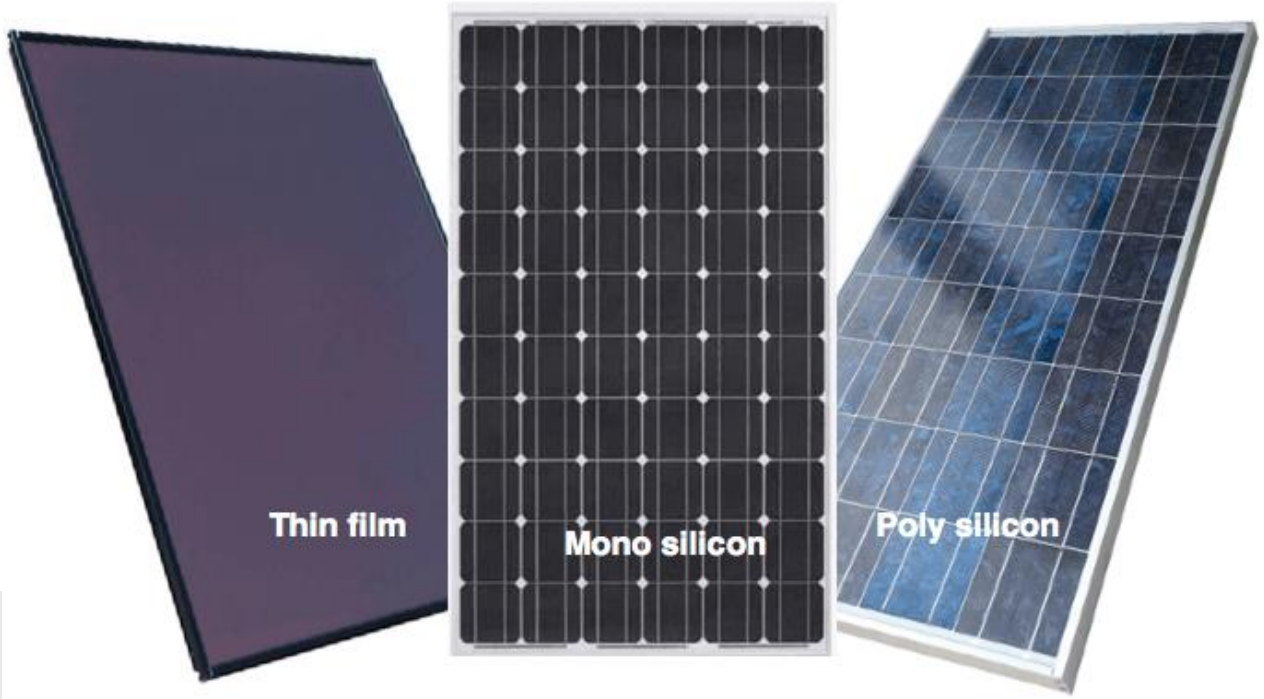
METHODOLOGY

- Module technology types, brands, models
- System design
- Simulation model:
  - Factors considered
  - Data used
  - Assumptions
- Comparing the results of:
  - technology types
  - brands
  - different system designs

CONSIDERED MODULE TECHNOLOGIES

Three different PV module technologies are considered in the work including:

1. Monocrystalline module:
   Lasts long, uniform look, good efficiency, expensive
2. Polycrystalline module:
   Speckled blue color, lower efficiency than monocrystalline
3. Thin film module:
   Homogenous appearance, low efficiency, cheap



CONSIDERED PV MODULE BRANDS & MODELS

- Current work considers the brands mentioned in the report by Fraunhofer Institute for Solar Energy Systems, ISE.

- **Fraunhofer ISE:**
  - ✓ The largest solar energy research institute in Europe.
  - ✓ Focus:
    - Investigation of scientific and technological aspects of sol
    - Solar energy application;
    - Development of production technology;
    - Construction of demonstration systems.

Considered PV module types

	TYPE		
BRANDS & MODELS	**Monocrystalline**	**Polycrystalline**	**Thin film**
	Motech XS72D3-320	Hanwha Solar One 310	Stion STO-150
	Panasonic N330	JaSolar 48-225/4BB	Solar Frontier SF170-S
	Silevo 310	Trina 315	Stion STN-125
	Sunpreme 360	SunTech 320	SolTech Energy 80
	Solar World SW350 XL	Jinko Solar JKM270	
	Silevo 220	Motech IM72C3-310	
	Optimus 60 OPT280	Canadian Solar CS6X-320P	
	LG Solar 320	Solar World SW260	
	Jinko Solar JKM275M	Yingli Solar YL305P	
	Solar World SW325 XL	PEAK BLK 255	
	JaSolar 72-315/SI	Gintech 240	
	Hyundai HiS-S265MG	Hyundai HiS-S250MG	
	Mitsubishi PV-MLE265HD2	Kyocera KD220GH-4FB2	

PHYSICAL SPECIFICATIONS AND PRICE OF CONSIDERED PV MODULES

In order to carry out the energy and economic analysis, physical specifications and price of each brands are required:

- Physical specifications were obtained through internet research.

- Finding the price of the module is a big challenge.
  In order to obtain tentative prices, manufacturers of the different brands were contacted. Not all prices were provided.

SYSTEM DESIGN: CONSIDERED PLACES OF MOUNTING PV SYSTEM

- Two different system designs were considered:
  1. PV system installed on the roof.
  2. PV system installed on south facing façade.

SIMULATION MODEL

A simulation model was built to simulate PV system.
In detail , the model has been built to:

- Determine the hour-by-hour available solar energy per square meter of the surface
- Determine the optimal inclination angel
- Demonstrate the effect inclination angle and azimuth angle of the surface have on the available solar energy
- Simulate hour-by-hour energy and economic performance of grid connected PV system

Input Data

Latitude	55.871254	N	degree	**Month**	Clearness KT	**PV Specification**		
Longitude	12.826451	e	degree	**Jan**	0.33	fill factor	0.77	-
Standard Longitude	15	degrees		**Feb**	0.39	derating factor	0.90	
Slop angle β	50.0	degrees		**Mar**	0.44	short circuit current	9.09	A
Surface azimuth	180.0	degrees		**Apr**	0.48	open circuit voltage	45.73	V
Avilable area	100	m^2		**May**	0.5	voltage temp. coefficient	340.00	%/C
Inflation rate	0.7%	%		**Jun**	0.48	NOCT (nominal operating cell temperature)	45.00	C
Real interest rate	3.4%			**Jul**	0.49			
Electrical price escalation rate	1.0%			**Aug**	0.49	nomional capacity	320.00	W
				Sep	0.45	module price	480.00	$
Electricity price	0.207	$/kWh		**Oct**	0.38	Area	1.64	m^2
				Nov	0.39	module degradation rate	1.0%	%
				Dec	0.35			

DATA AND ASSUMPTIONS IN THE CURRENT WORKS

In order to evaluate the economic performance of the PV system, data types presented below are needed. Some of the data could be collected via internet research, some was assumed.

Term	Inflation rate	Real interest rate	Electricity price	Electrical price escalation rate	Module degradation rate
Value	0.7%	3.4%	0.207 $/kWh	1%	1%

Collected data

Assumed data

TERMS USED TO DEMONSTRATE THE RESULTS

- **PV efficiency**: the ratio between the available solar energy and the electrical output of the module.
- **Installation costs**: the total cost required to build 100m^2 of PV system including the equipment costs, wiring costs, and labor costs.
- **Levelized cost of electricity**: the ratio of the total costs of the system (including the operation and maintenance costs) to the electrical energy produced over the lifetime of the system.
- **Payback time**: the time required for the system to recover its initial costs in terms of energy savings.

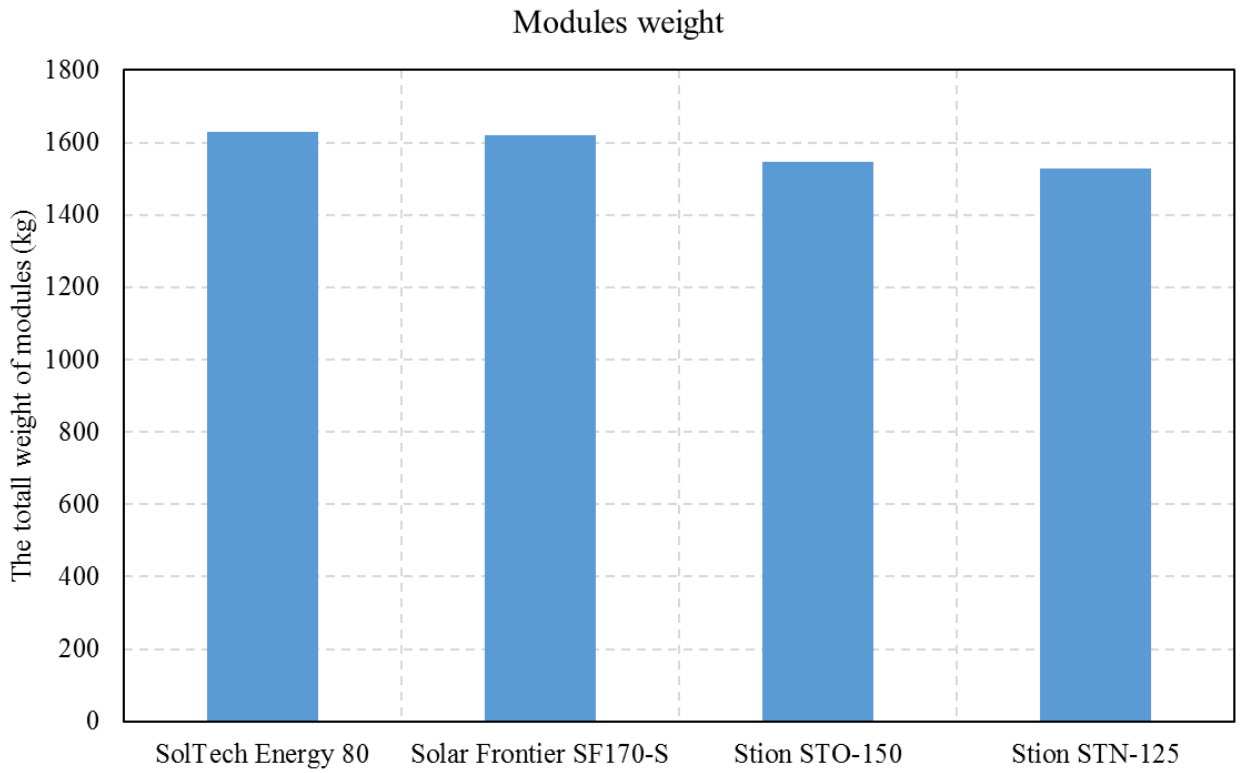
RESULTS 1: THIN-FILM

- 4 models were analyzed
- 2 systems were considered (i.e. on the roof and on the façade)
- Best-performing model from energy point of view was identified.
- Best-performing model from economic point of view was identified.

WEIGHT OF PROPOSED SYSTEM

The weight of 100 m^2 of the selected modules was calculated

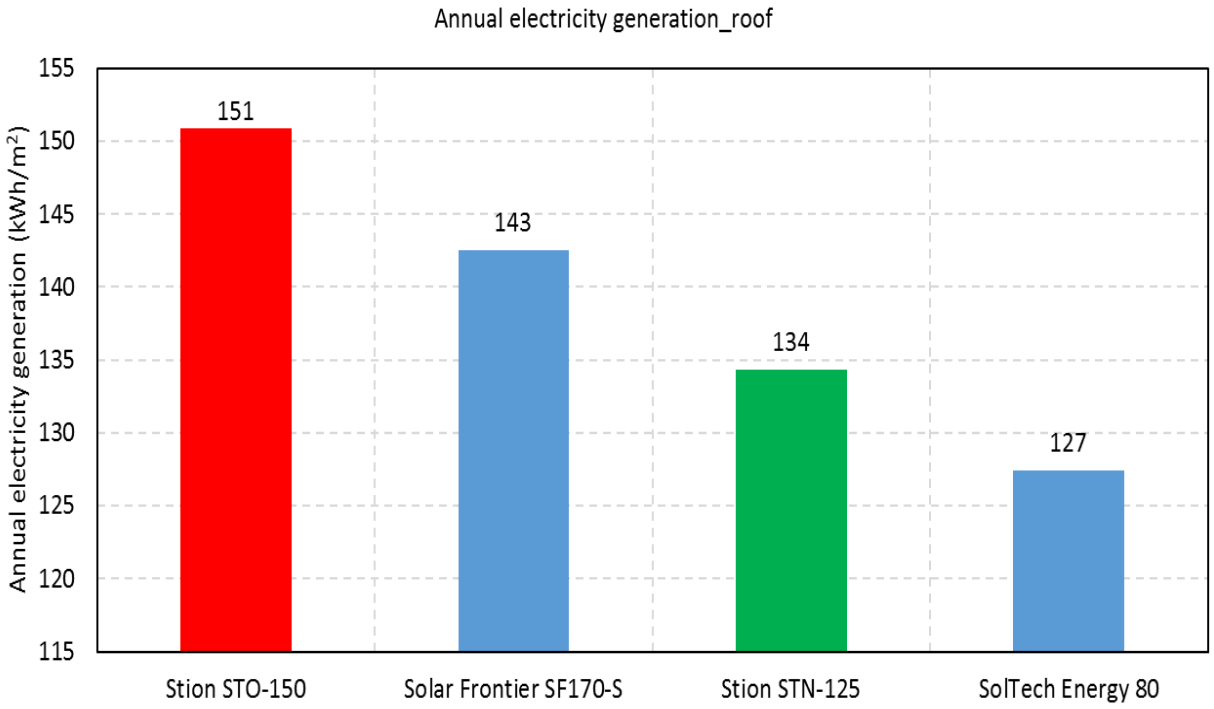
As shown, there is no big difference in the weight of selected brands.

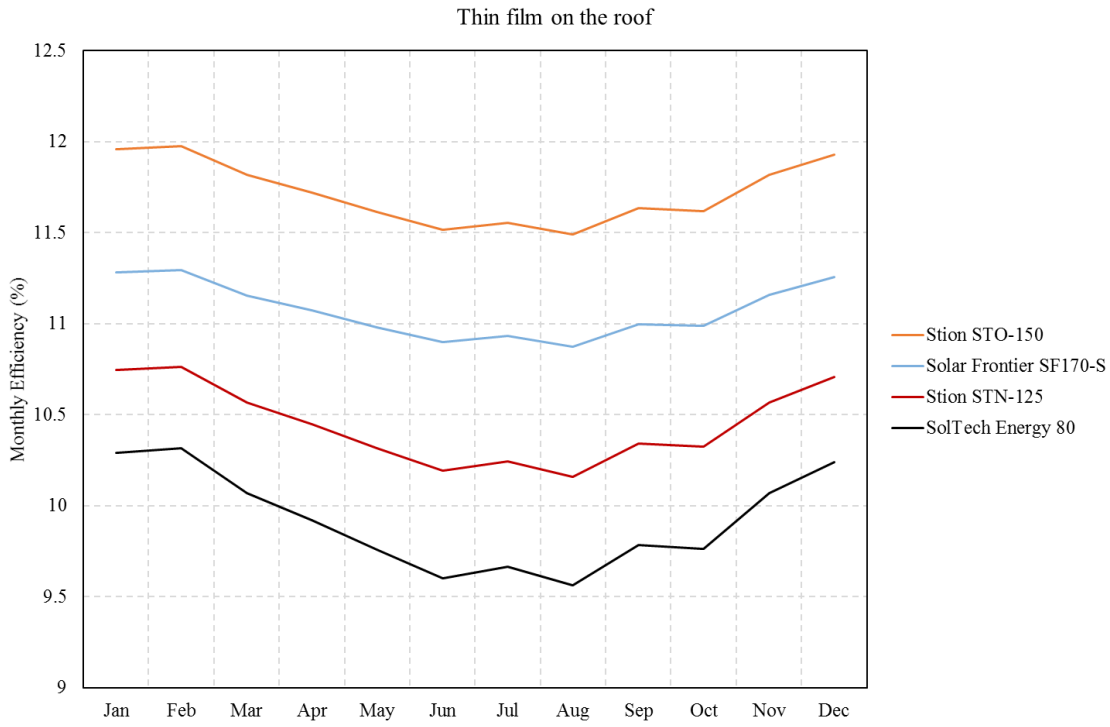


ELECTRICAL OUTPUT AND EFFICIENCY OF THIN FILM PV SYSTEM ON ROOF

The simulations show that the electricity output of the system varies from 177 to 150 kWh/m^2.a.

The efficinecy of modules ranged from 9 to 12%.

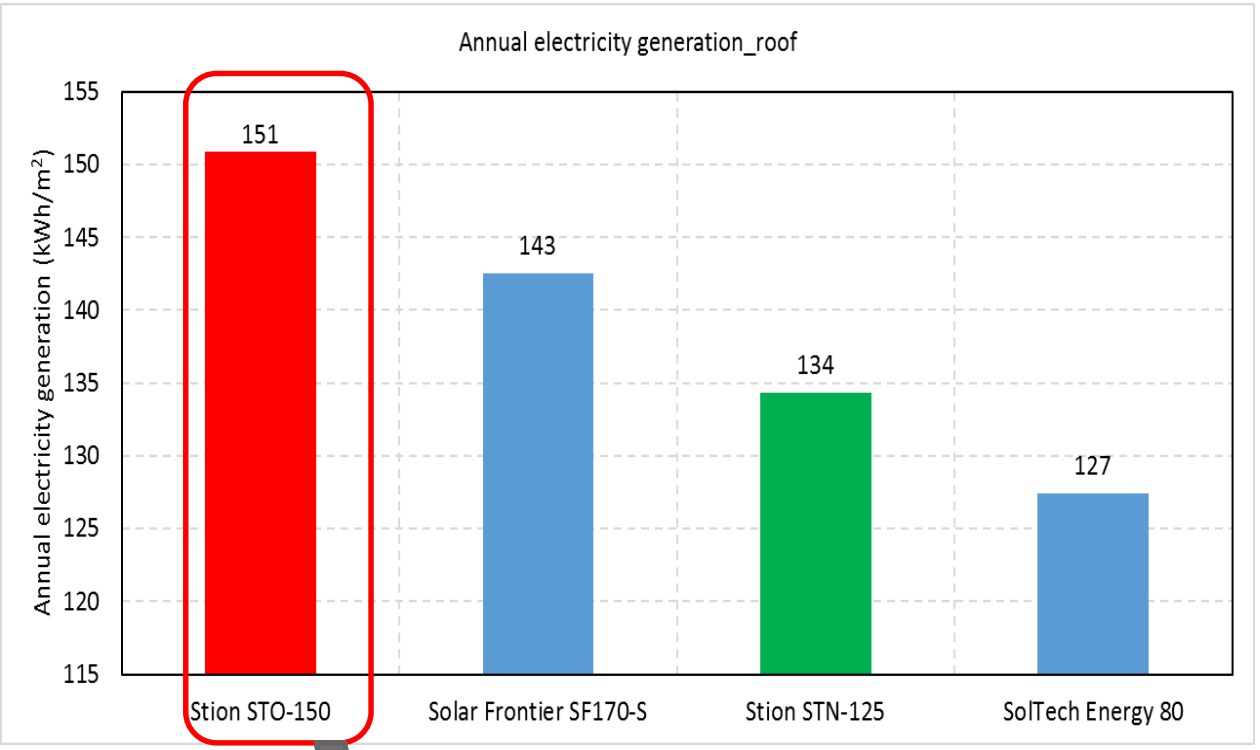


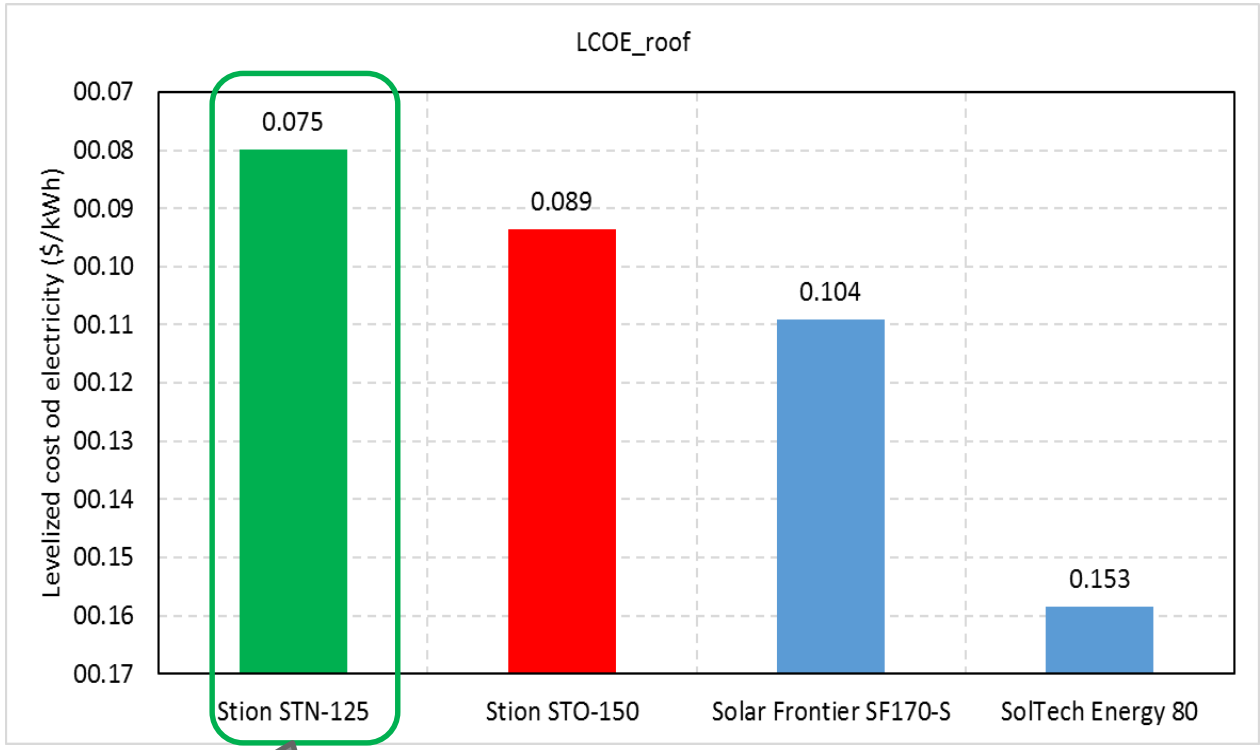


From energy viewpoint, Stion STO-150 thin film is the best-performing model among the considered brands/models.

LEVELIZED COST OF ELECTRICITY

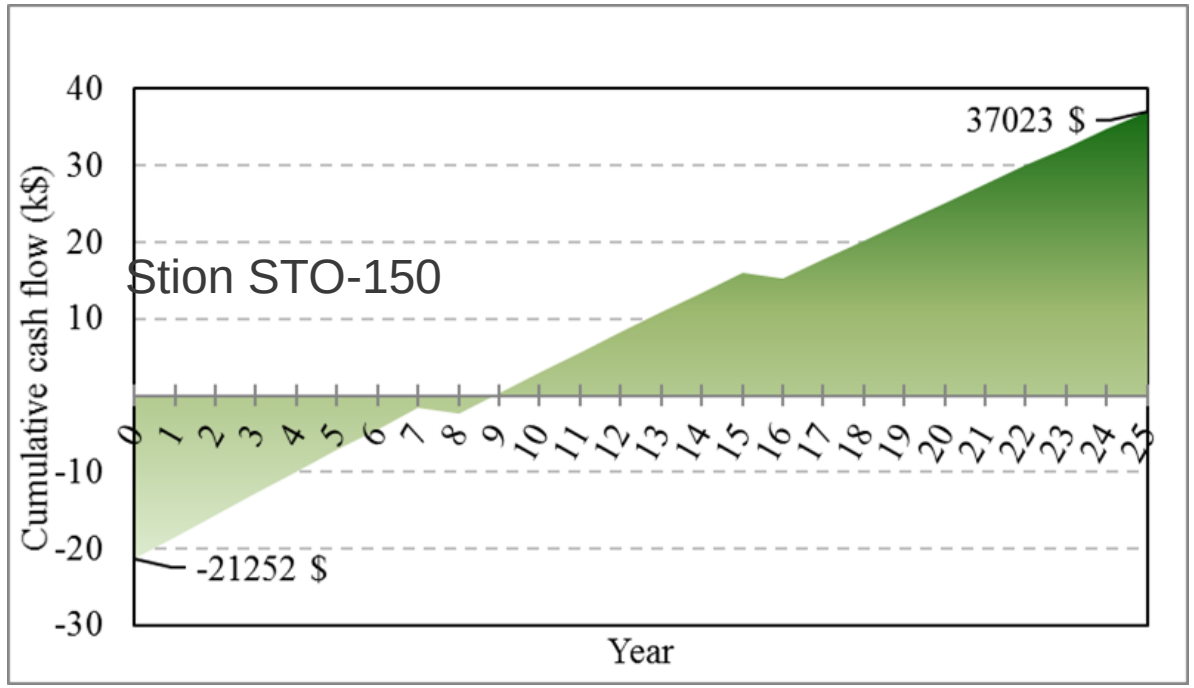
- From levelized cost of electricity viewpoint, Stion STN-125 is the best performing among the considered brands/models.

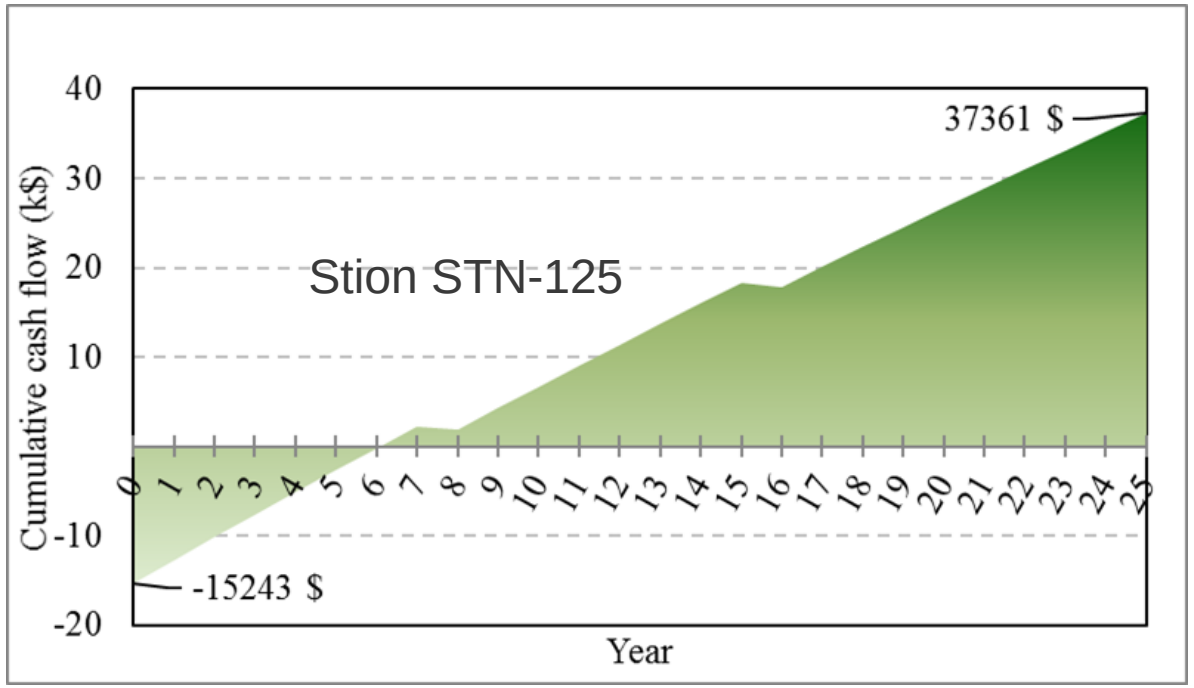




COMPARING BETWEEN THE BRANDS OF THE BEST PERFORMANCE

Accumulative cash flow of Stion STO-150 (of the best energy performance) and Stion STN-125 (of the best economic performance) was calculated.





Brand	Annual elect. (kWh/m^2)	Annual efficiency (%)	LCOE (¢/kWh)	Initial cost ($/100m^2)	Payback time (year)
Stion STO-150	151	11.7	8.9	21252	9
Stion STN-125	134	10.4	7.5	15243	6
Difference	12%	13%	19%	39%	50%

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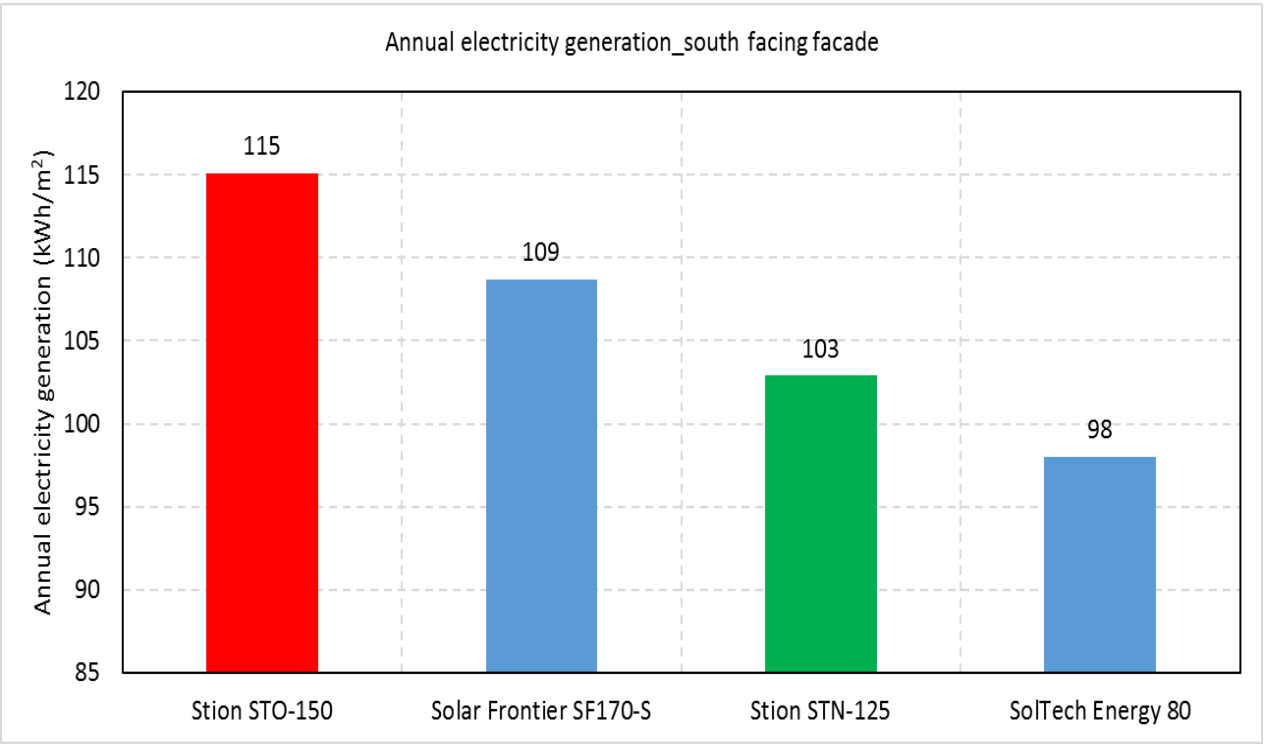
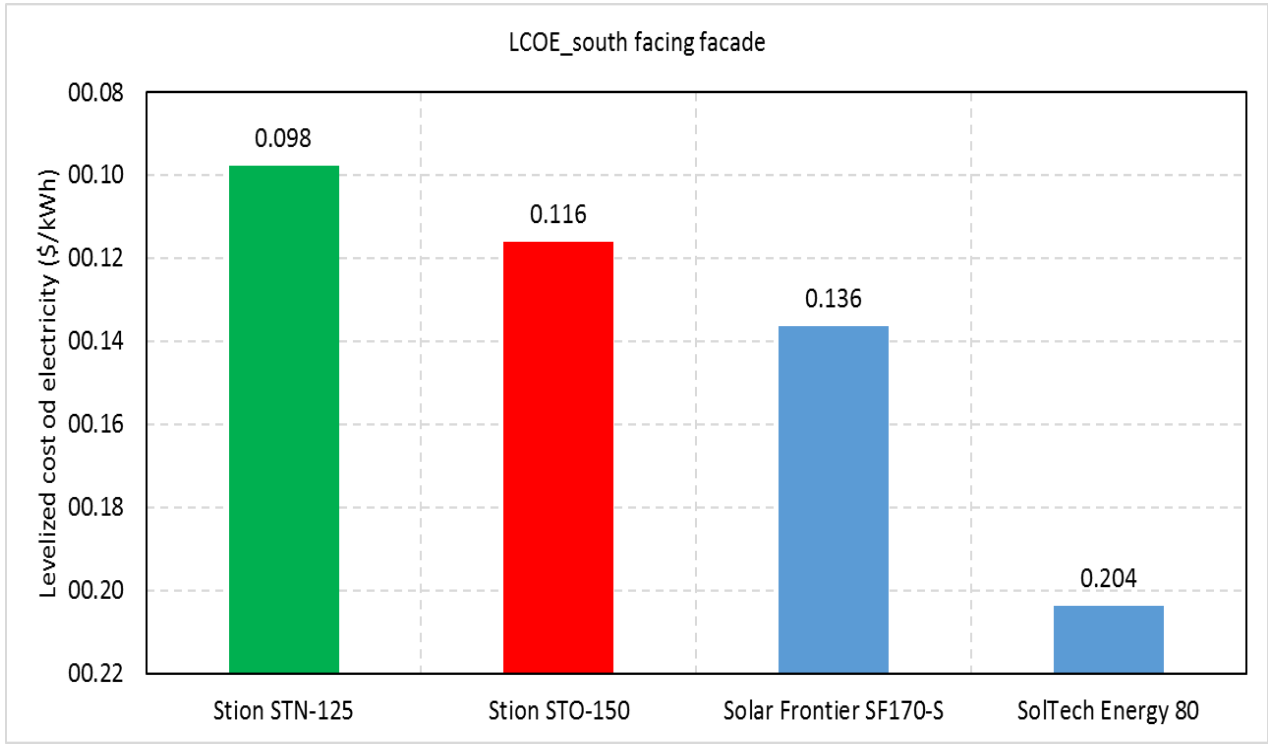
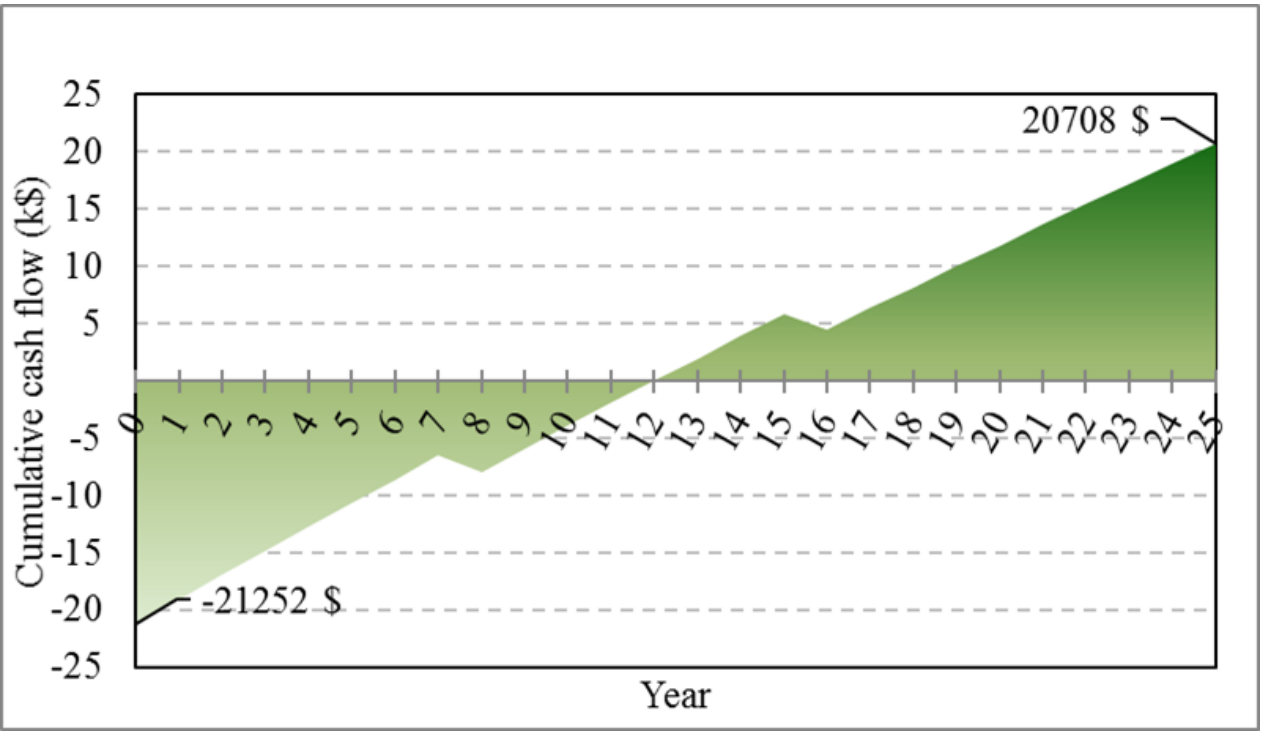
ENERGY OUTPUT AND LEVELIZED COST OF ELECTRICITY OF PV SYSTEM ON FAÇADE

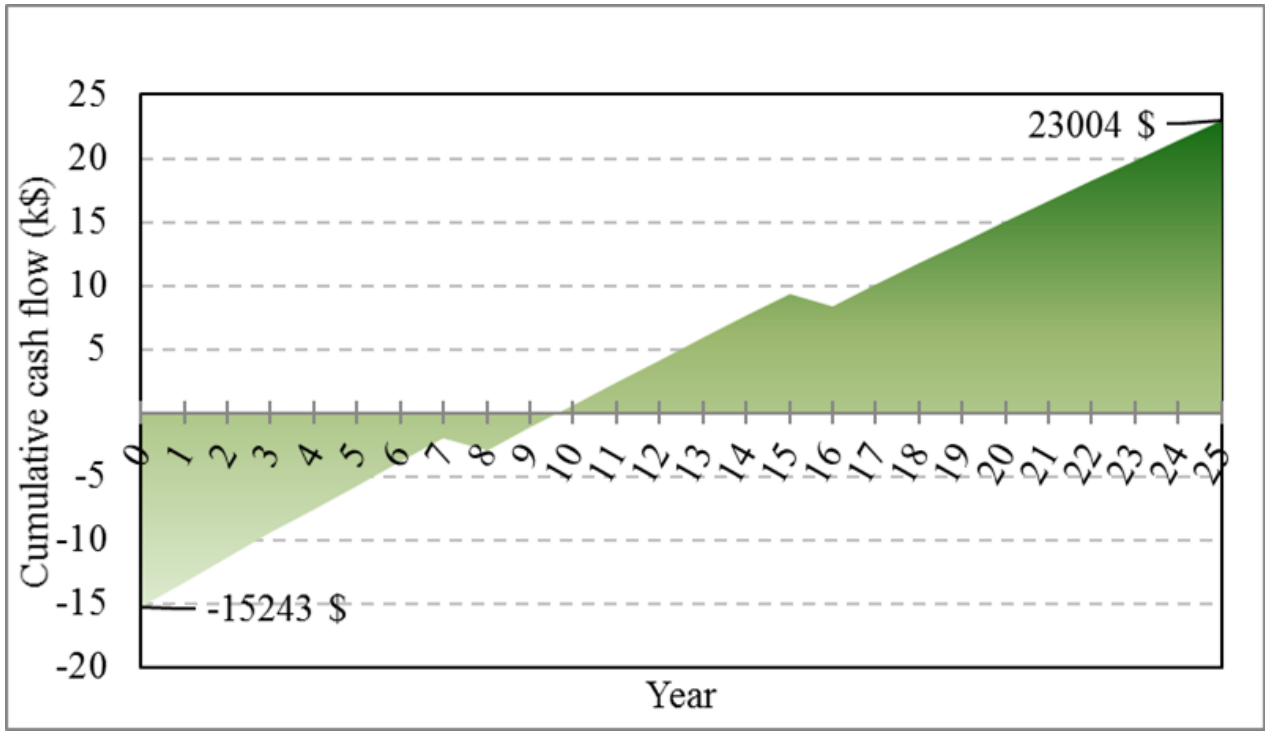




COMPARING BETWEEN THE BRANDS OF THE BEST PERFORMANCE



Stion STO-150



Stion STN-125

	Annual electricity generation (kWh/m²)	Avg. annual efficiency (%)	LCOE (¢/kWh)
Stion STO-150	115	11.8	11.6
Stion STN-125	103	10.6	9.8

COMPARING BETWEEN SYSTEM ON ROOF AND SYSTEM ON FAÇADE

Best energy performance

	Annual elect. (kWh/m²)			Avg. annual efficiency (%)			LCOE (¢/kWh)		
	roof	facade	difference	roof	facade	difference	roof	facade	difference
Stion STO-150	151	115	31%	11.7	11.8	-1%	8.9	11.6	23%
Stion STN-125	134	103	30%	10.4	10.6	-2%	7.5	9.8	23%

Best economic performance

Conclusion:

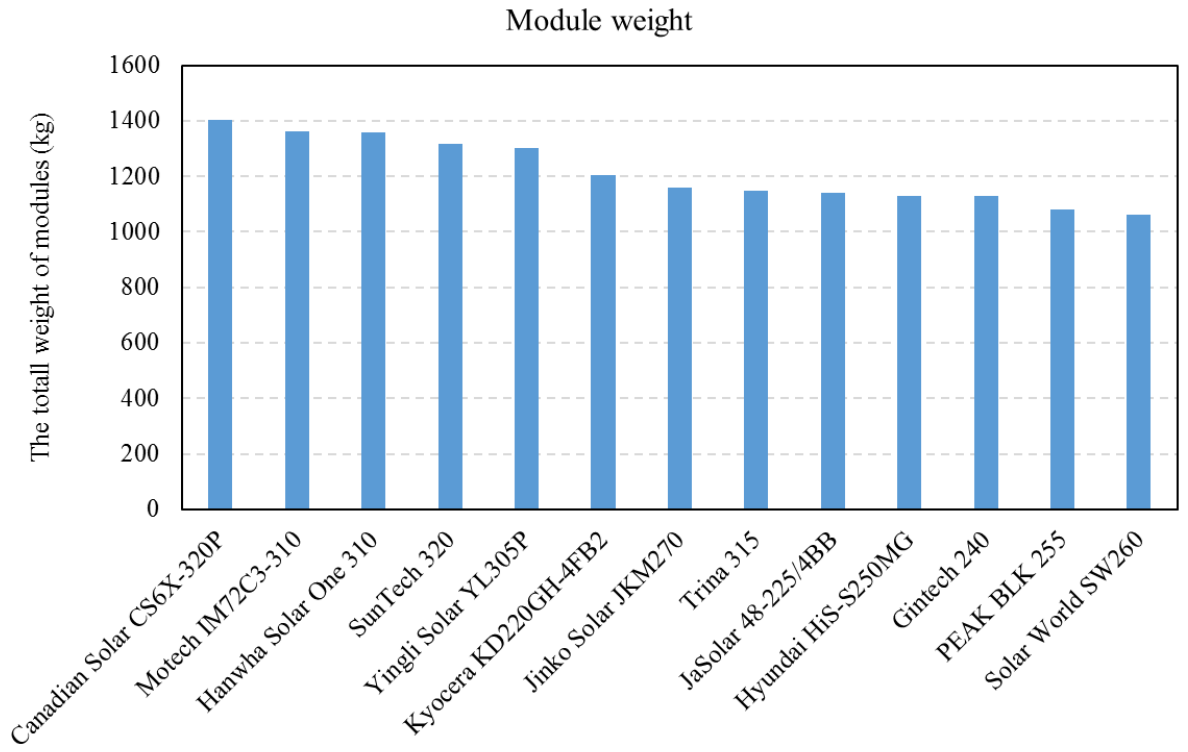
- ✓ From energy viewpoint, Stion STO-150 thin film is the best preforming model among the considered brands/models.
- ✓ From economic viewpoint, Stion STN-125 thin film is the best performing model among the considered brands/ models.

RESULTS 2: POLYCRYSTALLINE

- 13 models considered
- Two different systems:
  - On the roof
  - On the facade
- Best performing models from energy point of view identified.
- Best performing models from economic point of view identified.

WEIGHT OF 100 M² POLYCRYSTALLINE-BASE PV SYSTEM

As shown, there is no big difference in the weight of selected brands(about 250 kg over an area of 100 $m^{2)}$

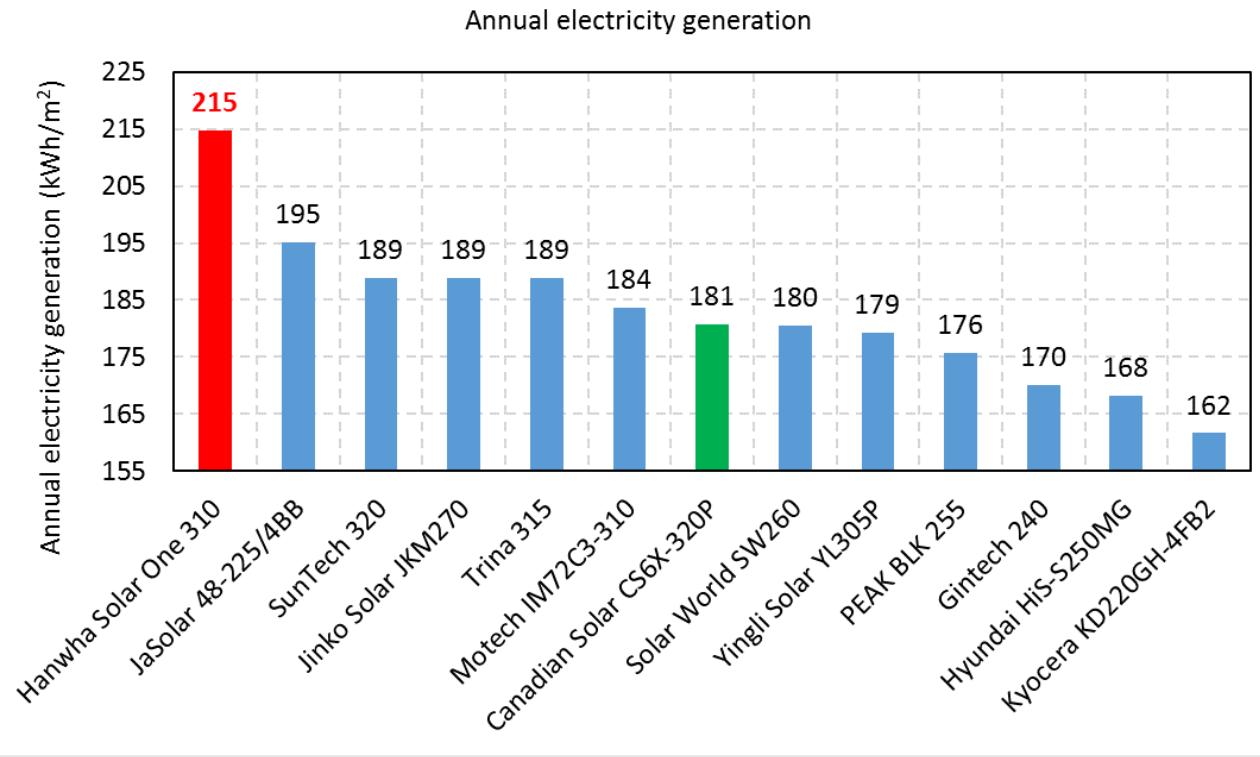


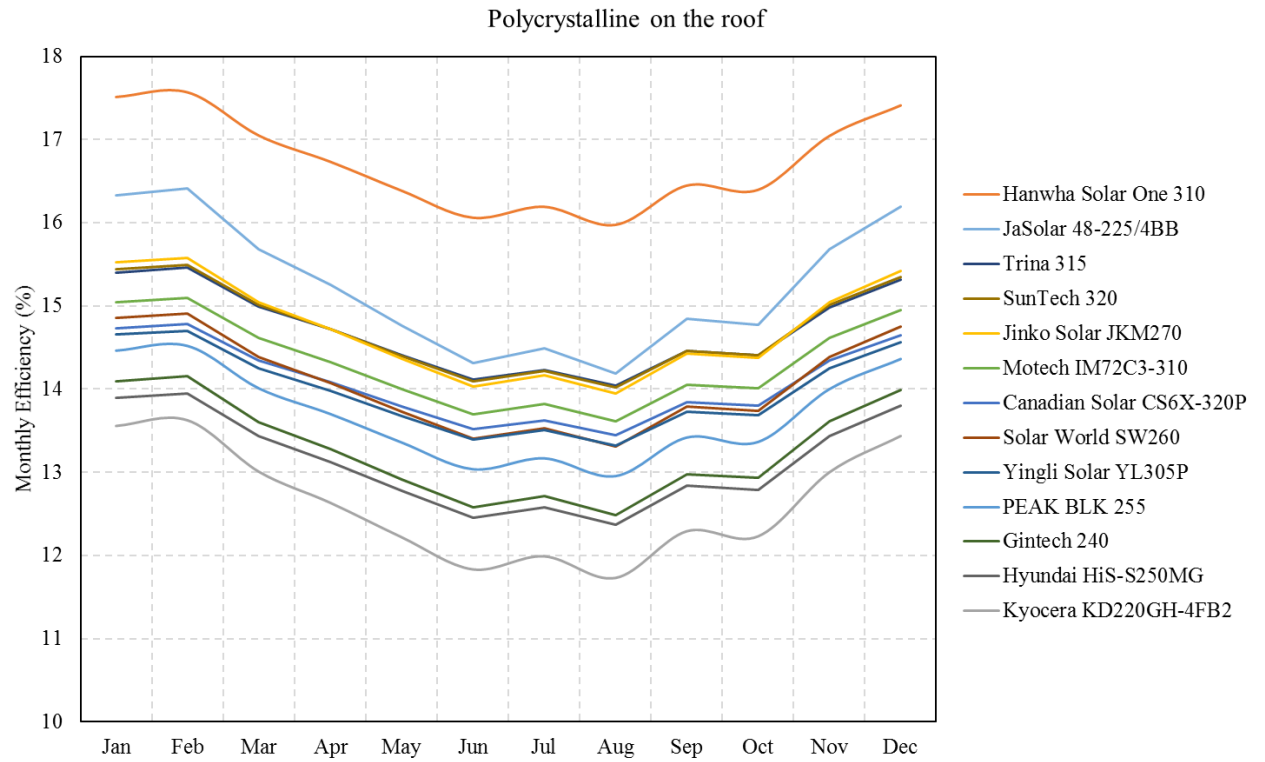
ELECTRICAL OUTPUT AND EFFICIENCY OF POLYCRYSTALLINE PV SYSTEM ON ROOF

The simulations show that the electricity output of the system varies from 189 to 252 kWh/m^2.a

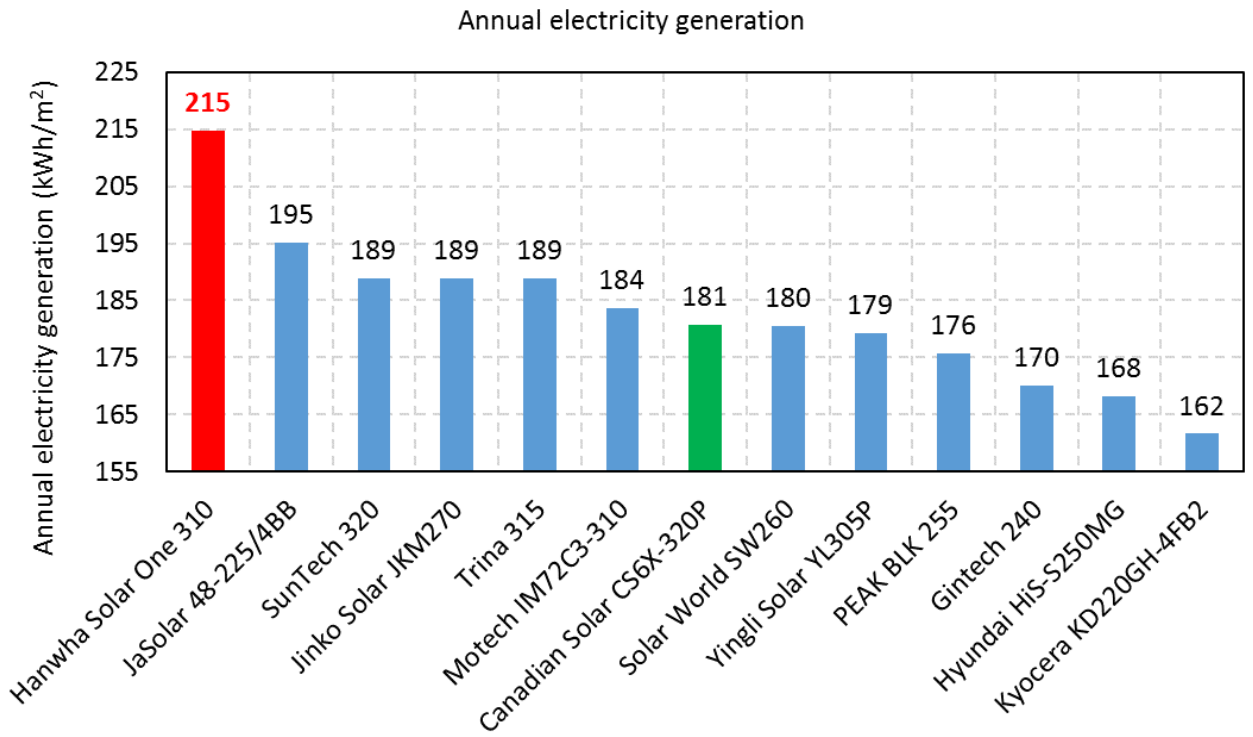
The efficinecy of modules ranged from 11.8 to 17.8%.

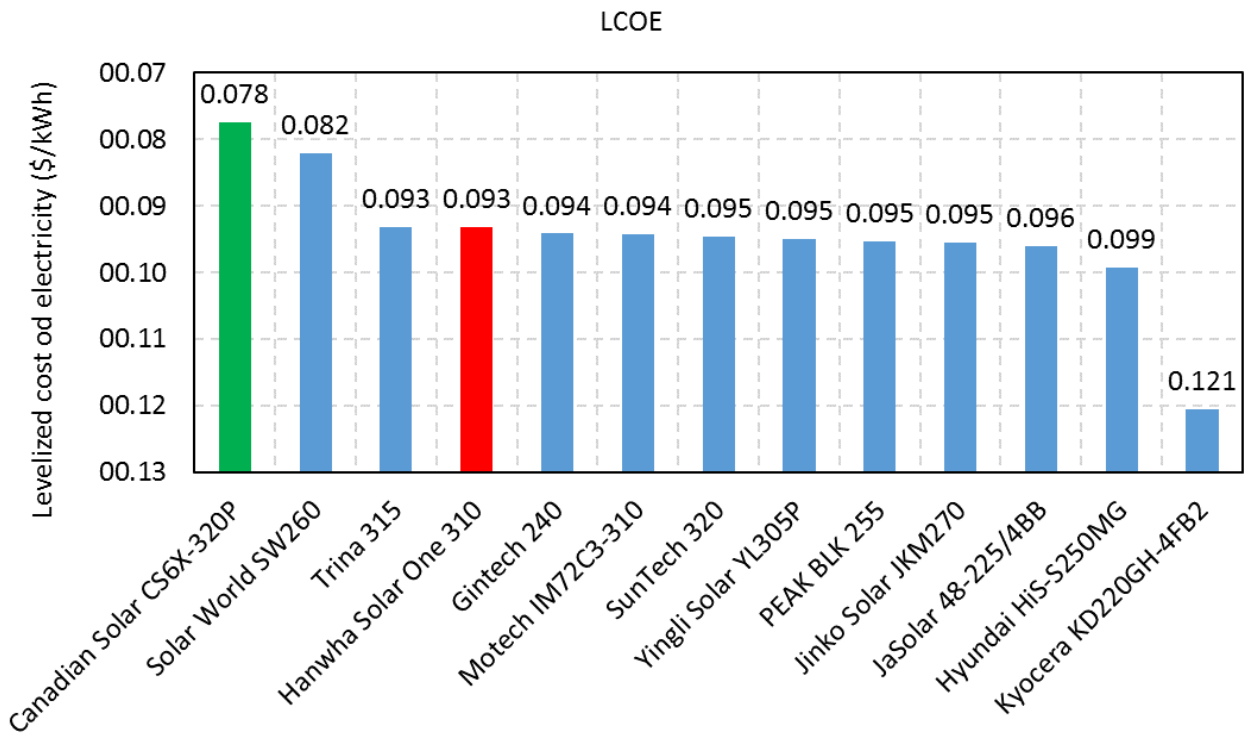
From energy viewpoint, Hanwha solar One 310 is the best performing model among the considered ones.





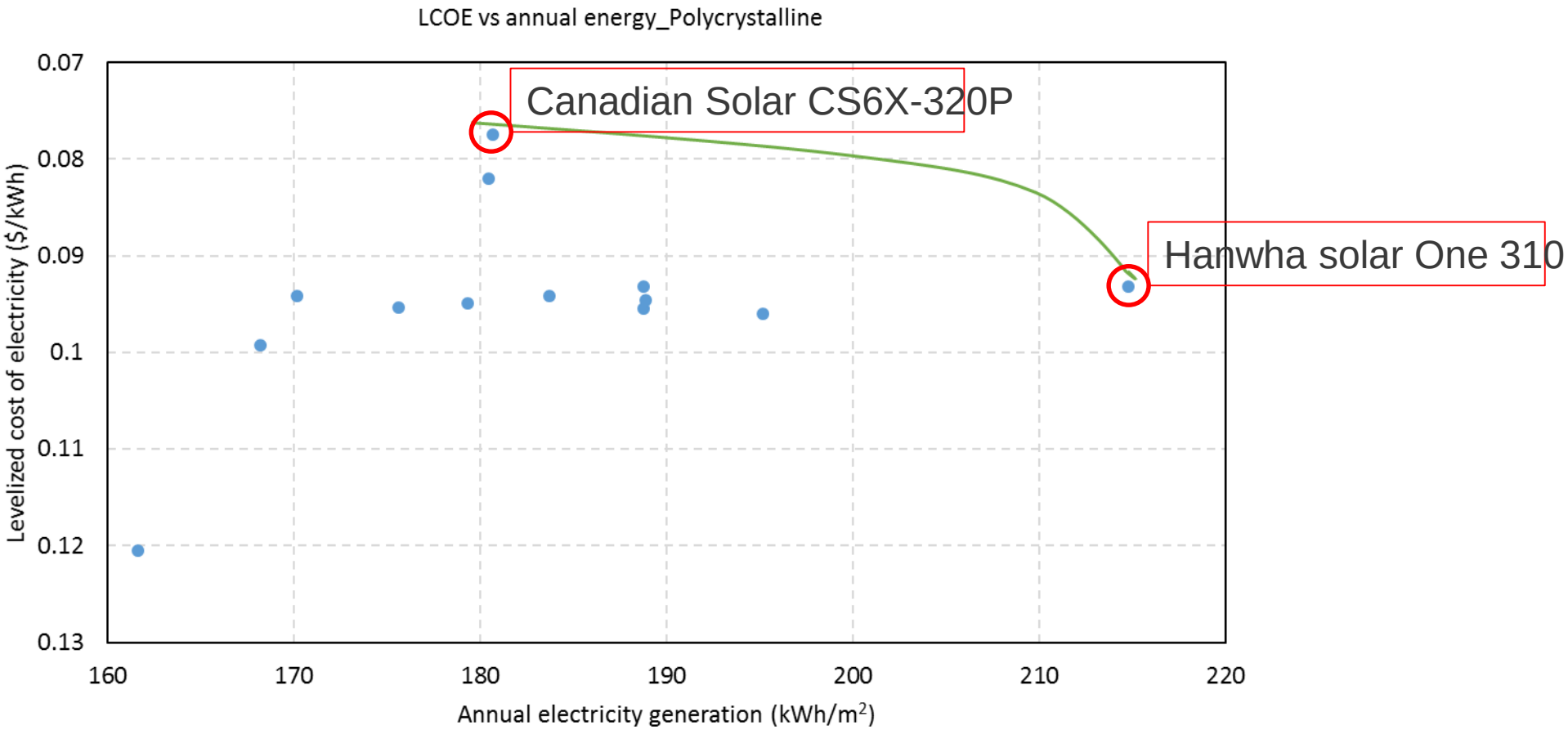
LEVELIZED COST OF ELECTRICITY





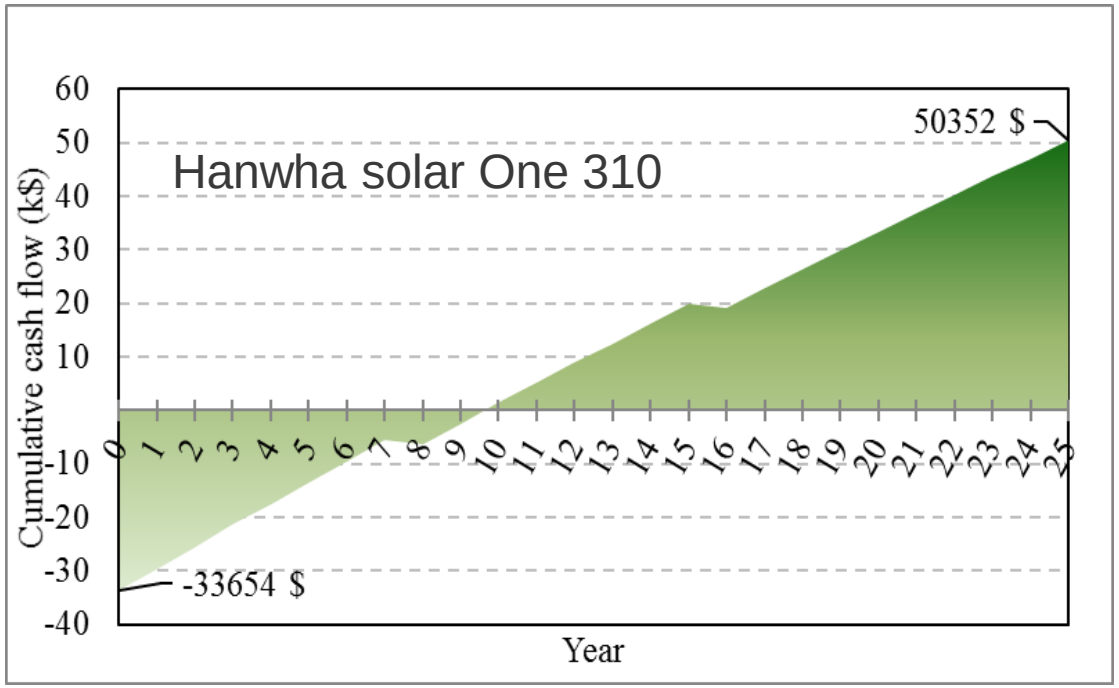
- Brand of the best energy performance is not the same one of the best economic performance.

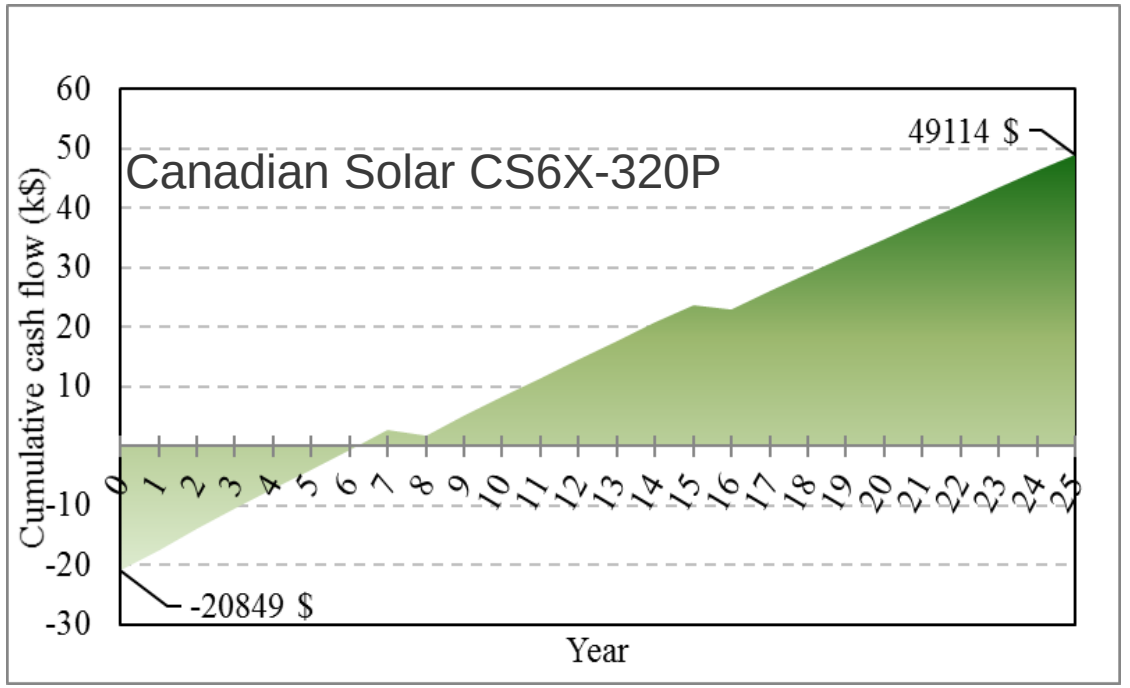
ECONOMIC PERFORMANCE VERSUS ENERGY PERFORMANCE OF PV SYSTEM



COMPARING BETWEEN THE BRANDS OF THE BEST PERFORMANCE

Accumulative cash flow of Hanwha solar One 310 (of the best energy performance) and Canadian Solar CS6X-320P (of the best economic performance) were calculated.



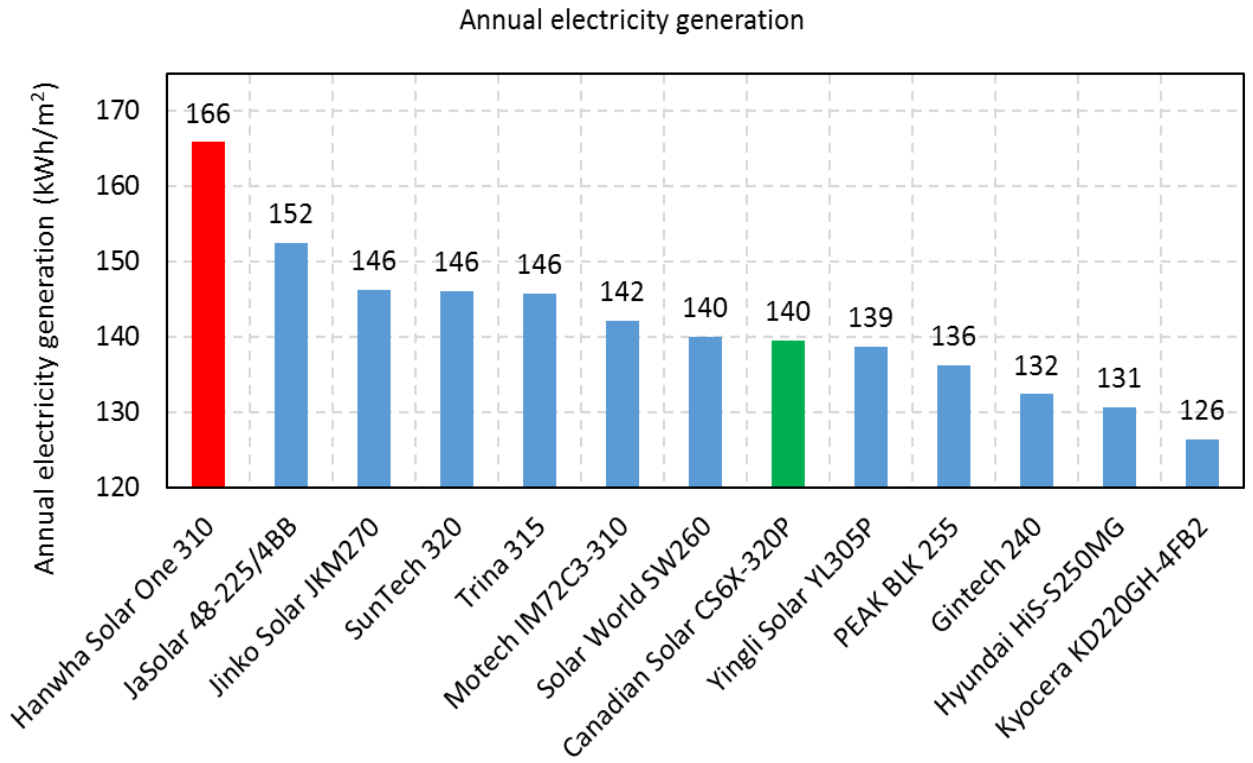


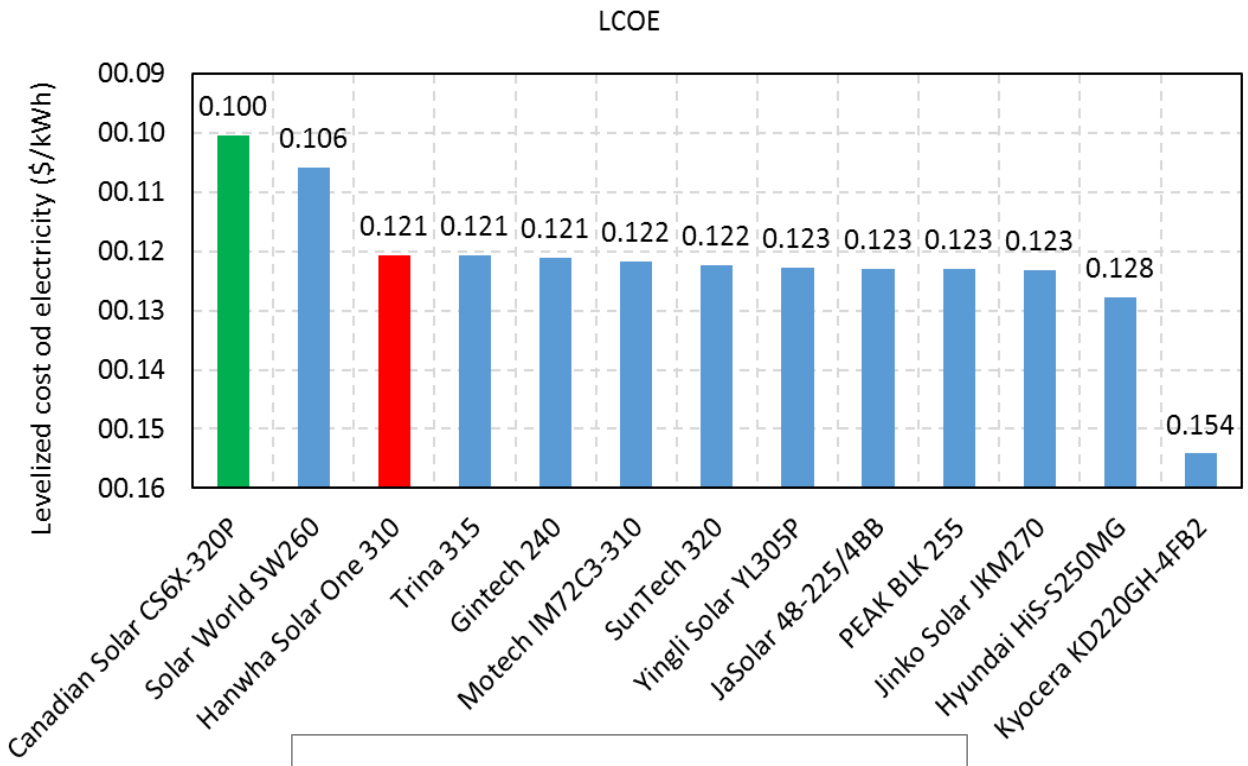
	Annual electricity (kWh/m^2)	Avg. annual efficiency (%)	LCOE (¢/kWh)	Initial cost ($/100m^2)	Payback time (year)
Hanwha Solar One 310	215	16.7	9.3	33654	9.8
Canadian Solar CS6X-320P	181	14.0	7.8	20849	6.2
difference	19%	19%	19%	61%	58%

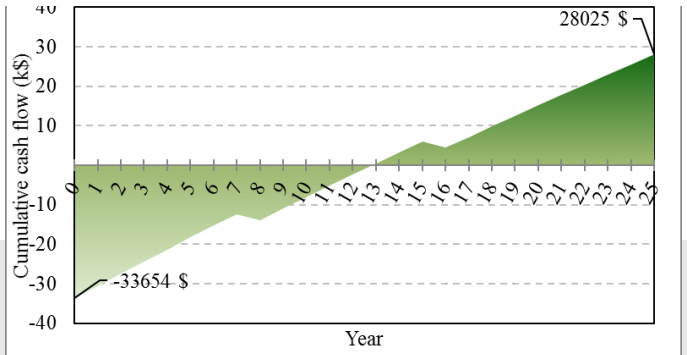
CONCLUSION: POLYCRYSTALLINE

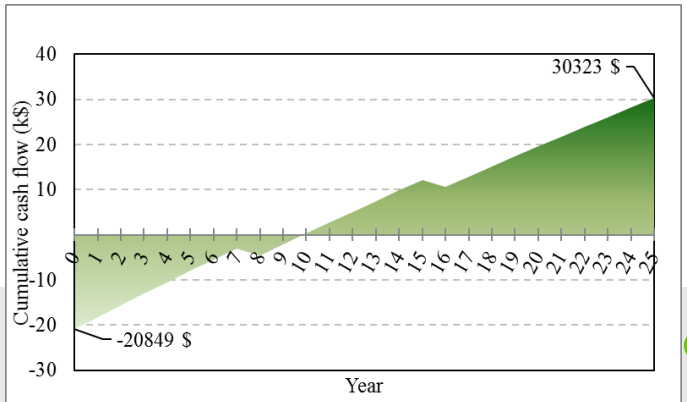
- From energy viewpoint, Hanwha solar One 310 PV module seems to be the best performing among the considered polycrystalline modules.
- From economic viewpoint, Canadian Solar Cs6X-320P seems to be the best performing among the considered Polycrystalline brands.
- Hanwha solar One 310 PV module produces 19% electricity more than Canadian Solar Cs6X-320P.
- Canadian Solar Cs6X-320P PV produces electricity at price 17% cheaper than that can be given by Hanwha solar One 310.

2. POLYCRYSTALLINE MODULE: INSTALLED ON SOUTH FACING FAÇADE









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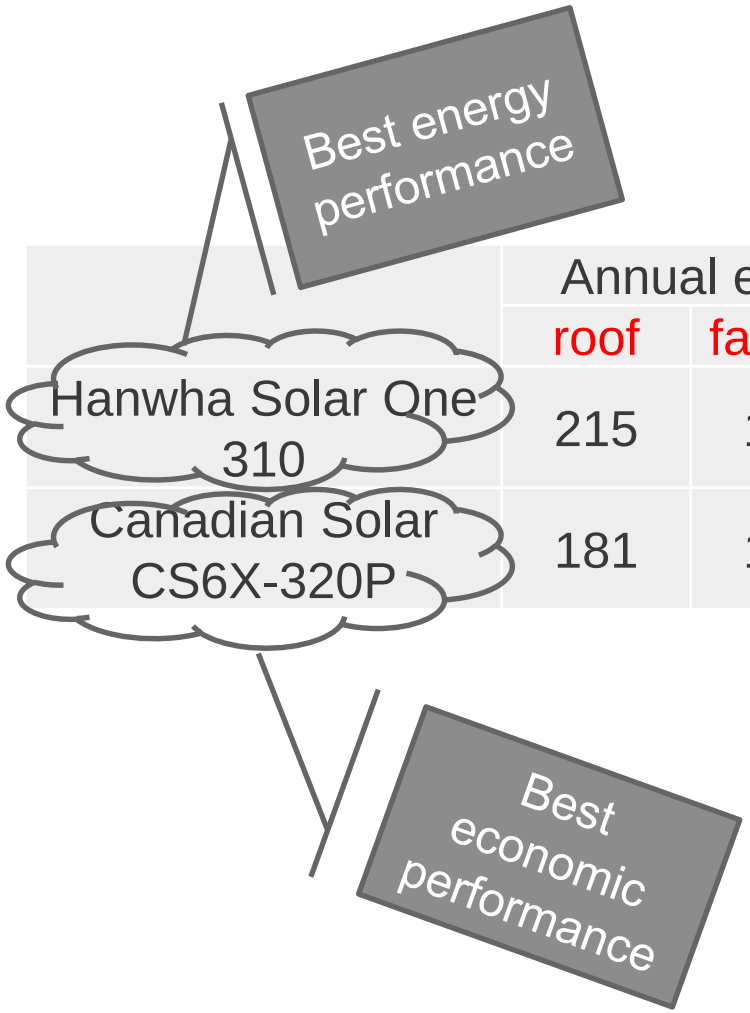
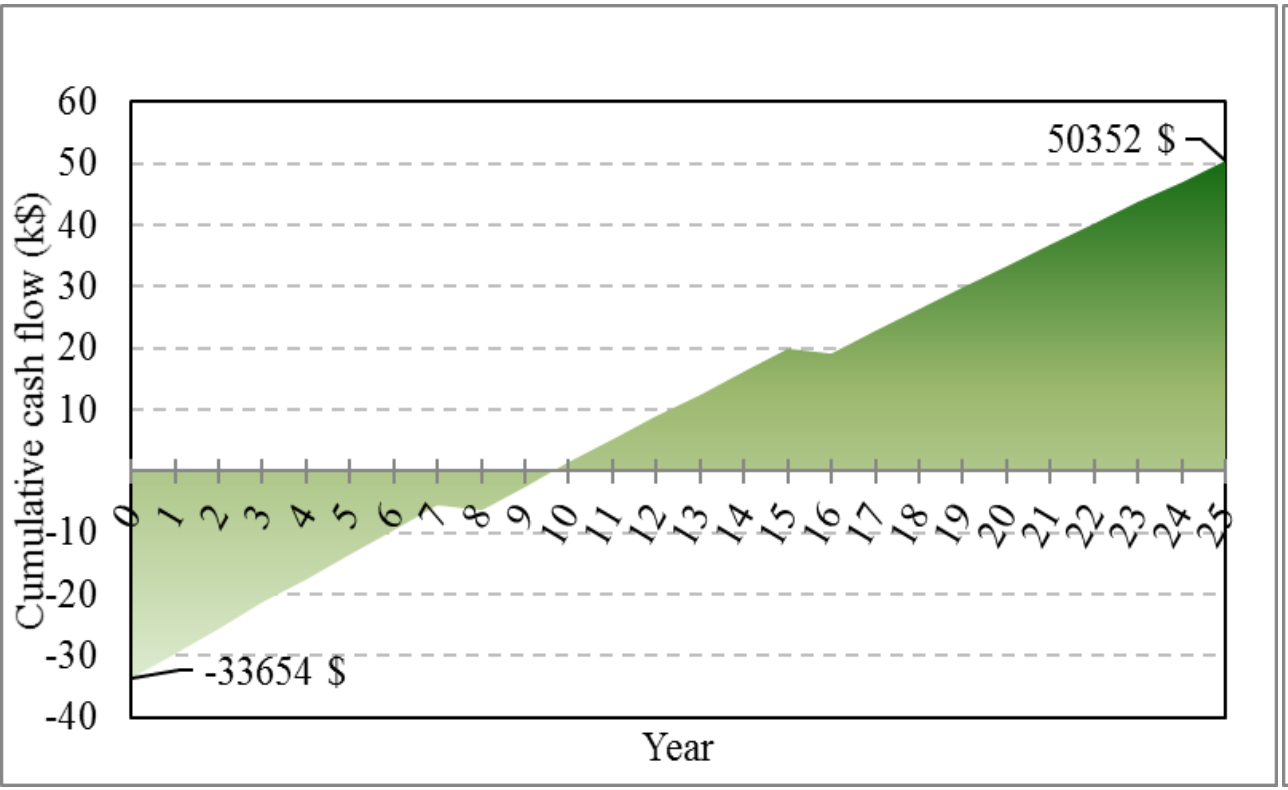
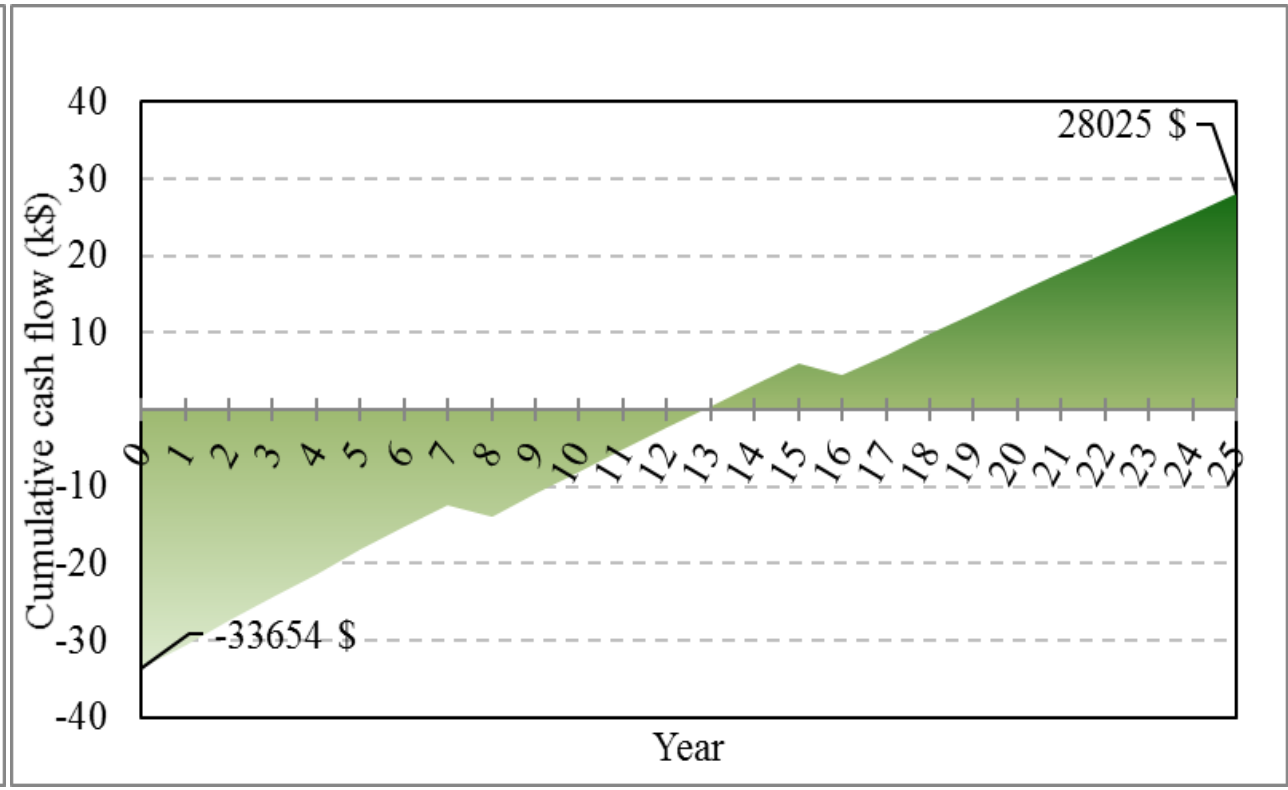
COMPARING BETWEEN SYSTEM ON ROOF AND FAÇADE



	Annual elect. (kWh/m^2)			Avg. annual efficiency (%)			LCOE (¢/kWh)		
	roof	facade	difference	roof	facade	difference	roof	facade	difference
Hanwha Solar One 310	215	166	30%	16.7	17	-2%	9.3	12.1	-23%
Canadian Solar CS6X-320P	181	140	29%	14.0	14.3	-2%	7.8	10.0	-22%

COMPARING BETWEEN SYSTEM ON ROOF AND FAÇADE : THE BEST ENERGY PERFORMANCE





Hanwha solar One 310

	Annual electricity (kWh/m²)		Avg. annual efficiency (%)		LCOE (¢/kWh)	
	on the roof	on facade	on the roof	on facade	on the roof	on facade
Hanwha Solar One 310	215	166	16.7	17.0	9.3	12.1

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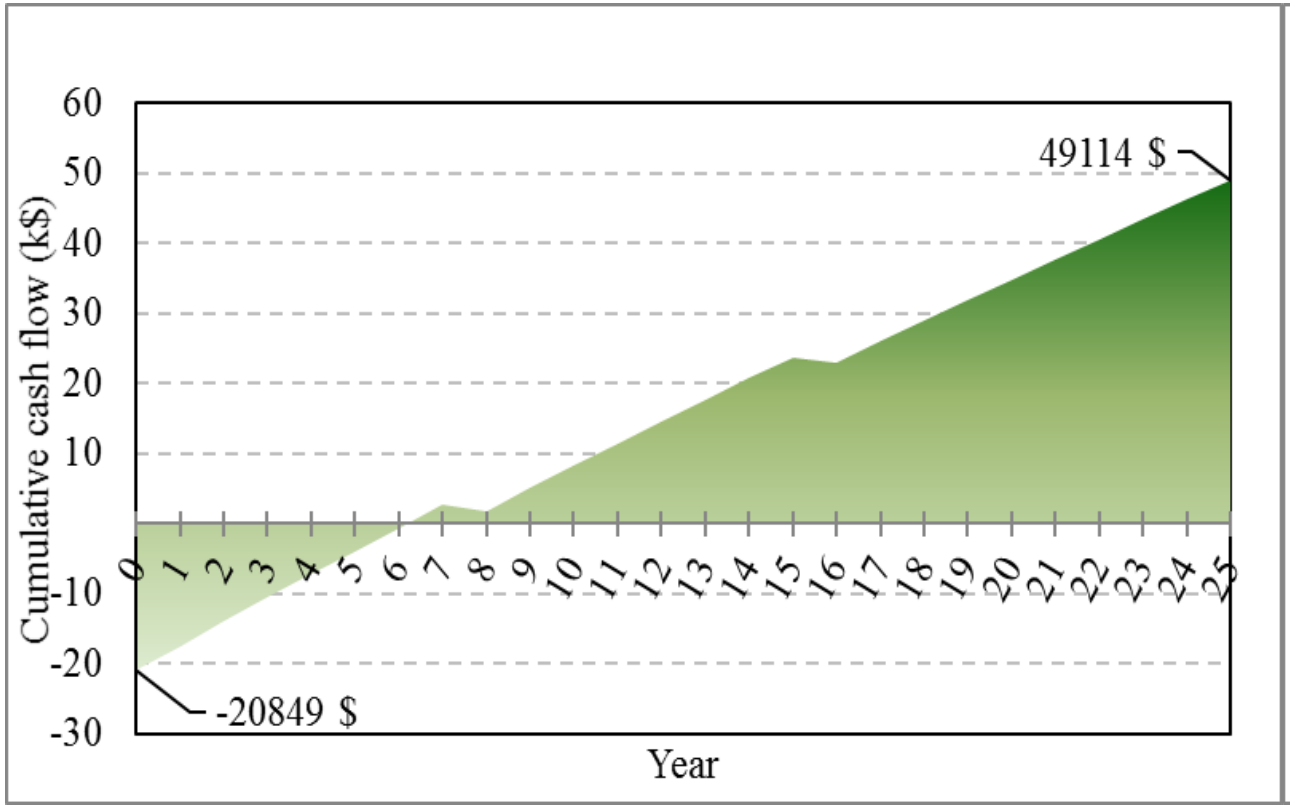
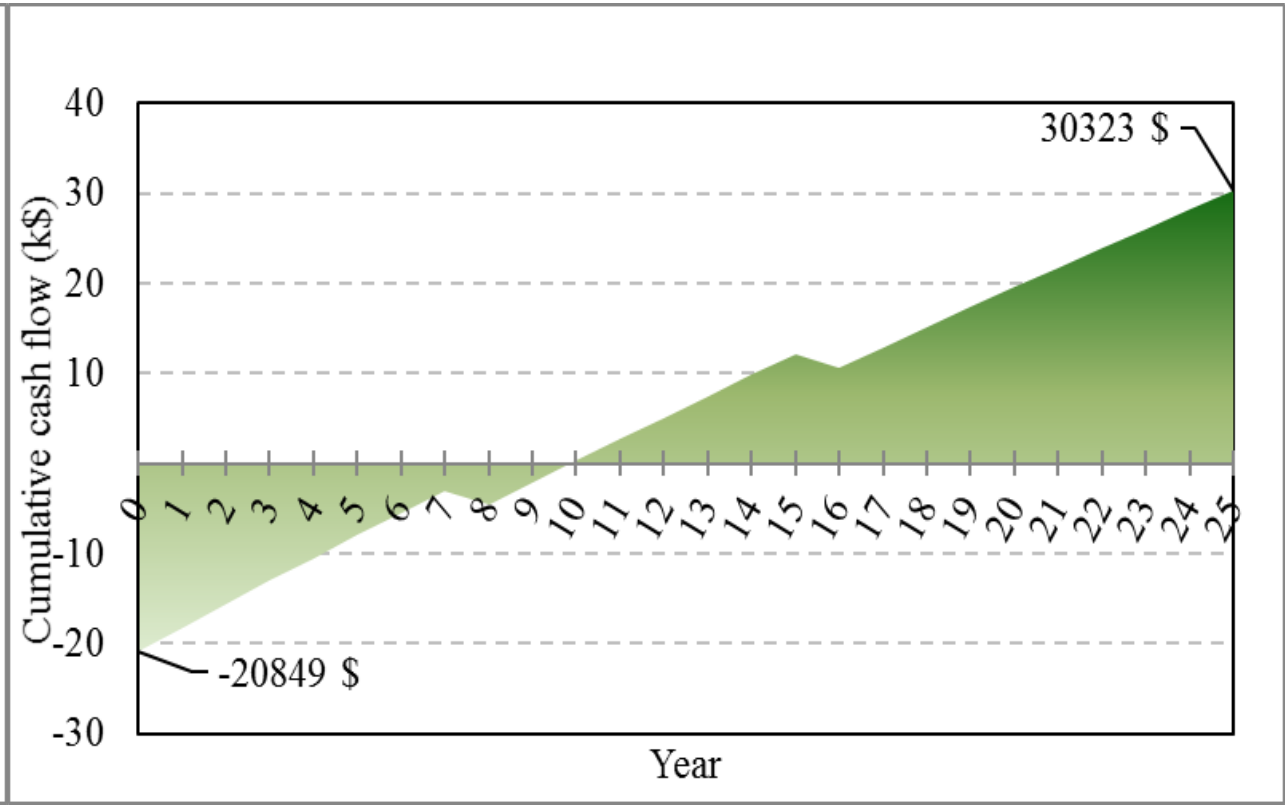
COMPARING BETWEEN SYSTEM ON ROOF AND FAÇADE : THE BEST ECONOMIC PERFORMANCE





Canadian Solar CS6X-320P

	Annual electricity (kWh/m²)		Avg. annual efficiency (%)		LCOE (¢/kWh)	
	on the roof	on facade	on the roof	on facade	on the roof	on facade
Canadian Solar CS6X-320P	181	140	14.0	14.3	7.8	10.0

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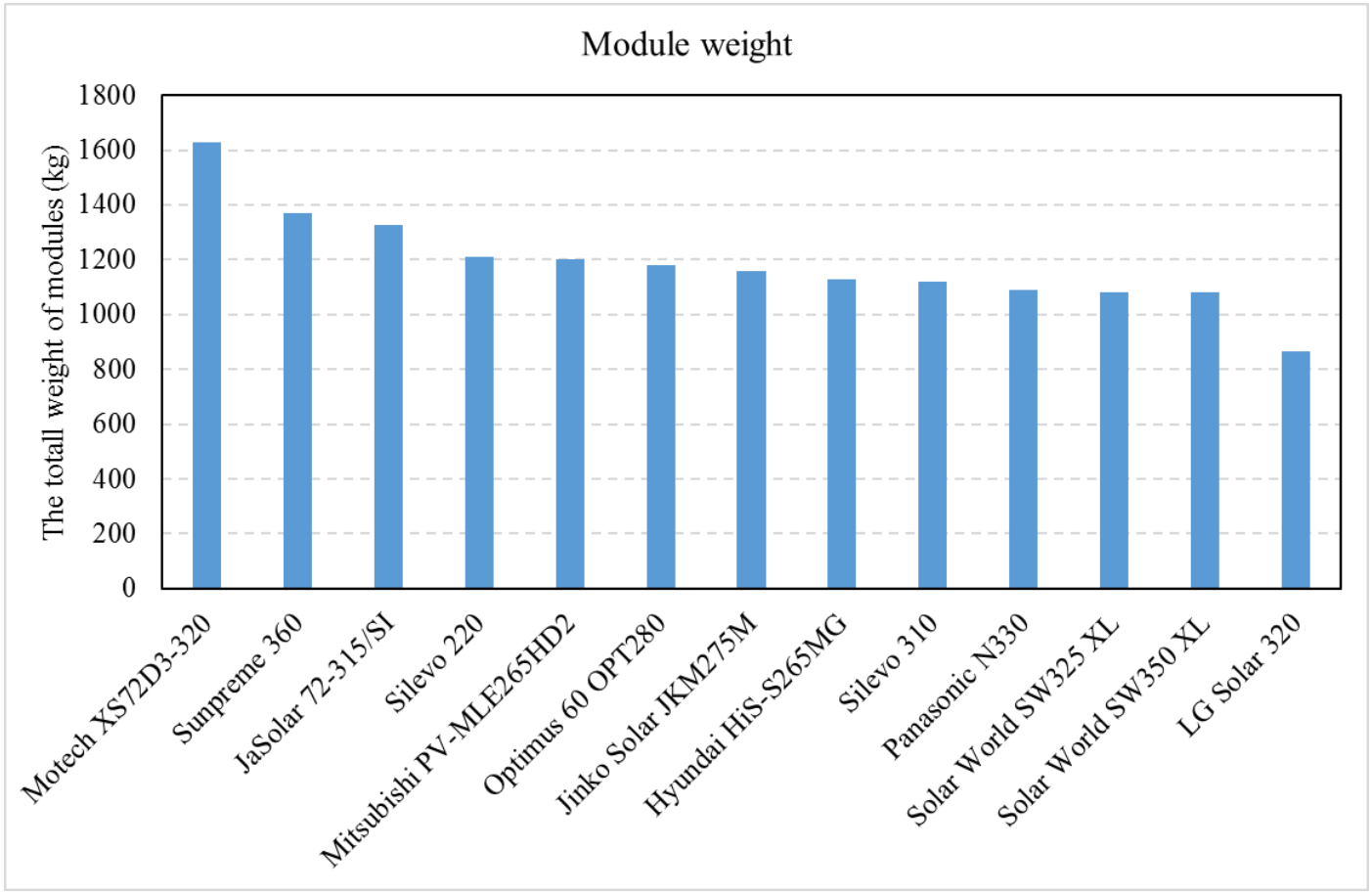
RESULTS 3: MONOCRYSTALLINE

- 13 models considered
- Two different systems:
  - On the roof
  - On the facade
- Best performing model from energy point of view identified.
- Best performing model from economic point of view identified.

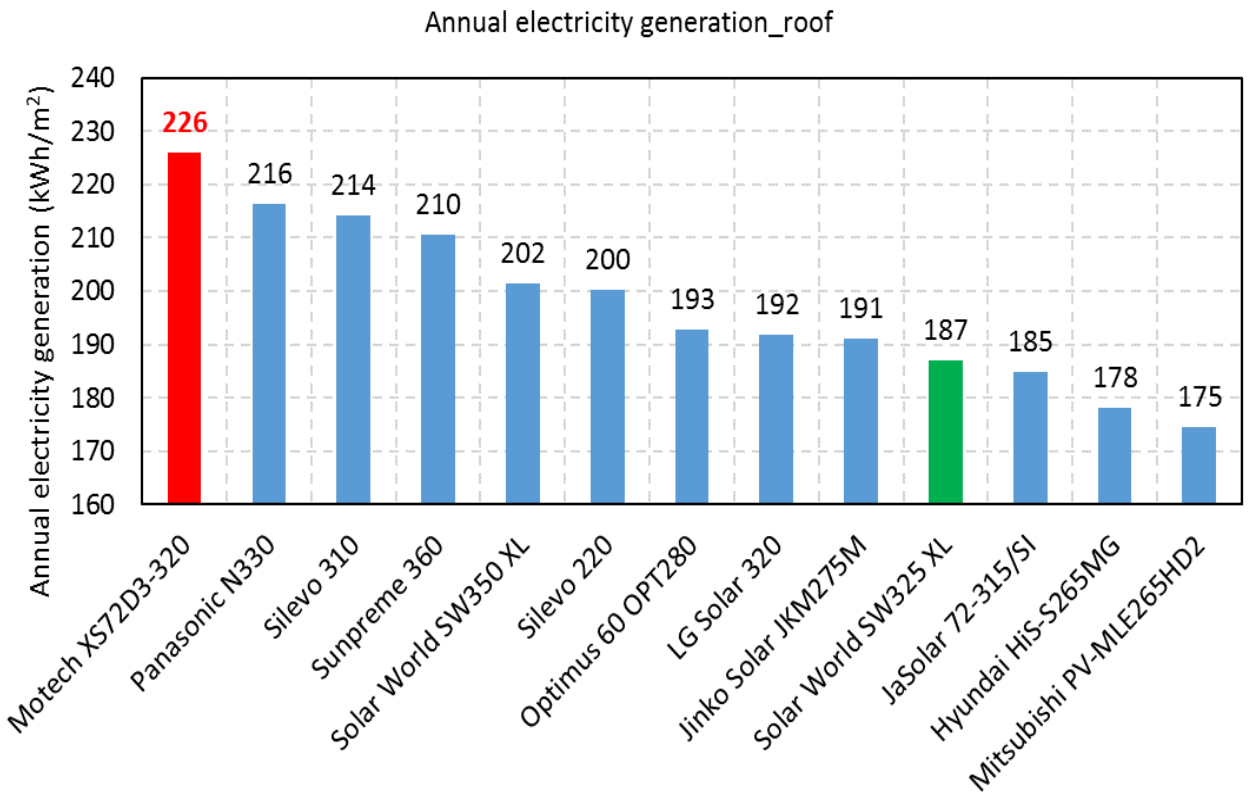
WEIGHT OF 100 M² MONOCRYSTALLINE-BASE PV SYSTEM

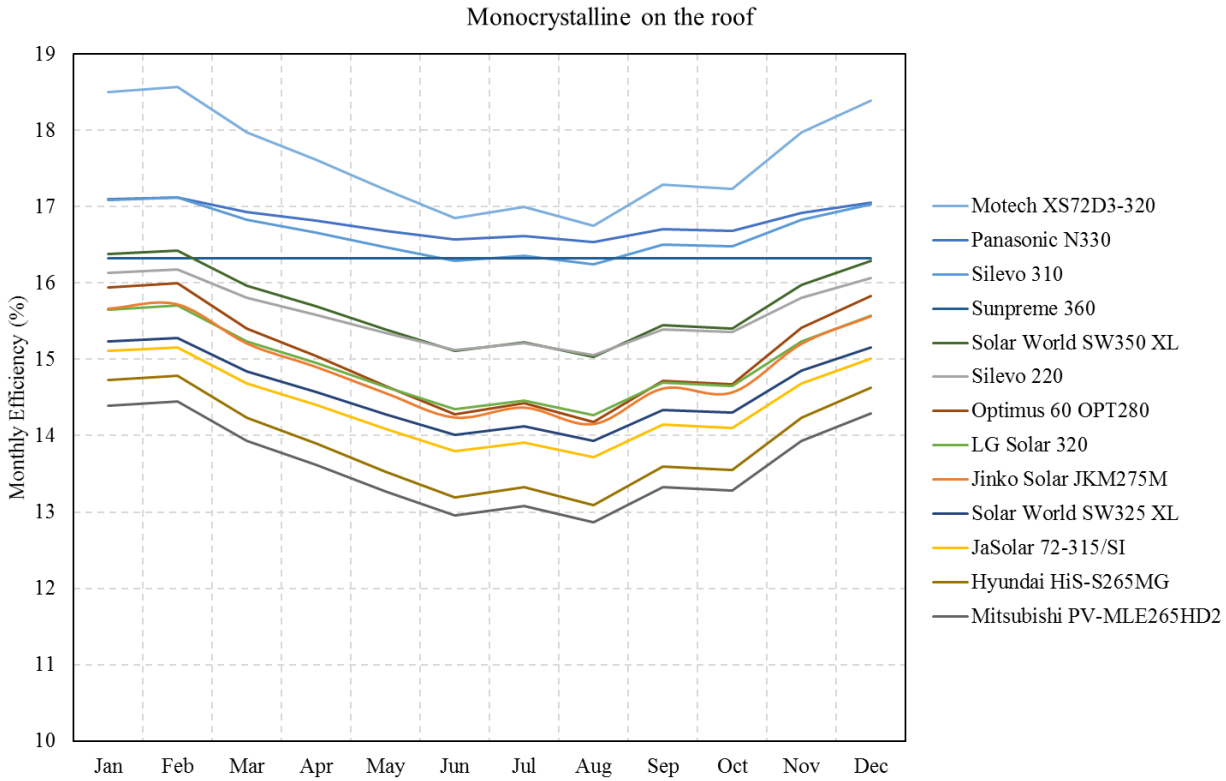


As shown, there is a considered difference in the weight of the moduls on the roof.

ELECTRICAL OUTPUT AND EFFICIENCY OF MONOCRYSTALLINE PV SYSTEM ON ROOF

- The simulations show that the electricity output of the system varies from 204 to 265 kWh/m^2.a
- The efficinecy of modules ranged from 12 to 19%
- From energy viewpoint, Motech XS72D3-320 PV module is the best among the considered brands.





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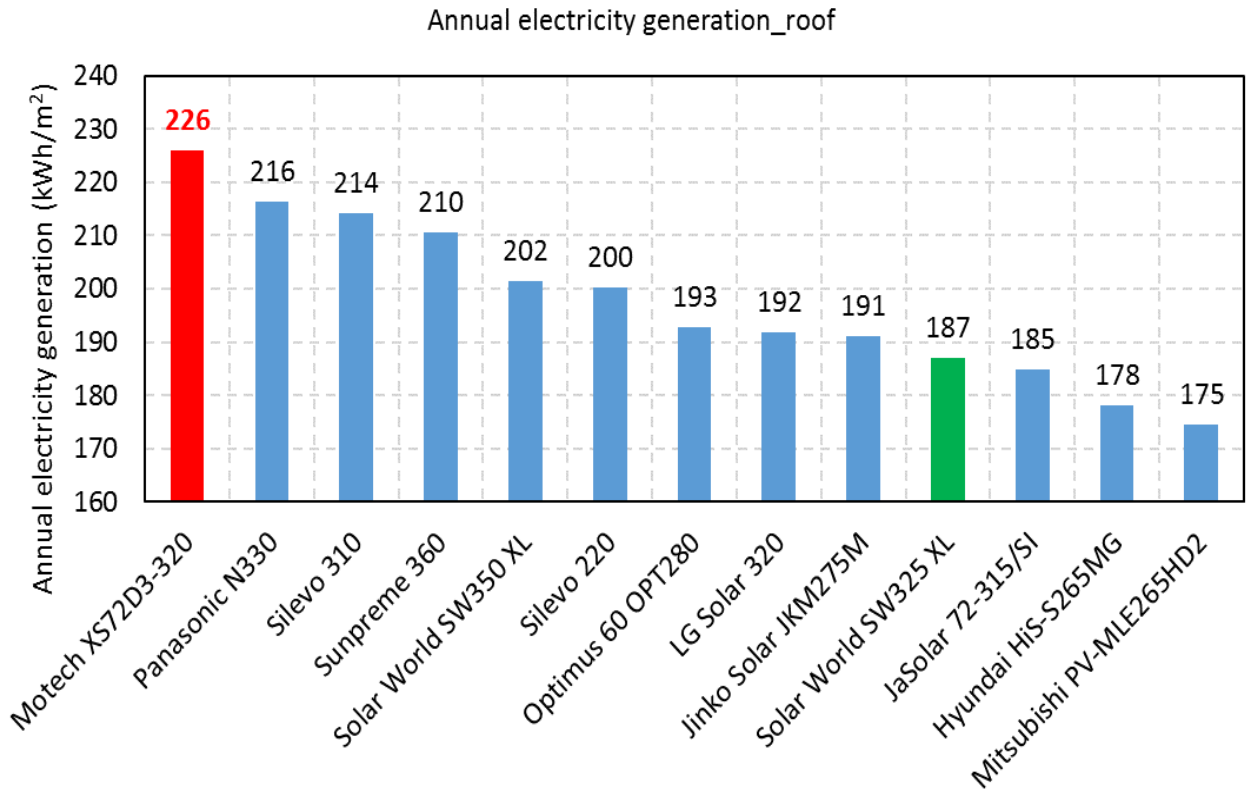
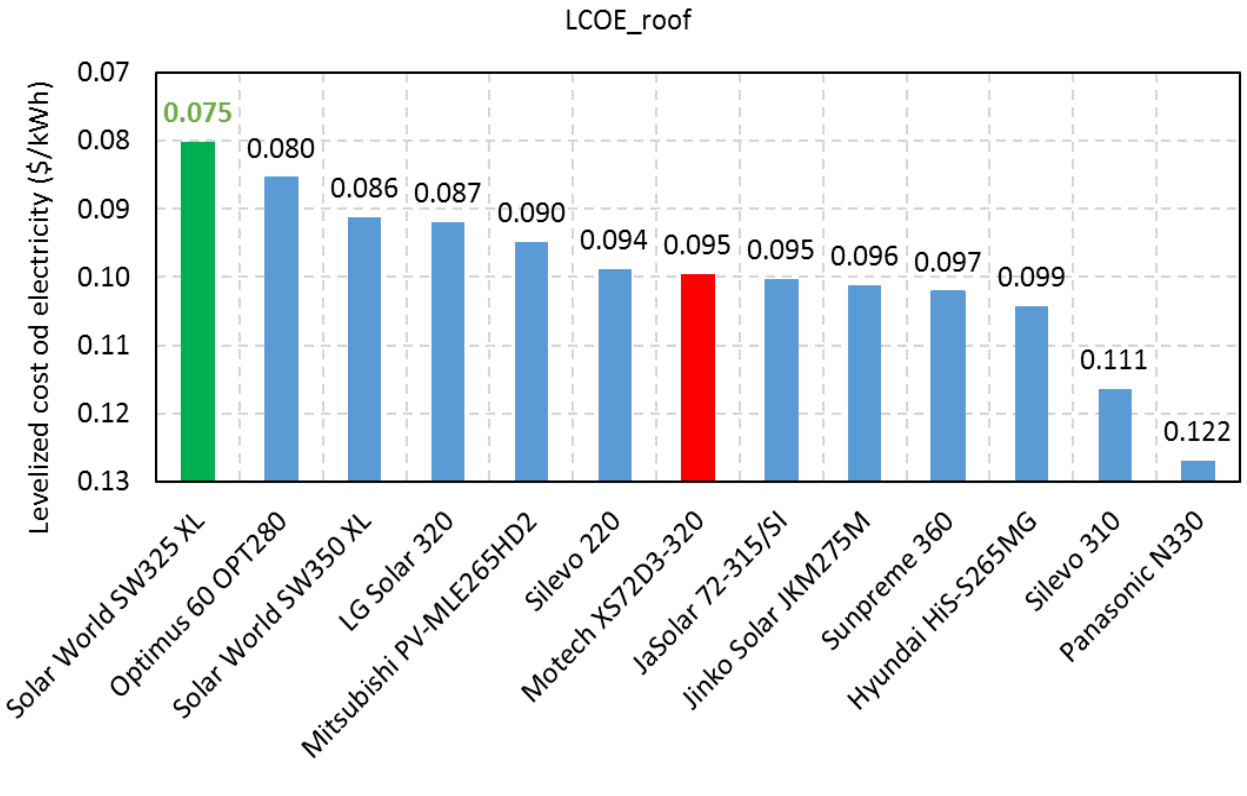
LEVELIZED COST OF ELECTRICITY

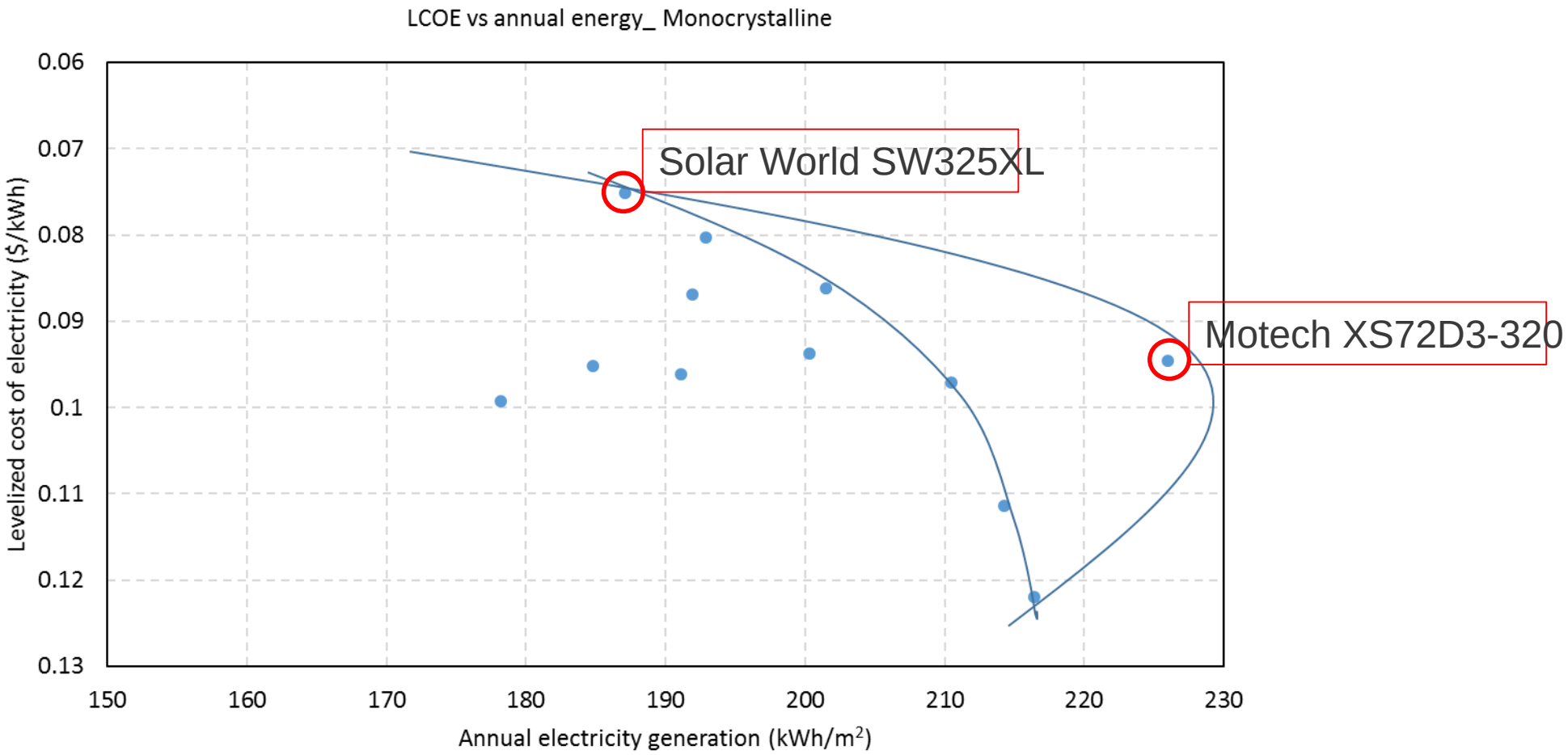




From economic viewpoint, Solar World SW325XL looks to be the best performing model among the considered models.

- The model showing best performance from energy point of view is not the same one as the model scoring best from economic viewpoint.

ECONOMIC PERFORMANCE VERSUS ENERGY PERFORMANCE OF PV SYSTEM



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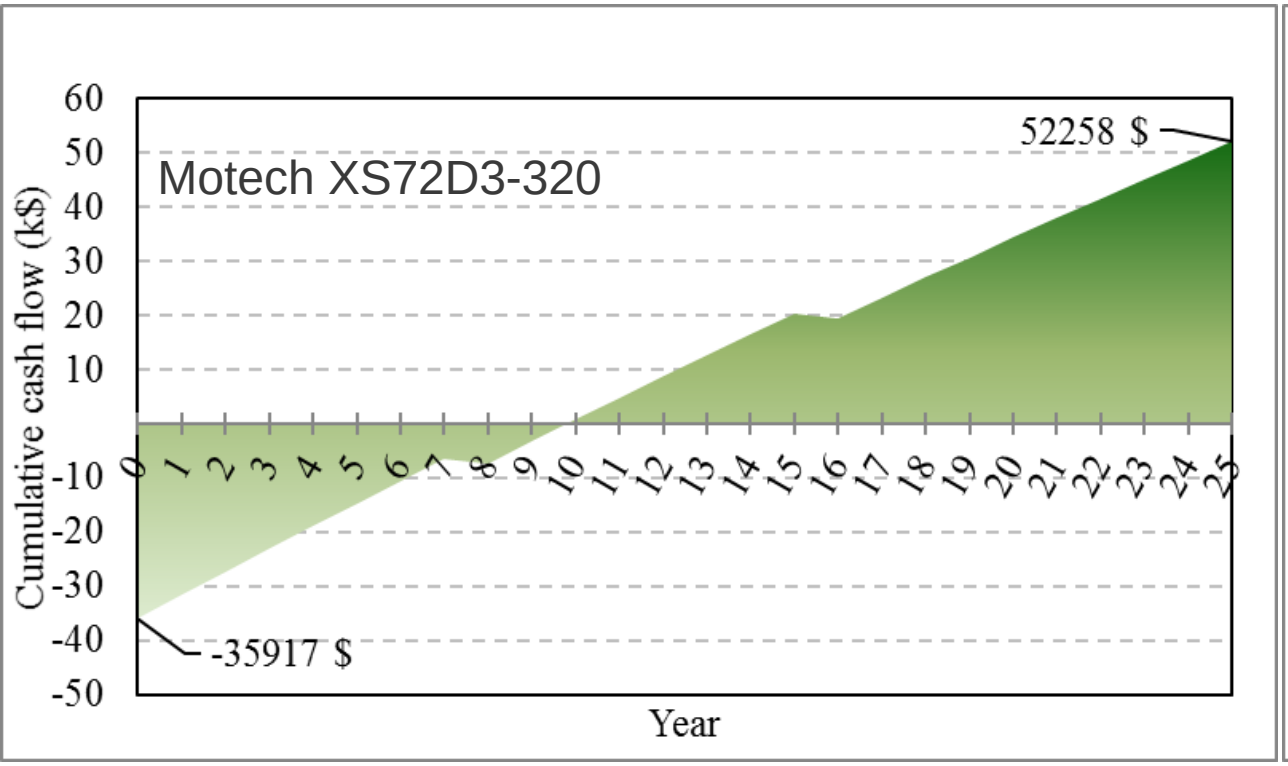
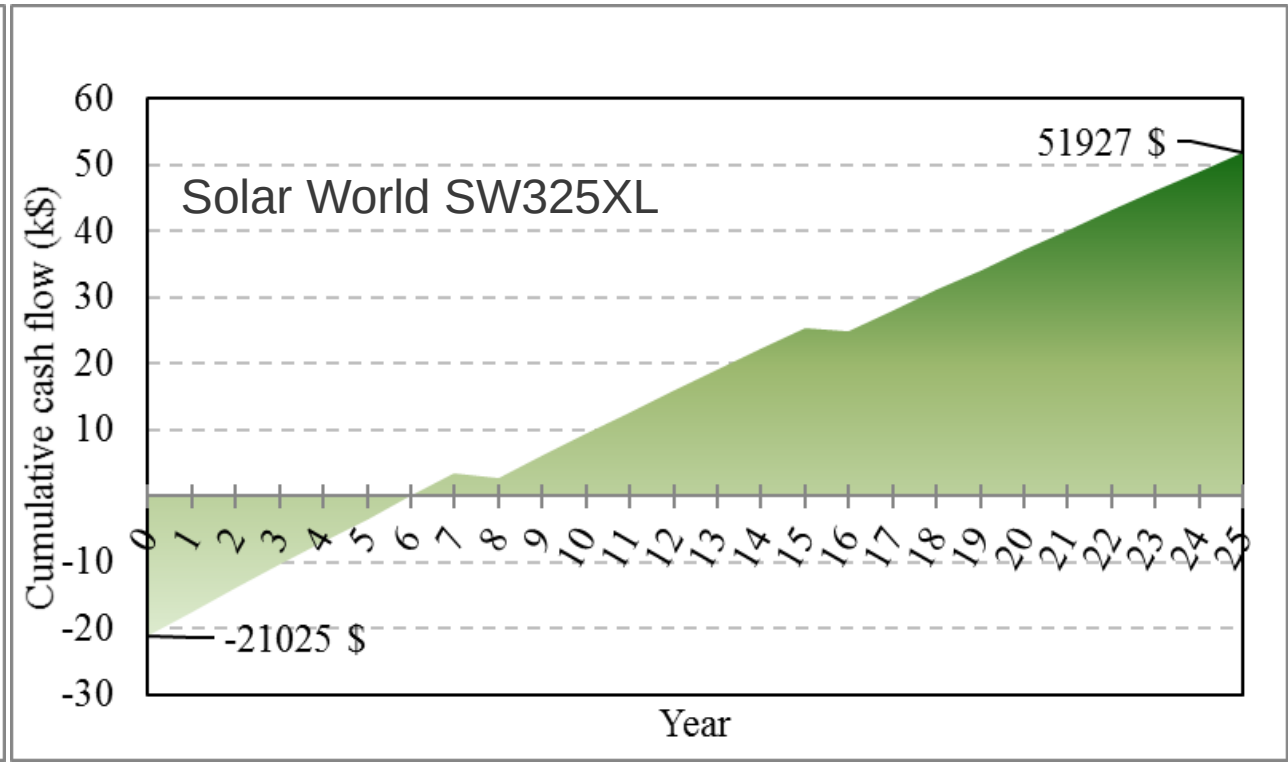
COMPARING BETWEEN THE BRANDS OF THE BEST PERFORMANCE

Accumulative cash flow of Motech XS72D3-320 (of the best energy performance) and Solar World SW325 XL (of the best economic performance) were calculated



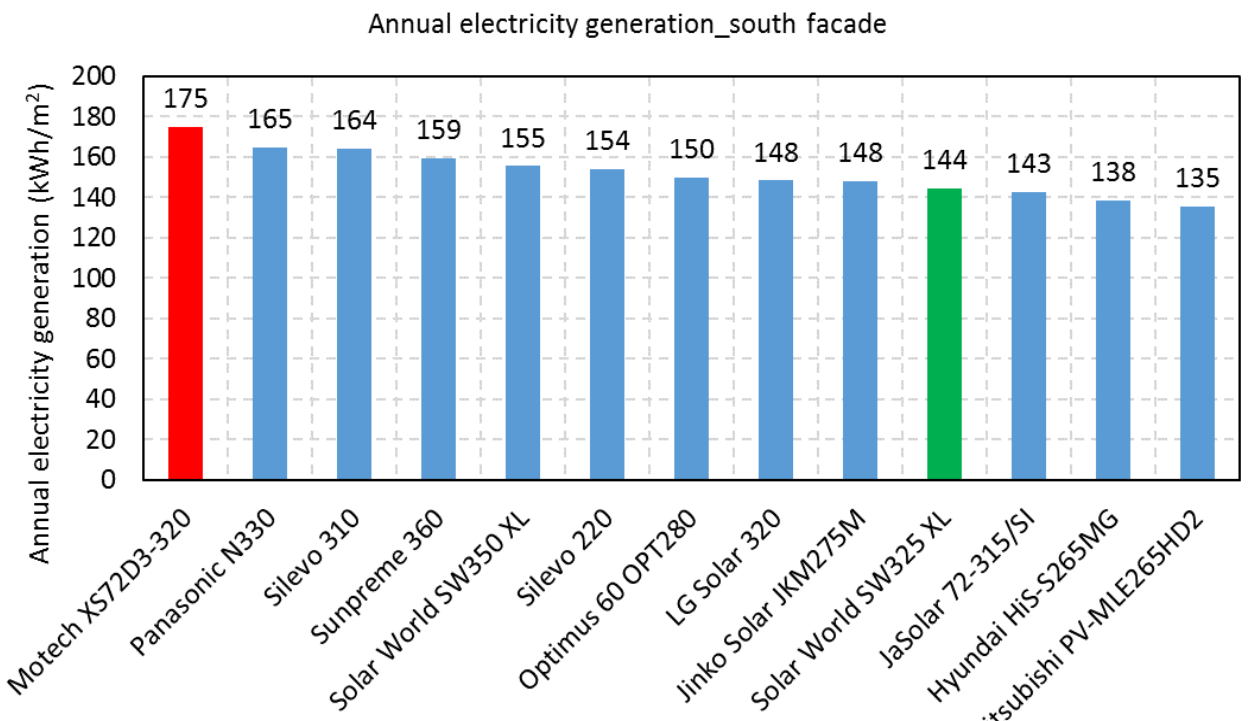


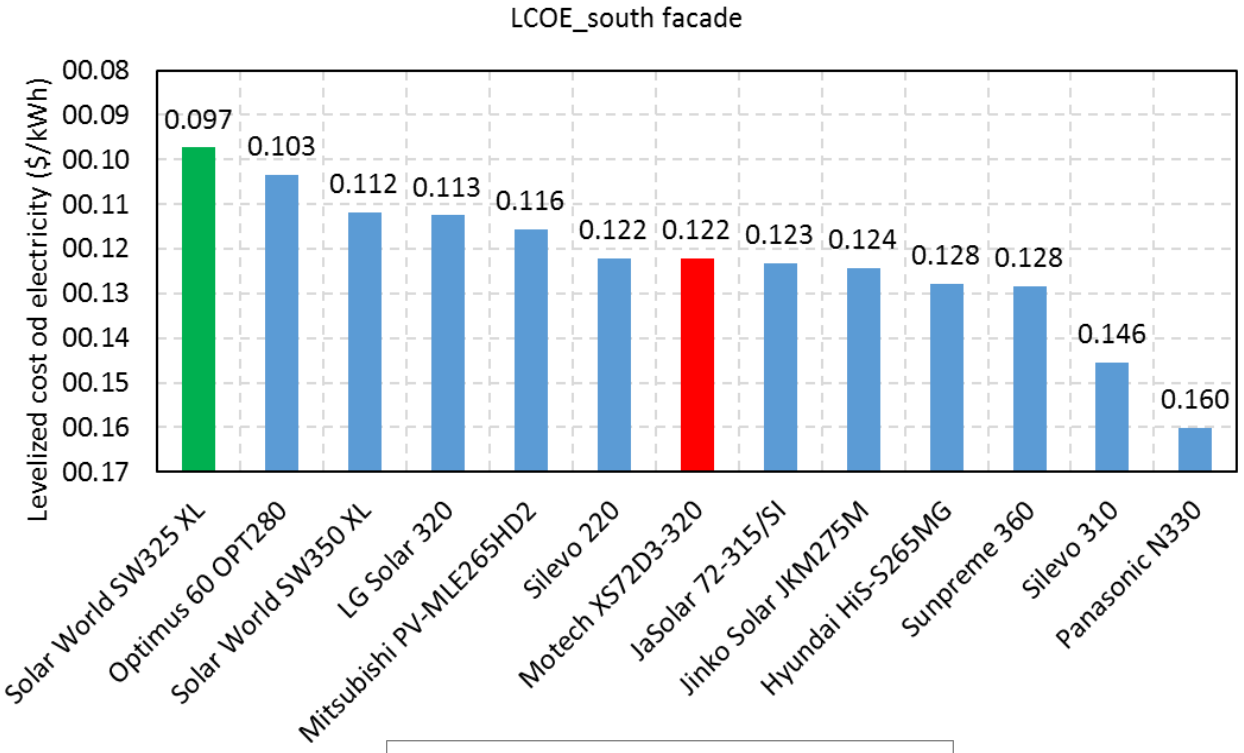
	Annual elect.(kWh/m^2)	Annual efficiency (%)	LCOE (¢/kWh)	Initial cost ($/100m^2)	Payback time (year)
Motech XS72D3-320	226	17.5	9.5	35917	9.9
Solar World SW325 XL	187	14.5	7.5	21025	6
difference	21%	21%	27%	71%	65%

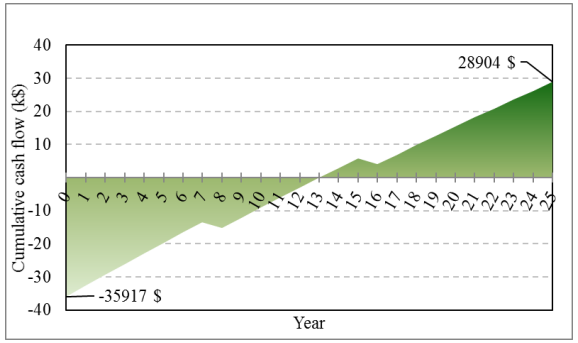
CONCLUSION: MONOCRYSTALLINE

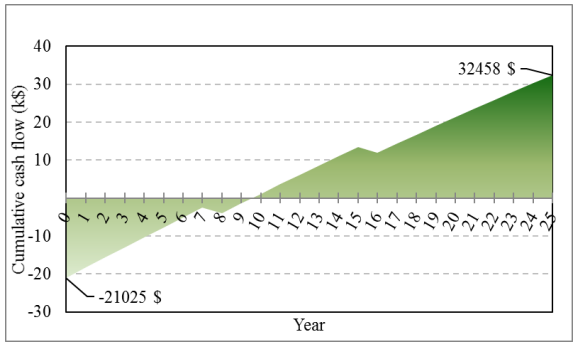
- From energy viewpoint, Motech XS72D3-320 PV module seems to be the best performing model among the considered Monocrystalline models.
- From economic viewpoint, Solar World SW325XL scores best.
- Motech XS72D3-320 PV module produces 21% electricity more than Solar World SW325XL.
- Solar World SW325XL PV module produces electricity at price 21% cheaper than that can be given by Motech XS72D3-320 .

3. MONOCRYSTALLINE MODULE: INSTALLED ON SOUTH FACING FAÇADE









Motech XS72D3-320

Solar World SW325XL

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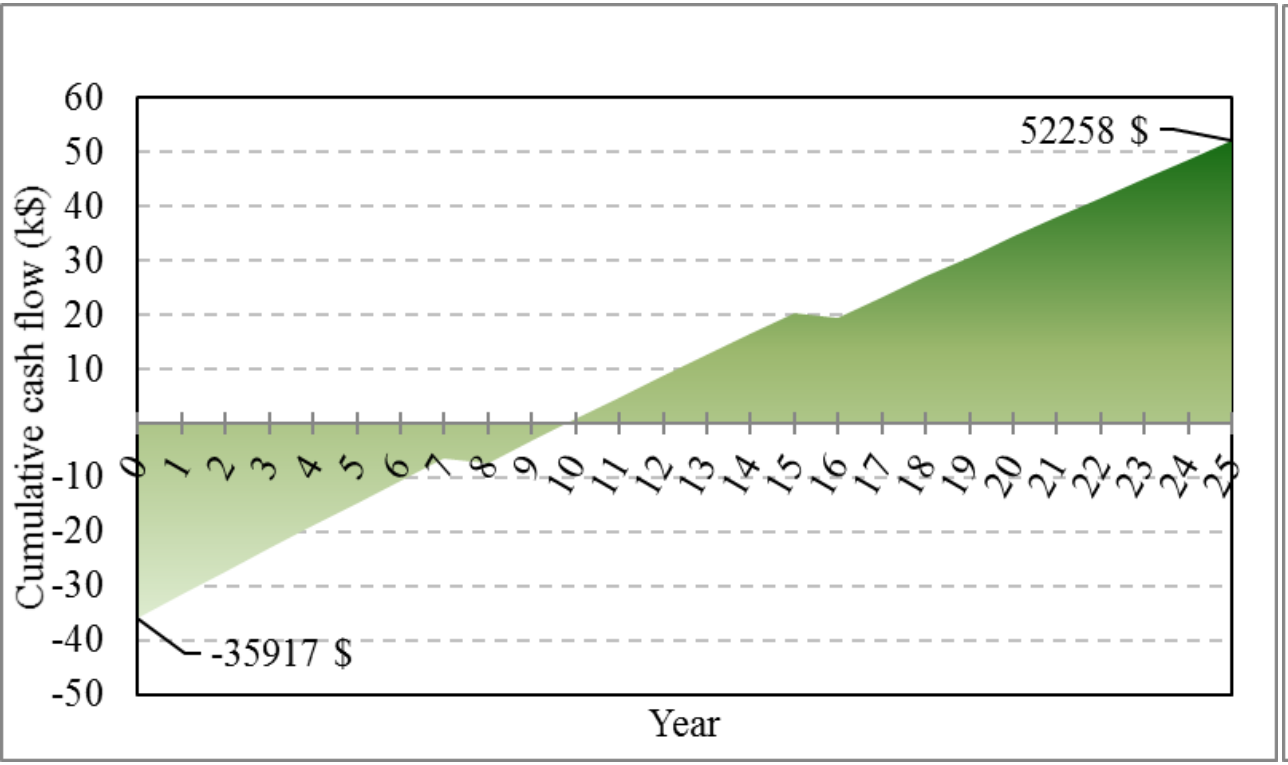
COMPARING BETWEEN SYSTEM ON ROOF AND FAÇADE

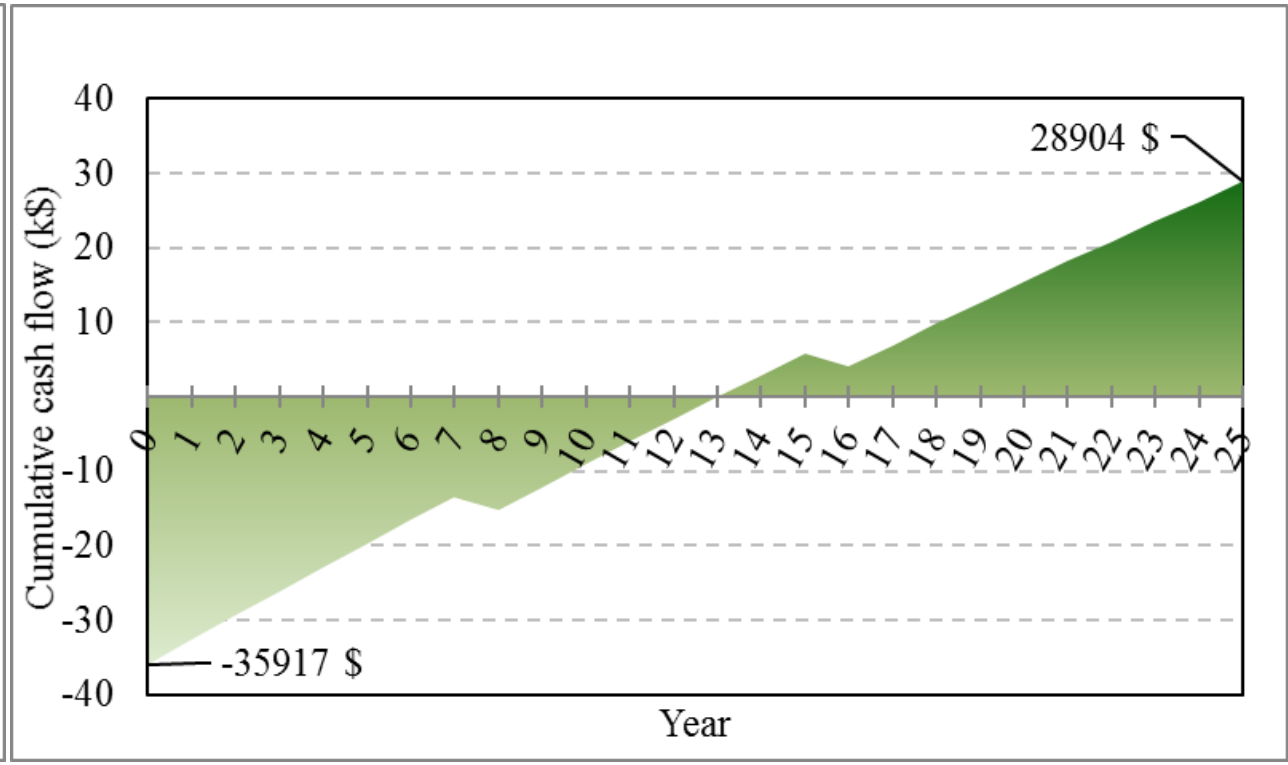
Best energy performance

	Annual elect. (kWh/m²)			Avg. annual efficiency (%)			LCOE (¢/kWh)		
	roof	facade	difference	roof	facade	difference	roof	facade	difference
Motech XS72D3-320	226	175	29%	17.5	17.9	-2%	9.5	12.2	-22%
Solar World SW325 XL	187	144	30%	14.5	14.8	-2%	7.5	9.7	-23%

Best economic performance

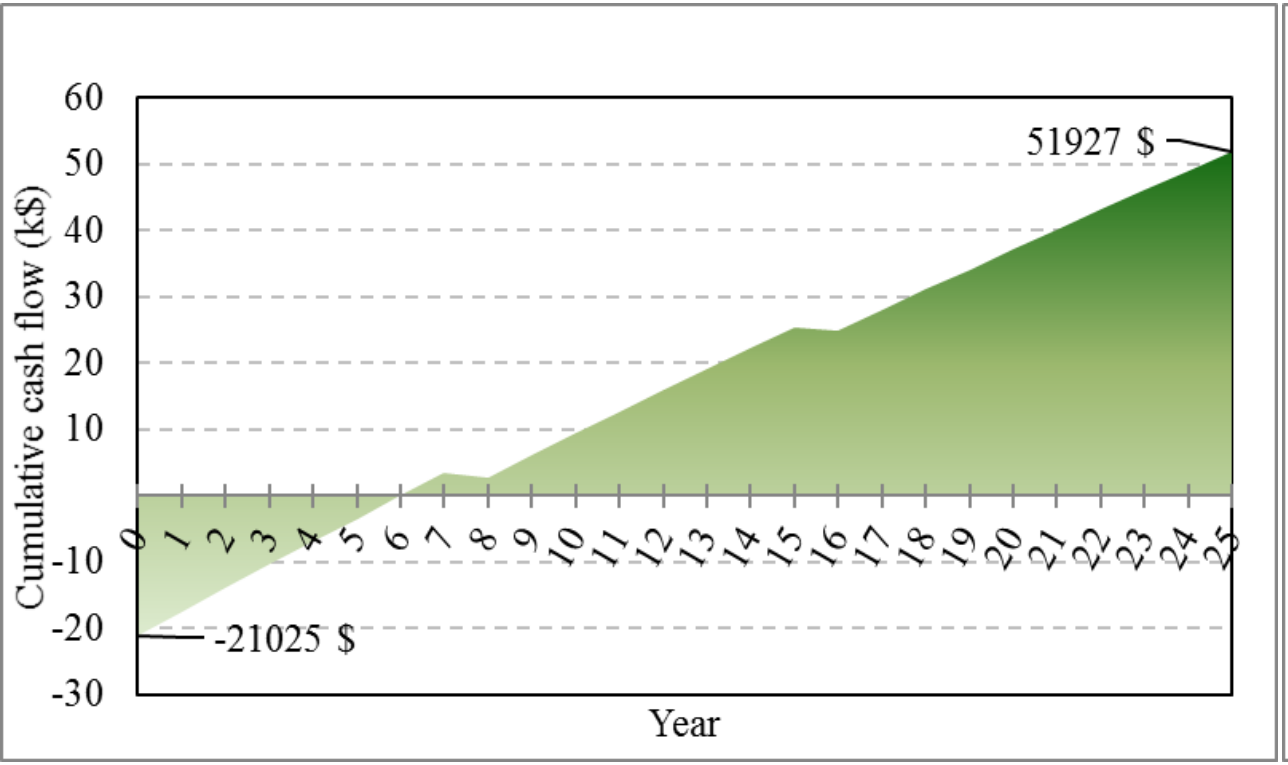
COMPARING BETWEEN SYSTEM ON ROOF AND FAÇADE : THE BEST ENERGY PERFORMANCE

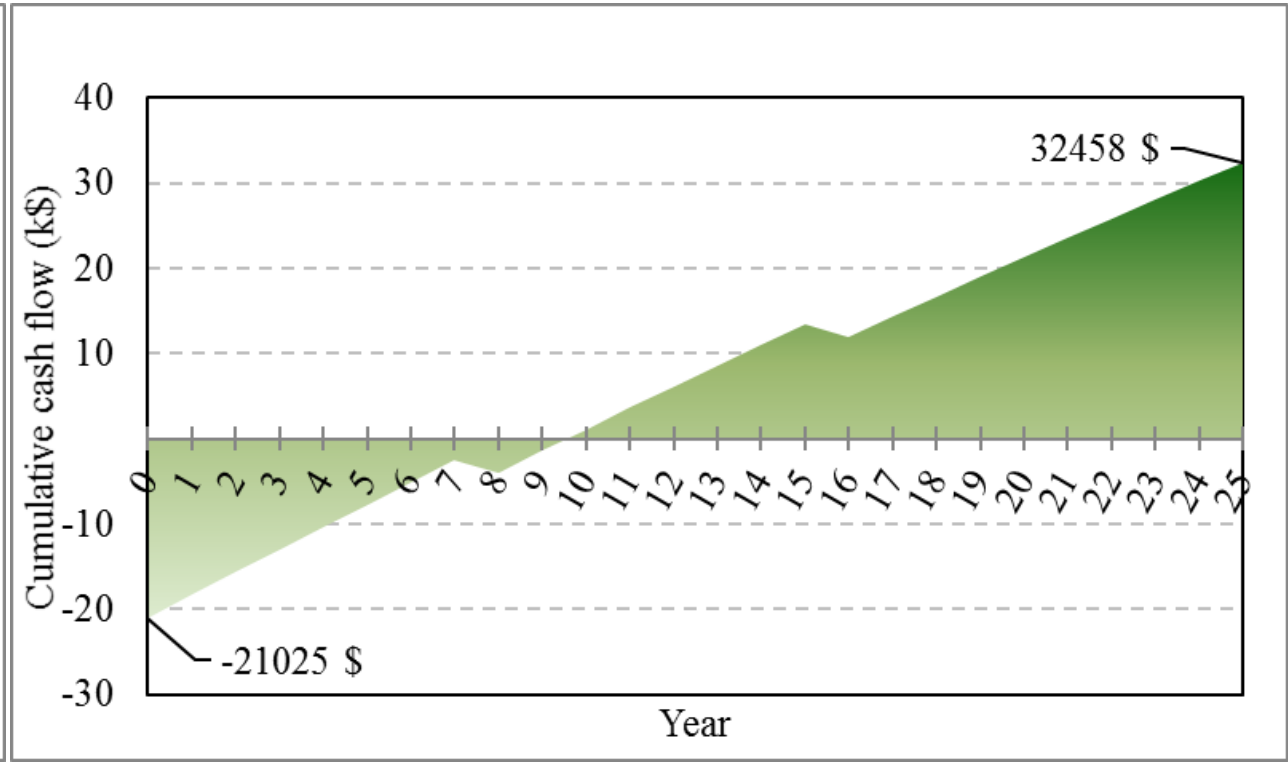




	Annual electricity (kWh/m²)		Avg. annual efficiency (%)		LCOE (¢/kWh)	
	on the roof	on facade	on the roof	on facade	on the roof	on facade
Motech XS72D3-320	226	175	17.5	17.9	9.5	12.2

COMPARING BETWEEN SYSTEM ON ROOF AND FAÇADE : THE BEST ECONOMIC PERFORMANCE





	Annual generation (kWh/m²)		Avg. annual efficiency (%)		LCOE (¢/kWh)	
	on the roof	on facade	on the roof	on facade	on the roof	on facade
Solar World SW325 XL	187	144	14.5	14.8	7.5	9.7

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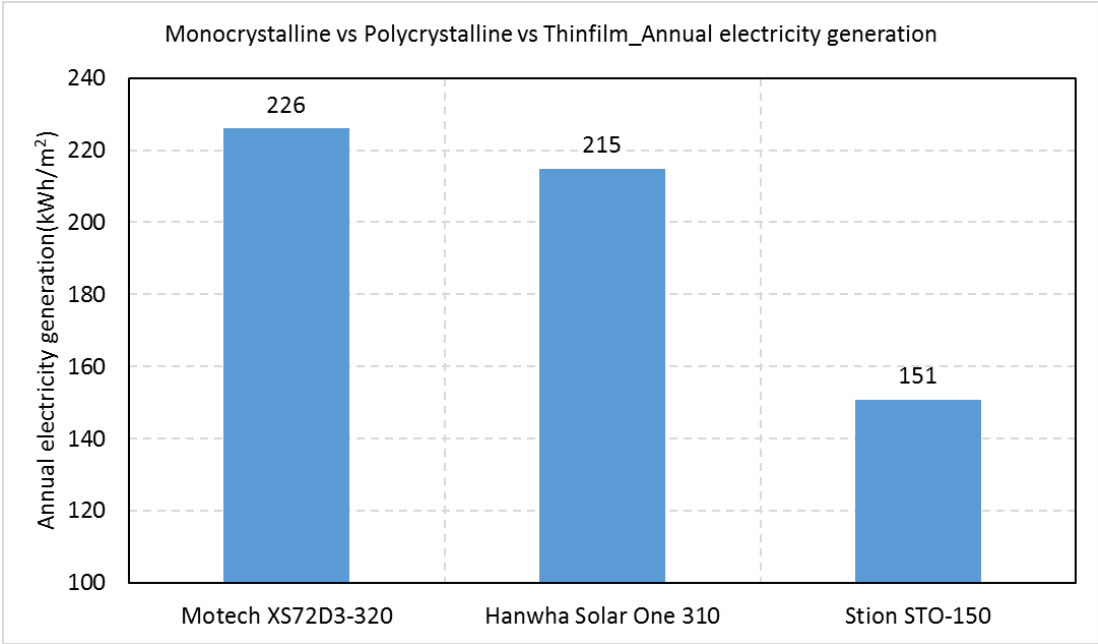
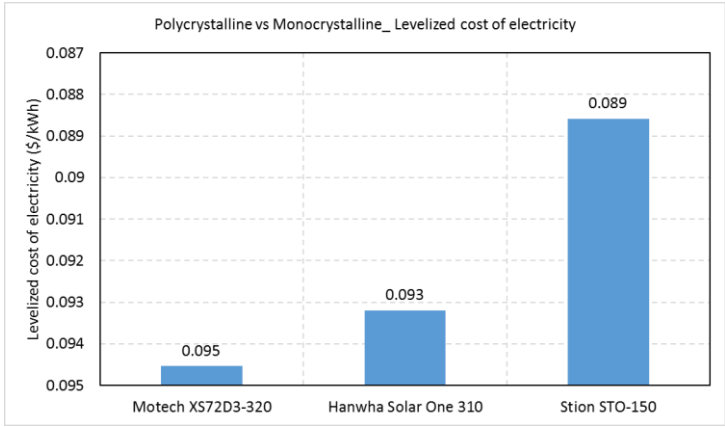
THE BEST BRAND: MONOCRYSTALLINE, POLYCRYSTALLINE, AND THIN FILM

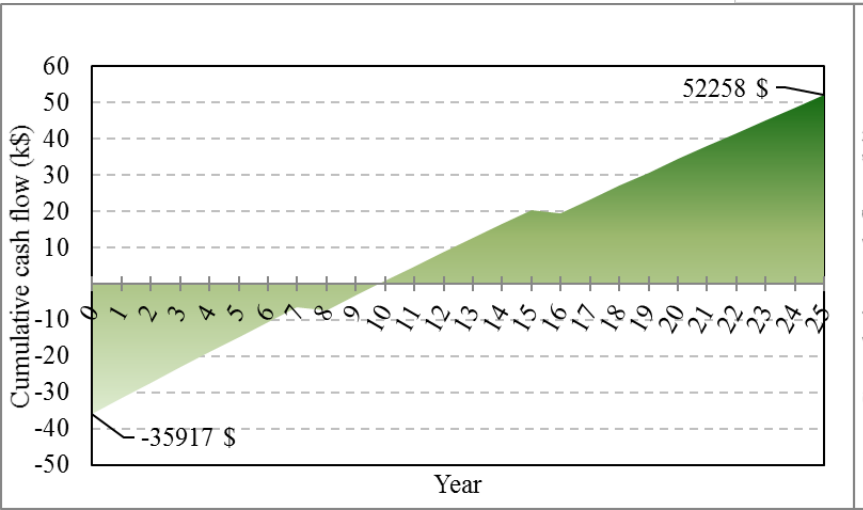
PV Type	Monocrystalline		Polycrystalline		Thin film	
Brand	Motech XS72D3-320	Solar World SW325XL	Hanwha Solar One 310	Canadian Solar CS6X-320P	Stion STO-150	Stion STN-125
Energy performance						
Economic performance						

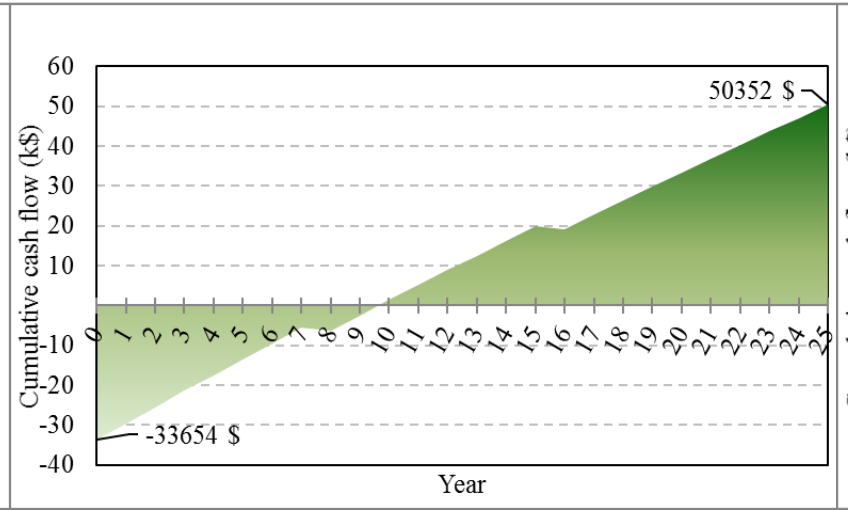
COMPARING MODULES OF THE BEST ENERGY OUTPUT

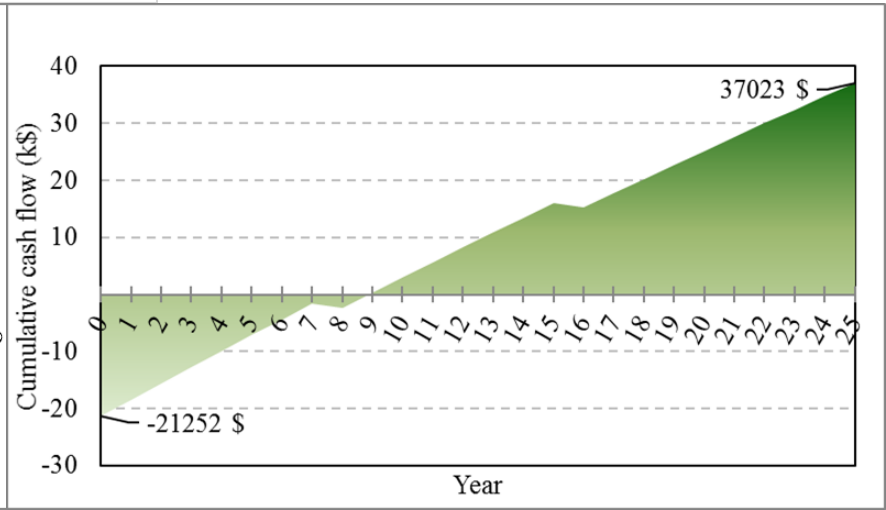
PV Type	Monocrystalline		Polycrystalline		Thin film	
Brand	Motech XS72D3-320		Hanwha Solar One 310		Stion STO-150	
Energy performance						





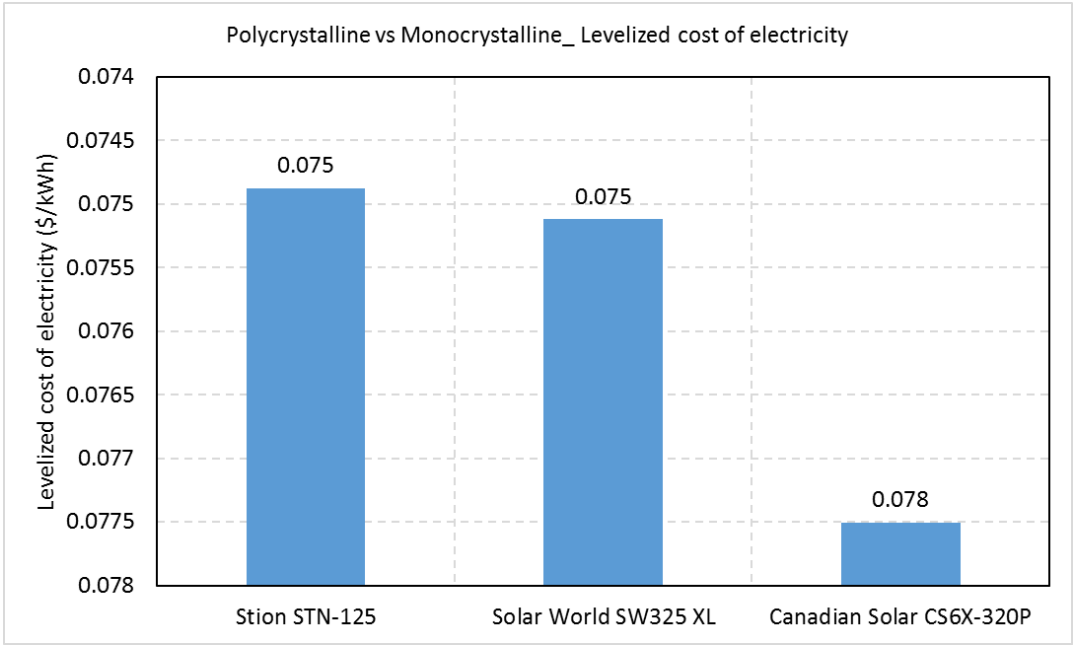


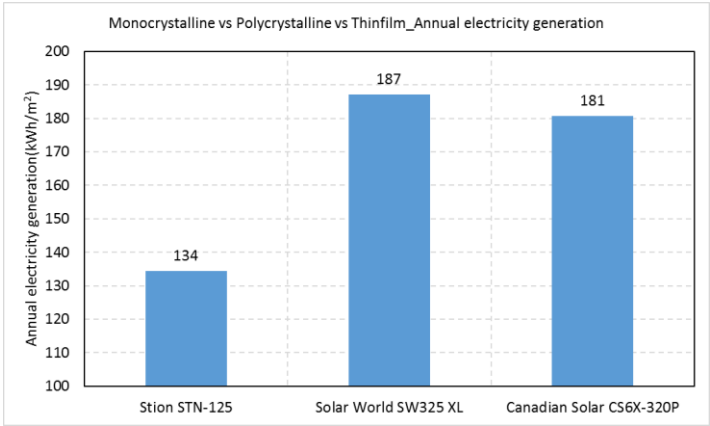


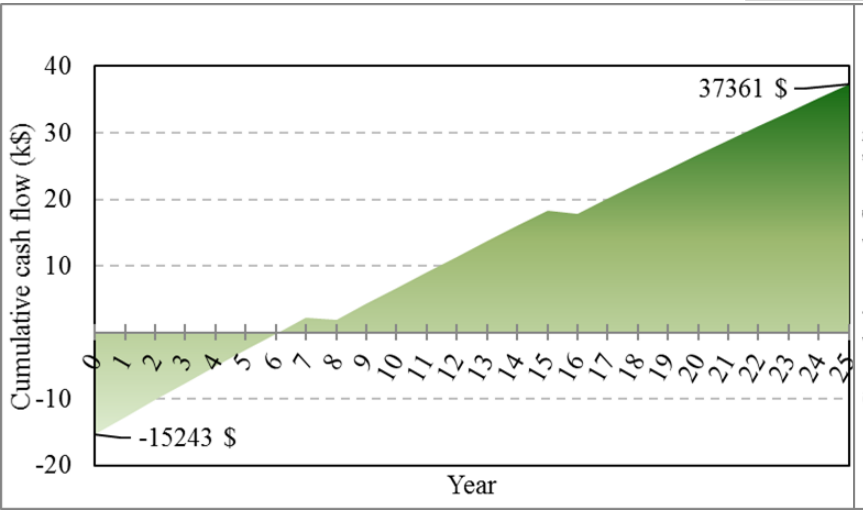


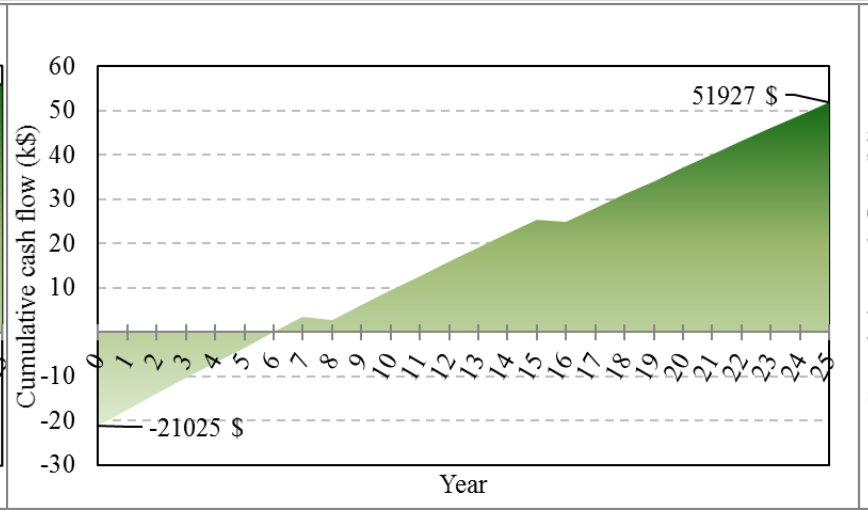
COMPARING MODULES OF THE BEST ECONOMIC PERFORMANCE

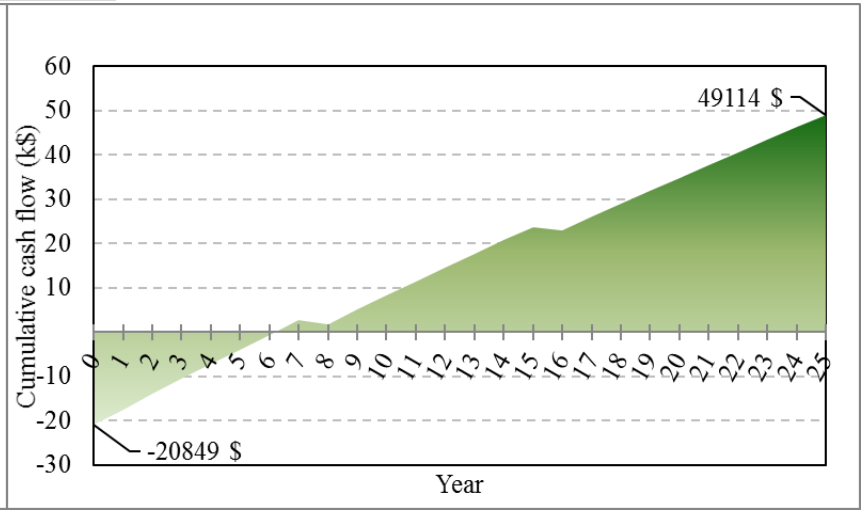
PV Type	Monocrystalline		Polycrystalline		Thin film	
Brand		Solar World SW325XL		Canadian Solar CS6X-320P		Stion STN-125
Economic performance						











CONCLUSION

General Conclusion

- ✓ There is a big potential to use grid-connected PV system in Preston.
- ✓ Up to 226 kWh/y can be generated per square meter.
- ✓ The initial cost of 11.4 kW (thin film) is tentatively $15000.
- ✓ The initial cost of 19.5 kW (monocrystalline) is tentatively $36000.
- ✓ Initial cost per installed capacity is:
  - 1.54 $/W thin film based system, or,
  - 1.84 $/W monocrystalline based system
- ✓ The payback time of the systems varies between 6 and 10 years.

POTENTIAL OF GRID-CONNECTED PV SYSTEM AT THE WORKING CONDITIONS OF LANDSKRONA, SWEDEN: COMPARING DIFFERENT PV MODULE TYPES AND BRANDS

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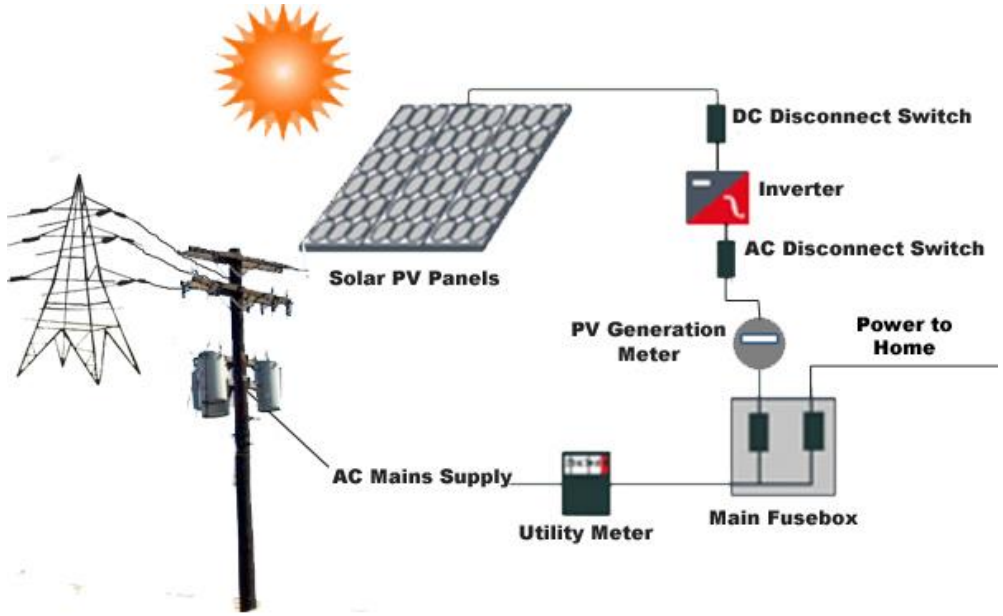
OBJECTIVE

- Current work studies the potential of utilizing PV system for electricity generation at current ***conditions*** of Landskrona, Sweden.
- In addition, the energy and economic performance of different PV module brands and technologies were compared.



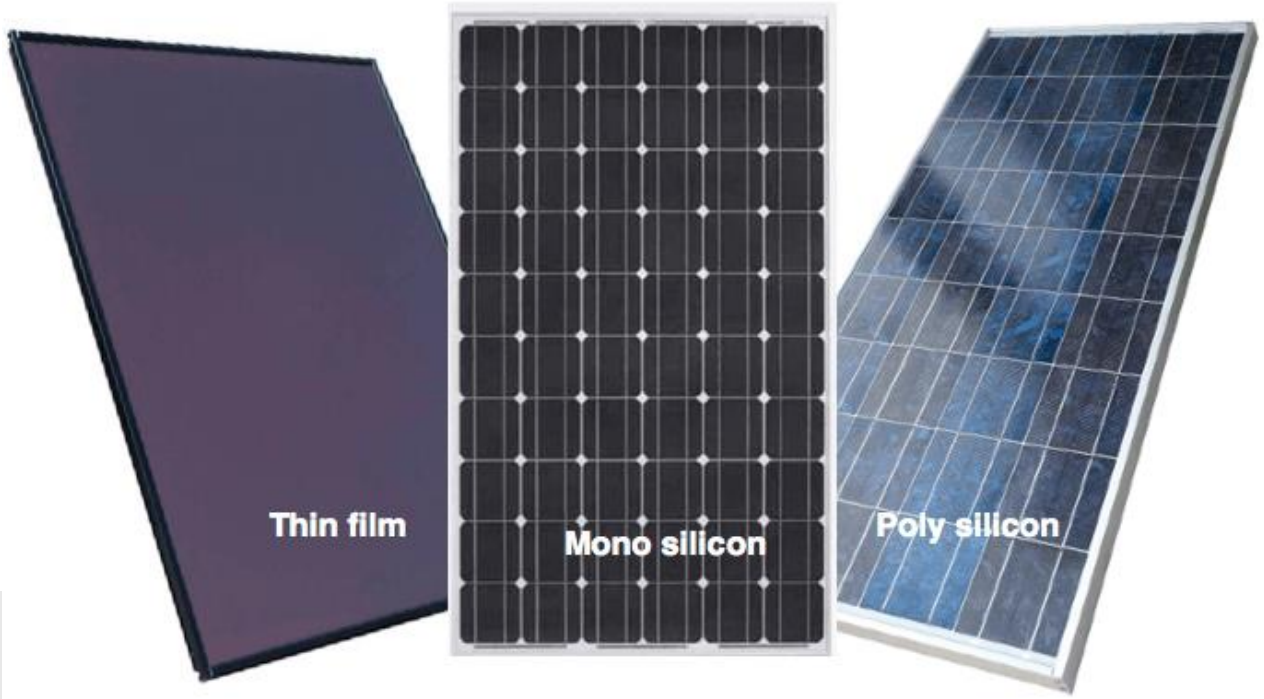
METHODOLOGY

- Module technology types, brands, models
- System design
- Simulation model:
  - Factors considered
  - Data used
  - Assumptions
- Comparing the results of:
  - technology types
  - brands
  - different system designs

CONSIDERED MODULE TECHNOLOGIES

Three different PV module technologies are considered in the work including:

1. Monocrystalline module:
   Lasts long, uniform look, good efficiency, expensive
2. Polycrystalline module:
   Speckled blue color, lower efficiency than monocrystalline
3. Thin film module:
   Homogenous appearance, low efficiency, cheap



CONSIDERED PV MODULE BRANDS & MODELS

- Current work considers the brands mentioned in the report by Fraunhofer Institute for Solar Energy Systems, ISE.

- **Fraunhofer ISE:**
  - ✓ The largest solar energy research institute in Europe.
  - ✓ Focus:
    - Investigation of scientific and technological aspects of sol
    - Solar energy application;
    - Development of production technology;
    - Construction of demonstration systems.

Considered PV module types

	TYPE		
BRANDS & MODELS	**Monocrystalline**	**Polycrystalline**	**Thin film**
	Motech XS72D3-320	Hanwha Solar One 310	Stion STO-150
	Panasonic N330	JaSolar 48-225/4BB	Solar Frontier SF170-S
	Silevo 310	Trina 315	Stion STN-125
	Sunpreme 360	SunTech 320	SolTech Energy 80
	Solar World SW350 XL	Jinko Solar JKM270	
	Silevo 220	Motech IM72C3-310	
	Optimus 60 OPT280	Canadian Solar CS6X-320P	
	LG Solar 320	Solar World SW260	
	Jinko Solar JKM275M	Yingli Solar YL305P	
	Solar World SW325 XL	PEAK BLK 255	
	JaSolar 72-315/SI	Gintech 240	
	Hyundai HiS-S265MG	Hyundai HiS-S250MG	
	Mitsubishi PV-MLE265HD2	Kyocera KD220GH-4FB2	

PHYSICAL SPECIFICATIONS AND PRICE OF CONSIDERED PV MODULES

In order to carry out the energy and economic analysis, physical specifications and price of each brands are required:

- Physical specifications were obtained through internet research.

- Finding the price of the module is a big challenge.
  In order to obtain tentative prices, manufacturers of the different brands were contacted. Not all prices were provided.

SYSTEM DESIGN: CONSIDERED PLACES OF MOUNTING PV SYSTEM

- Two different system designs were considered:
  1. PV system installed on the roof.
  2. PV system installed on south facing façade.

DATA AND ASSUMPTIONS IN THE CURRENT WORKS

In order to evaluate the economic performance of the PV system, data types presented below are needed. Some of the data could be collected via internet research, some was assumed.

Term	Inflation rate	Real interest rate	Electricity price	Electrical price escalation rate	Module degradation rate
Value	0.7%	3.4%	0.207 $/kWh	1%	1%

Collceted data

Assumed data

SYSTEM DESIGN: CONSIDERED PLACES OF MOUNTING PV SYSTEM

- Two different system designs were considered:
  1. PV system installed on the roof
  2. PV system installed on south facing facade

SIMULATION MODEL

A Computer model was built to simulate PV system.
In detail , the model has been built to:

- determine hour-by-hour available solar energy per square meter of the surface
- determine the optimal inclination angel
- demonstrate the effect inclination angle and azimuth angle of the surface on the available solar energy
- simulate hour-by-hour energy and economic performance of grid connected PV system

Input Data

Latitude	55.871254	N	degree	**Month**	Clearness KT	**PV Specification**		
Longitude	12.826451	e	degree	**Jan**	0.33	fill factor	0.77	-
Standard Longitude	15	degrees		**Feb**	0.39	derating factor	0.90	
Slop angle β	50.0	degrees		**Mar**	0.44	short circuit current	9.09	A
Surface azimuth	180.0	degrees		**Apr**	0.48	open circuit voltage	45.73	V
Avilable area	100	m^2		**May**	0.5	voltage temp. coefficient	340.00	%/C
Inflation rate	0.7%	%		**Jun**	0.48	NOCT (nominal operating cell temperature)	45.00	C
Real interest rate	3.4%			**Jul**	0.49			
Electrical price escalation rate	1.0%			**Aug**	0.49	nomional capacity	320.00	W
				Sep	0.45	module price	480.00	$
Electricity price	0.207	$/kWh		**Oct**	0.38	Area	1.64	m^2
				Nov	0.39	module degradation rate	1.0%	%
				Dec	0.35			

TERMS USED TO DEMONSTRATE THE RESULTS

- **PV efficiency**: the ratio between the available solar energy and the electrical output of the module.
- **Installation costs**: the total cost required to build 100m^2 of PV system including the equipment costs, wiring costs, and labor costs.
- **Levelized cost of electricity**: the ratio of the total costs of the system (including the operation and maintenance costs) to the electrical energy produced over the lifetime of the system.
- **Payback time**: the time required for the system to recover its initial costs in terms of energy savings.

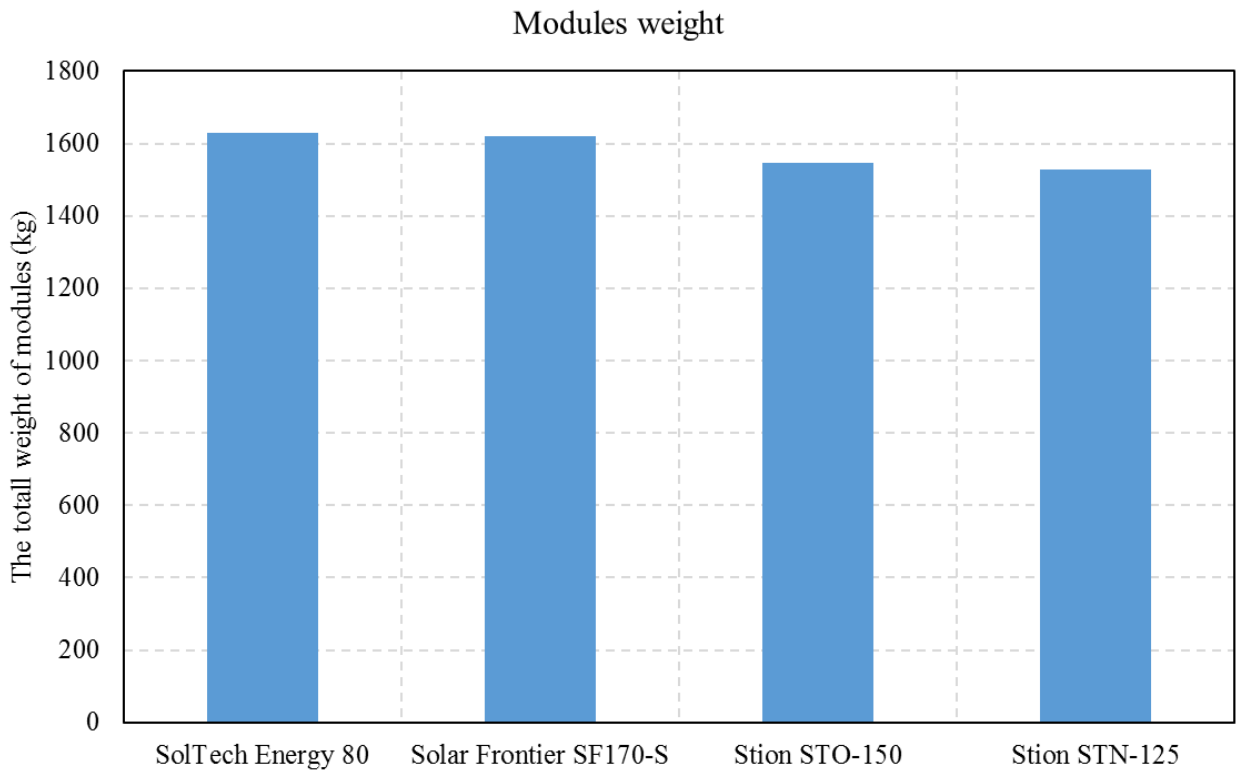
RESULTS 1: THIN-FILM

- 4 models were analyzed
- 2 systems were considered (i.e. on the roof and on the façade)
- Best-performing model from energy point of view was identified.
- Best-performing model from economic point of view was identified.

WEIGHT OF PROPOSED SYSTEM

The weight of 100 m^2 of the selected modules was calculated

As shown, there is no big difference in the weight of selected brands

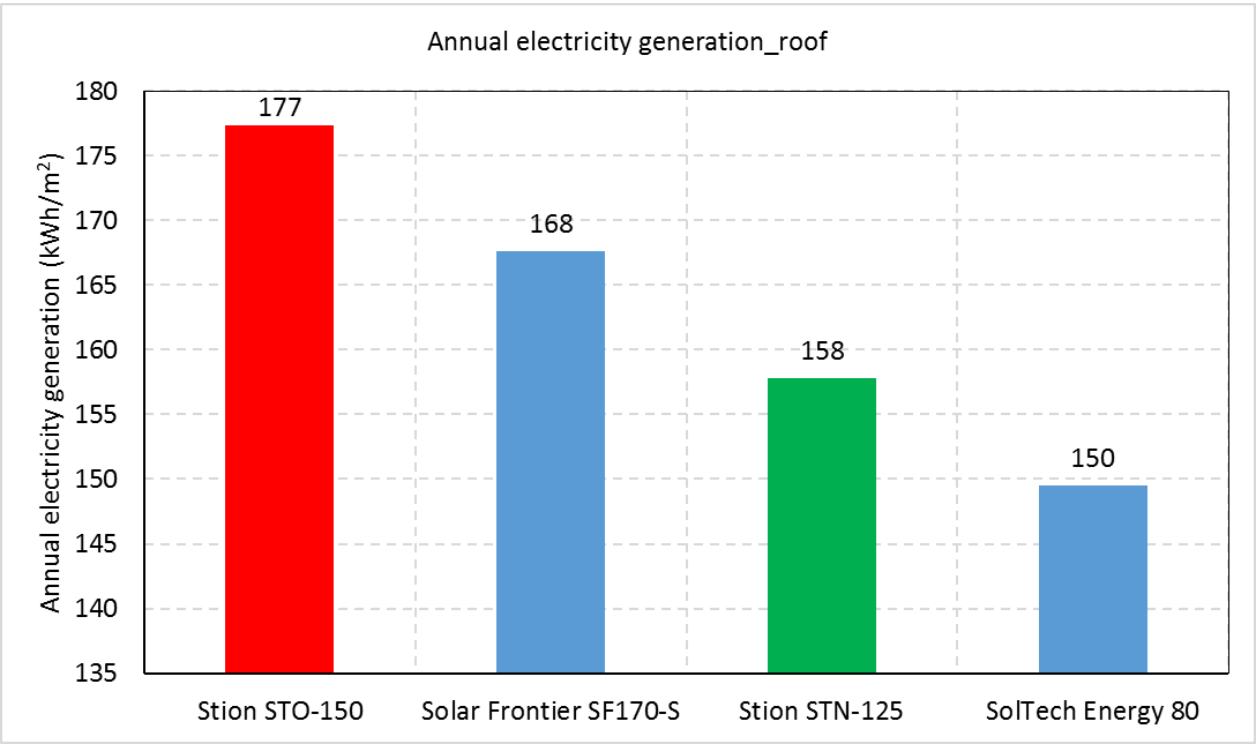


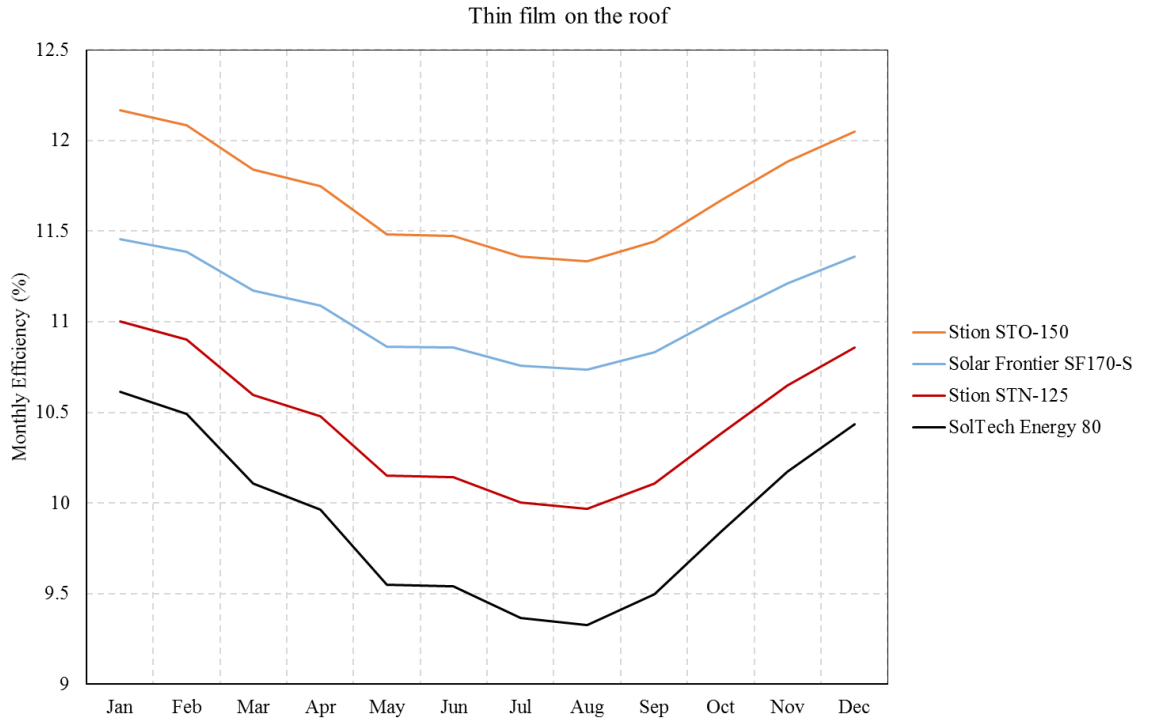
ELECTRICAL OUTPUT AND EFFICIENCY OF THIN FILM PV SYSTEM ON ROOF

From energy viewpoint, Stion STO-150 thin film is the best among the considered brands

The simulations show that the electricity output of the system varies from 177 to 150 kWh/m^2.a

The efficinecy of modules ranged from 9 to 12%

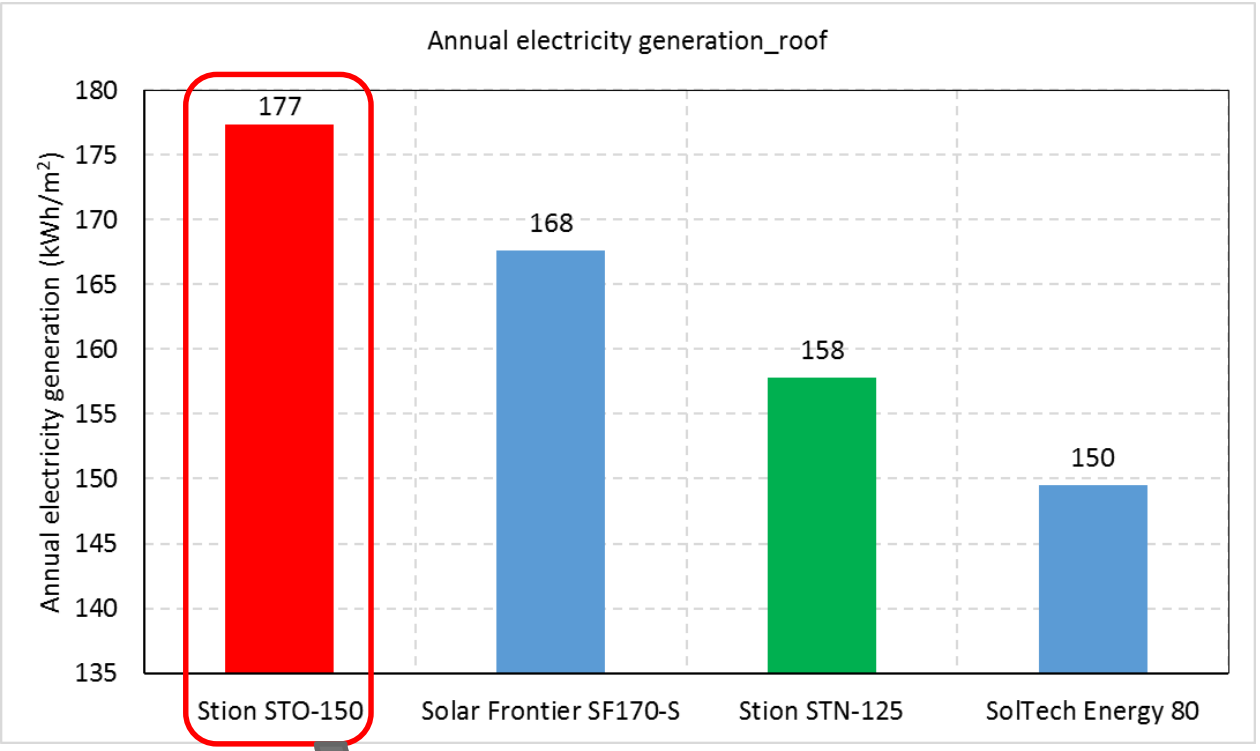


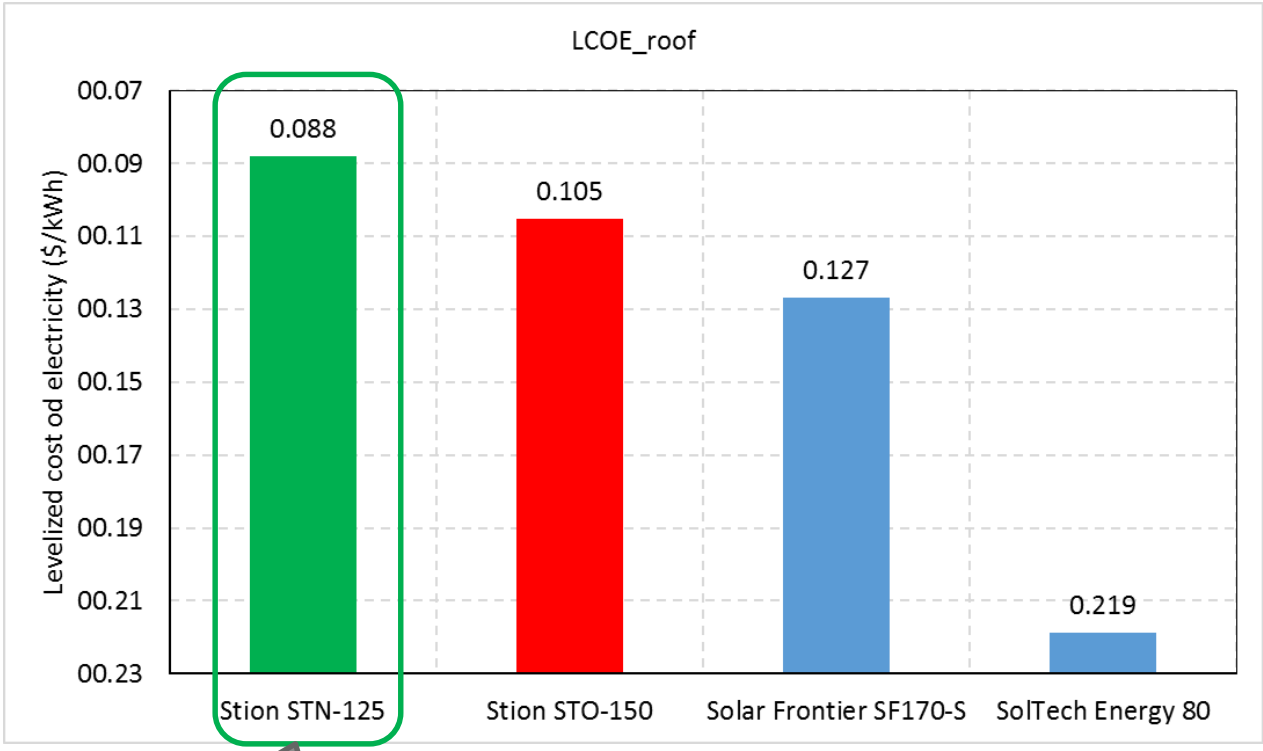


LEVELIZED COST OF ELECTRICITY

Levelized cost of electricity generated by the proposed system was calculated

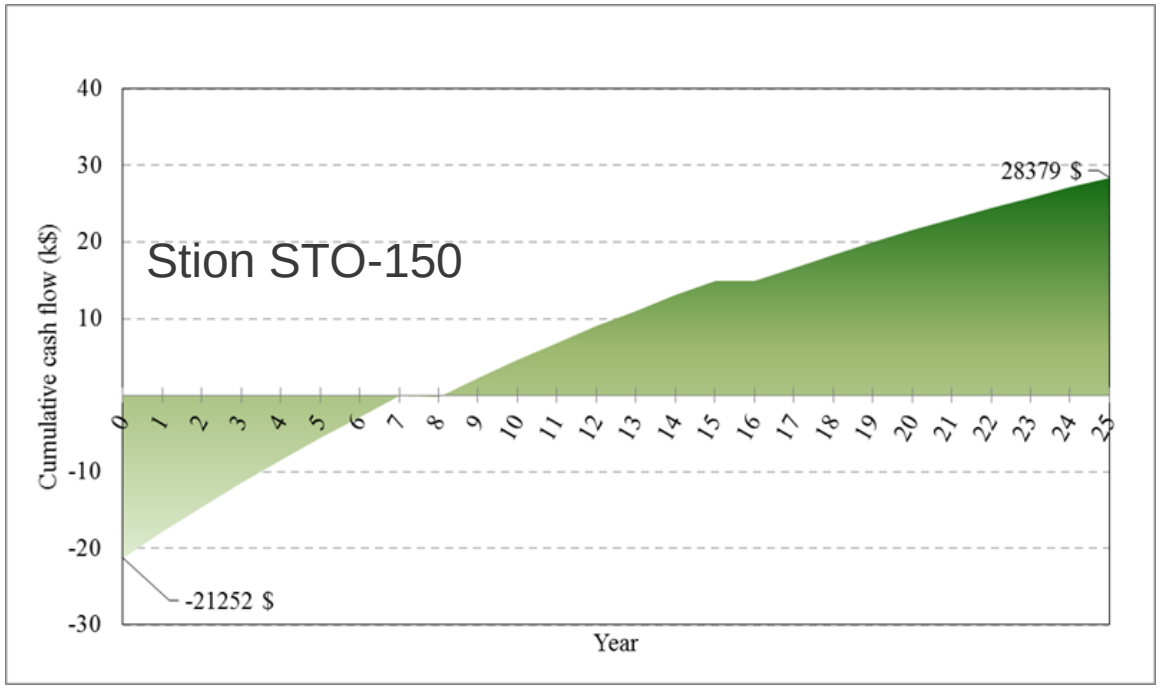
- From levelized cost of electricity viewpoint, Stion STN-125 is the best among the considered brands

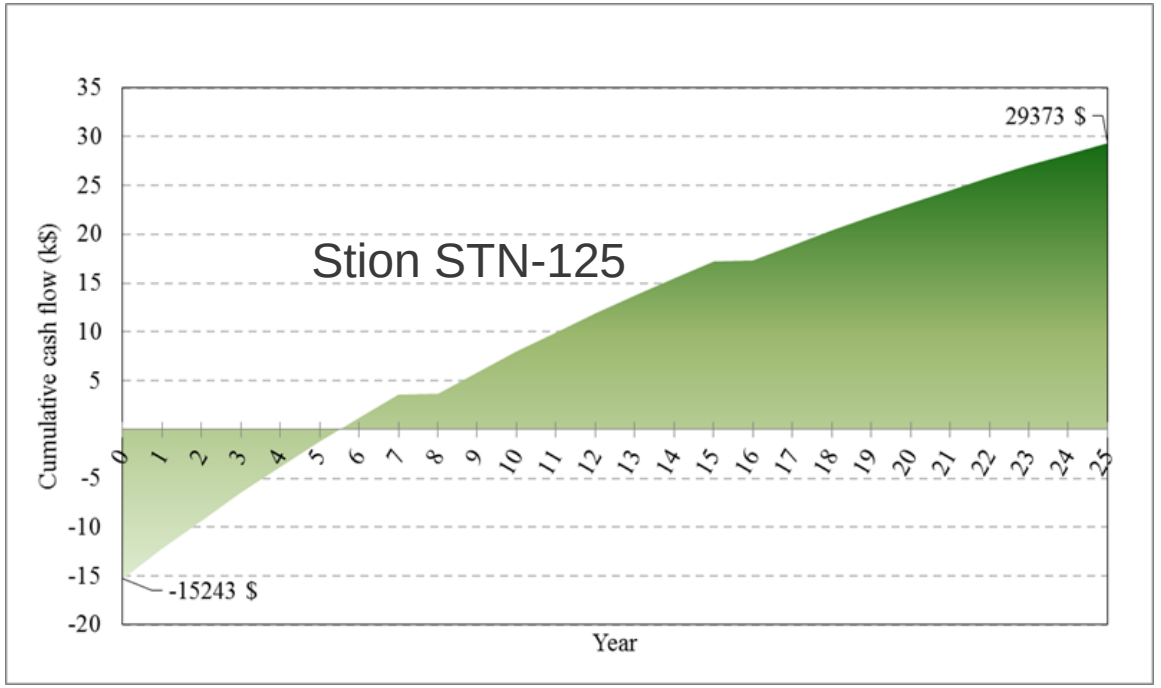




COMPARING BETWEEN THE BRANDS OF THE BEST PERFORMANCE

Accumulative cash flow of Stion STO-150 (of the best energy performance) and Stion STN-125 (of the best economic performance) was calculated.





Brand	Annual elect. (kWh/m^2)	Annual efficiency (%)	LCOE (¢/kWh)	Initial cost ($/100m^2)	Payback time (year)
Stion STO-150	177	11.7	10.5	21252	7
Stion STN-125	158	10.4	8.8	15243	5.5
Difference	**12%**	**13%**	**19%**	**39%**	**27%**

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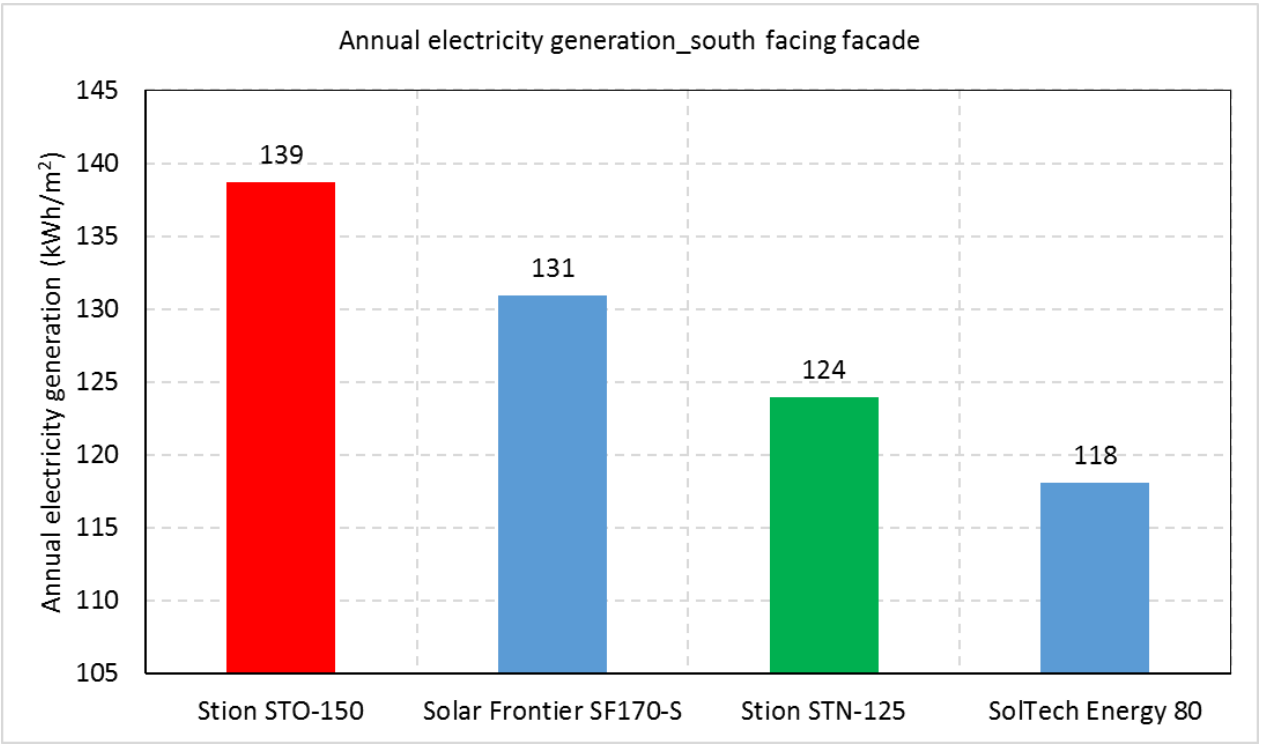
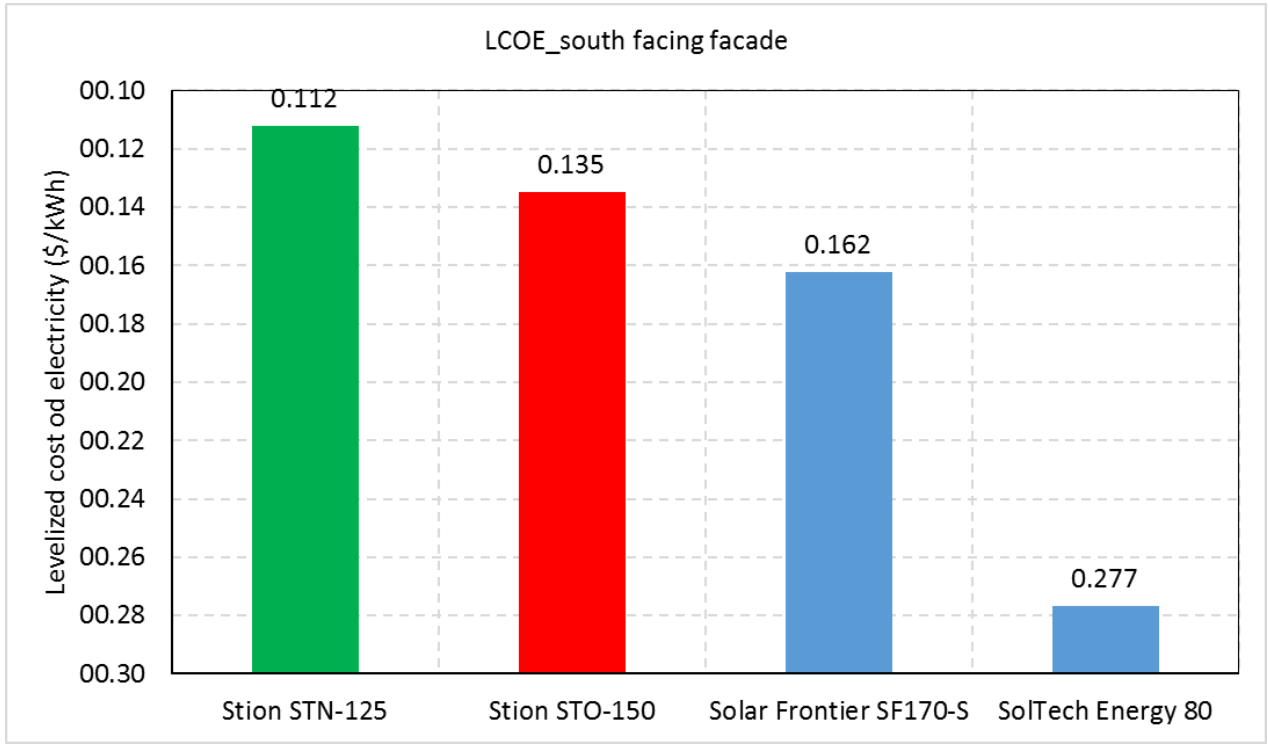
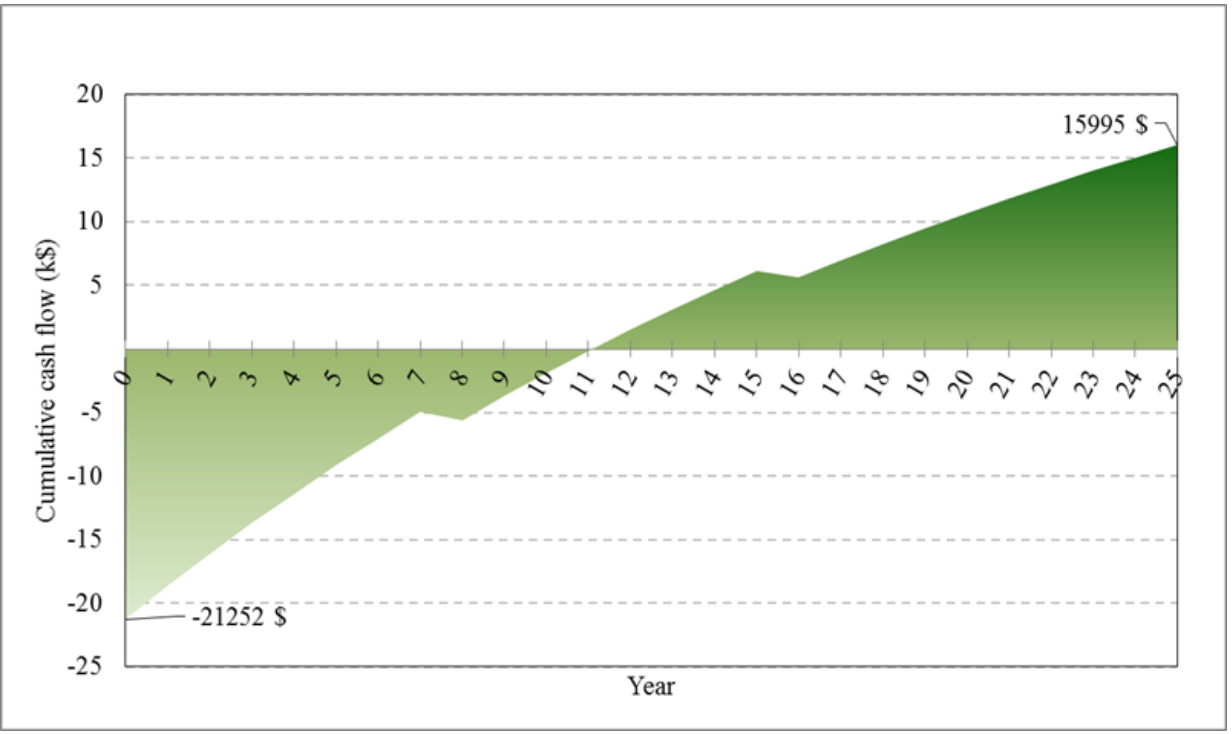
ENERGY OUTPUT AND LEVELIZED COST OF ELECTRICITY OF PV SYSTEM ON FAÇADE

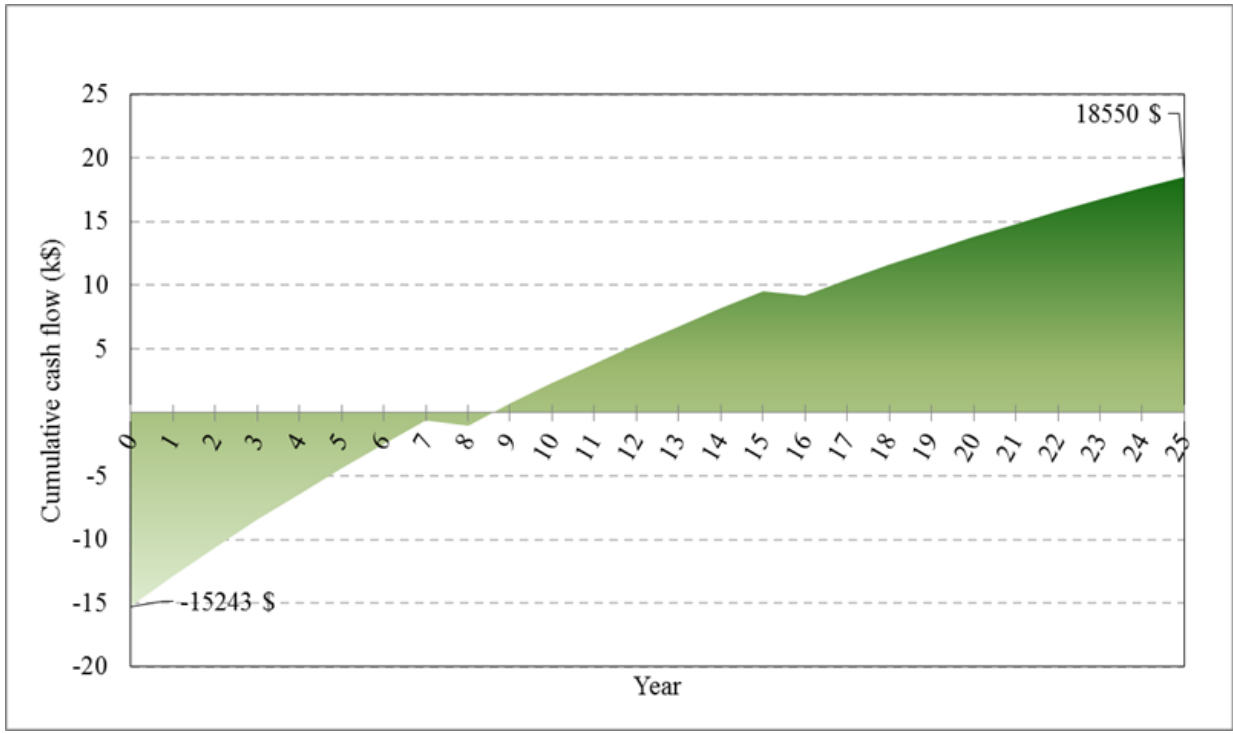




COMPARING BETWEEN THE BRANDS OF THE BEST PERFORMANCE



Stion STO-150



Stion STN-125

	Annual electricity generation (kWh/m^2)	Avg. annual efficiency (%)	LCOE (¢/kWh)
Stion STO-150	139	11.8	13.5
Stion STN-125	124	10.6	11.2

COMPARING BETWEEN SYSTEM ON ROOF AND SYSTEM ON FAÇADE

Best energy performance

	Annual elect. (kWh/m²)			Avg. annual efficiency (%)			LCOE (¢/kWh)		
	roof	facade	difference	roof	facade	difference	roof	facade	difference
Stion STO-150	177	139	27%	11.7	11.8	-1%	10.5	13.5	22%
Stion STN-125	158	124	27%	10.4	10.6	-2%	8.8	11.2	21%

Best economic performance

Conclusion:

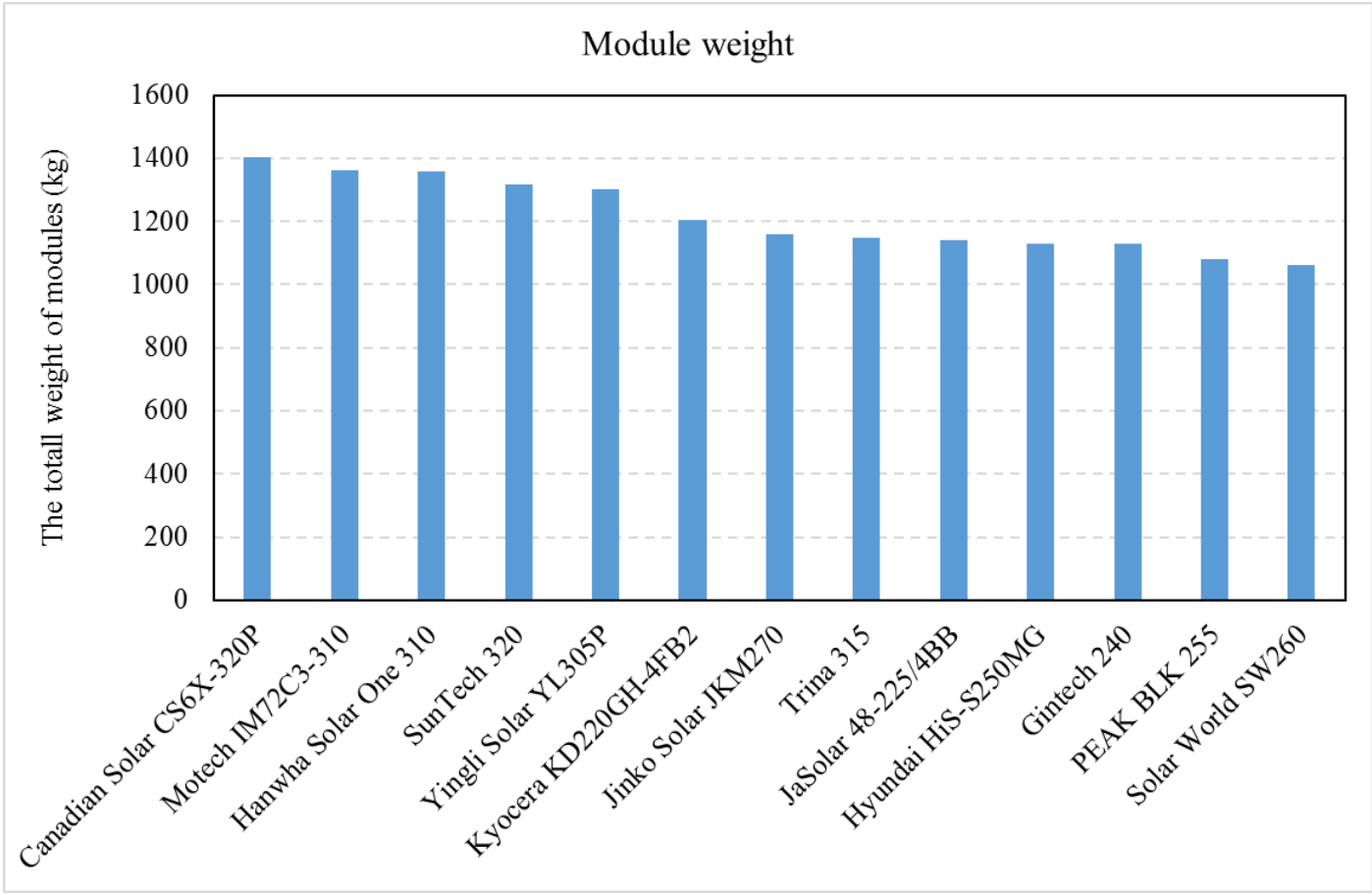
- ✓ From energy viewpoint, Stion STO-150 thin film is the best among the considered brands
- ✓ From economic viewpoint, Stion STN-125 thin film is the best among the considered brands

RESULTS: 2. POLYCRYSTALLINE

- 13 brands
- Two different systems:
  - On the roof
  - On the facade
- Best brand from energy point of view is defined
- Best brand from economic point of view is defined

WEIGHT OF 100 M² POLYCRYSTALLINE-BASE PV SYSTEM

As shown, there is no big difference in the weight of selected brands(about 250 kg over an area of 100 m$^{2)}$

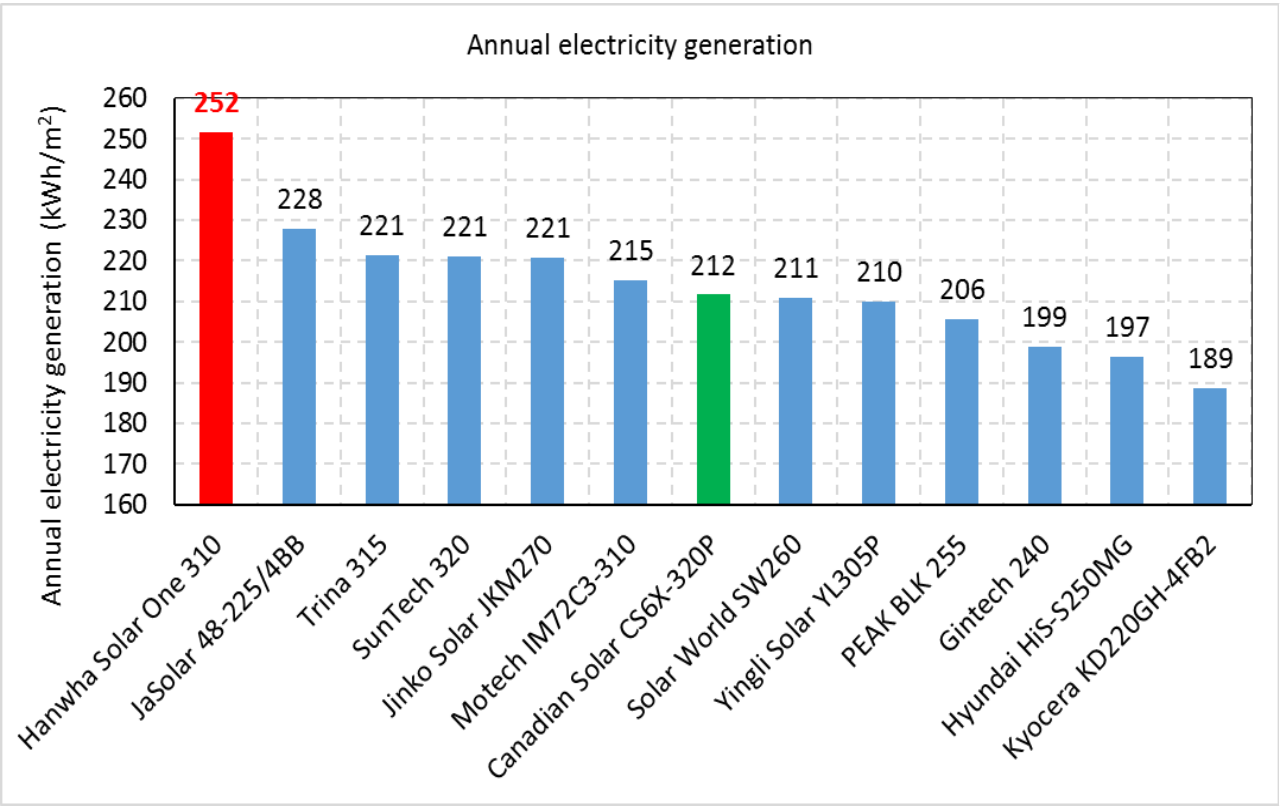


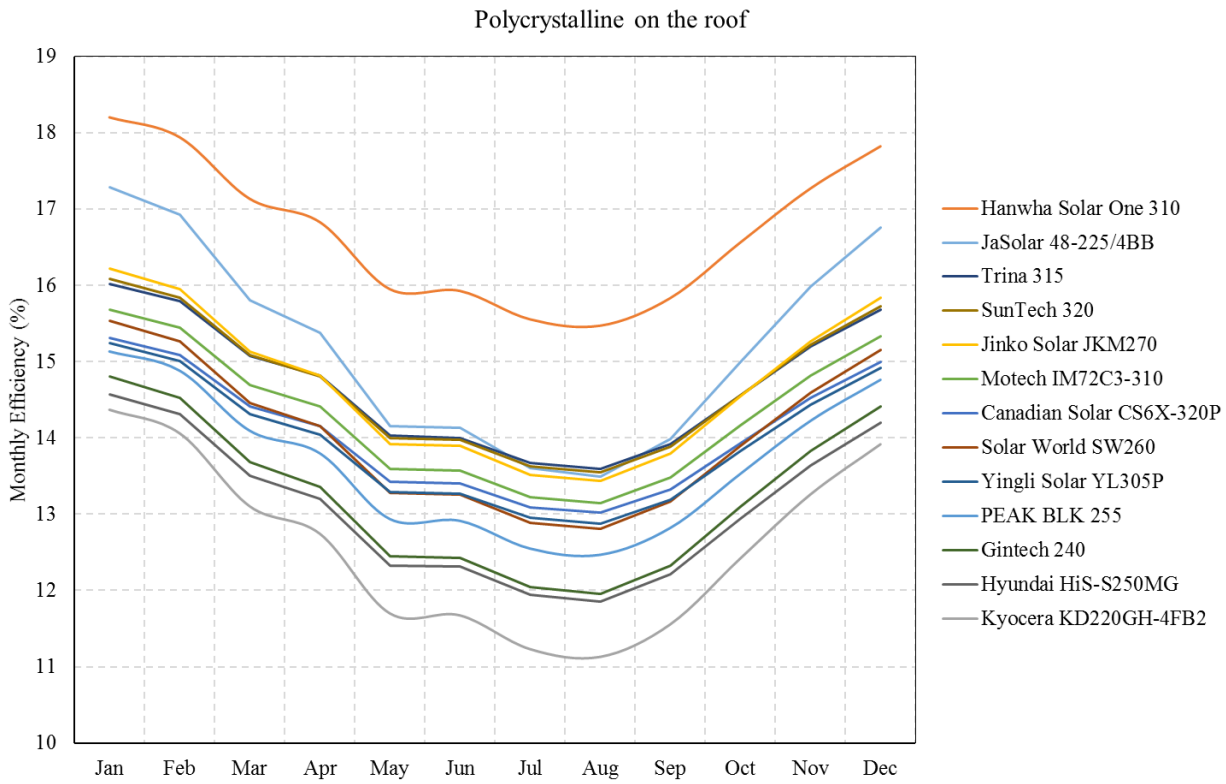
ELECTRICAL OUTPUT AND EFFICIENCY OF POLYCRYSTALLINE PV SYSTEM ON ROOF

The simulations show that the electricity output of the system varies from 189 to 252 kWh/m^2.a

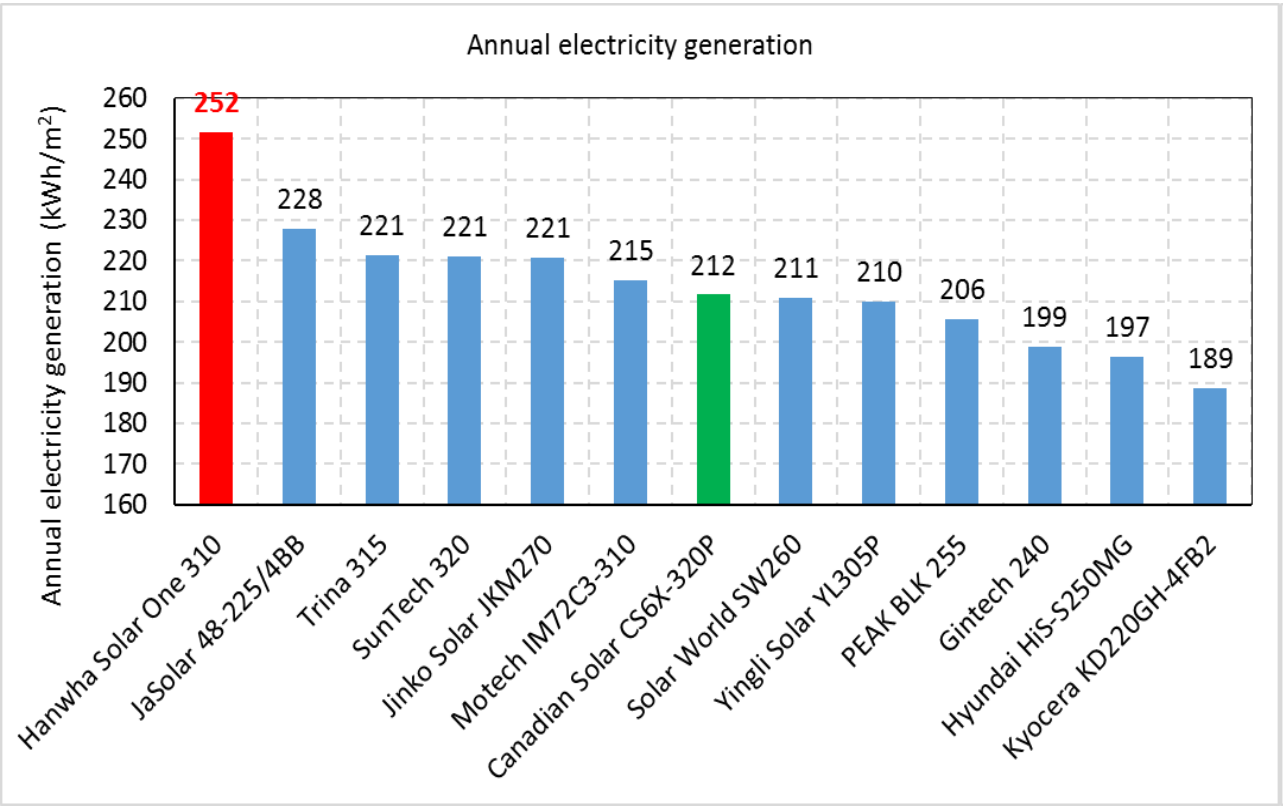
The efficinecy of modules ranged from 11 to 18%

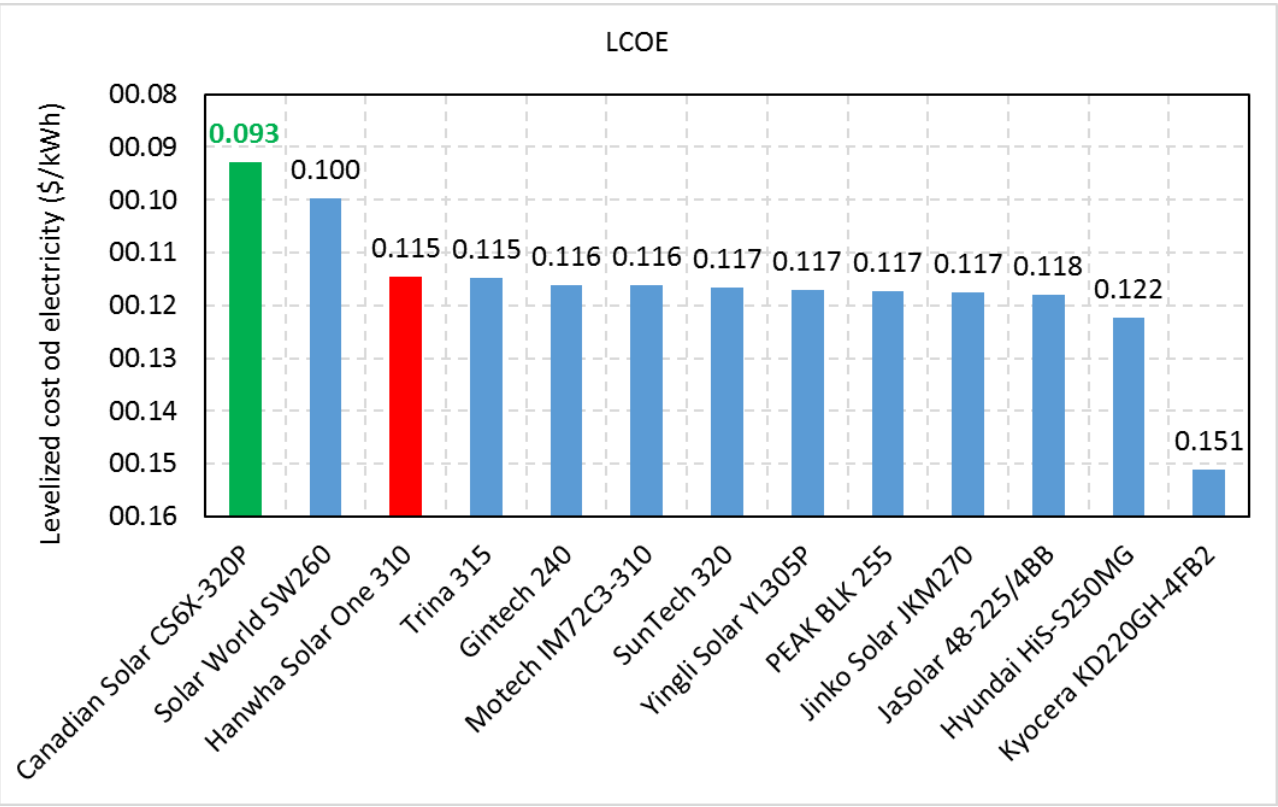
From energy viewpoint, Hanwha solar One 310 is the best among the considered brands





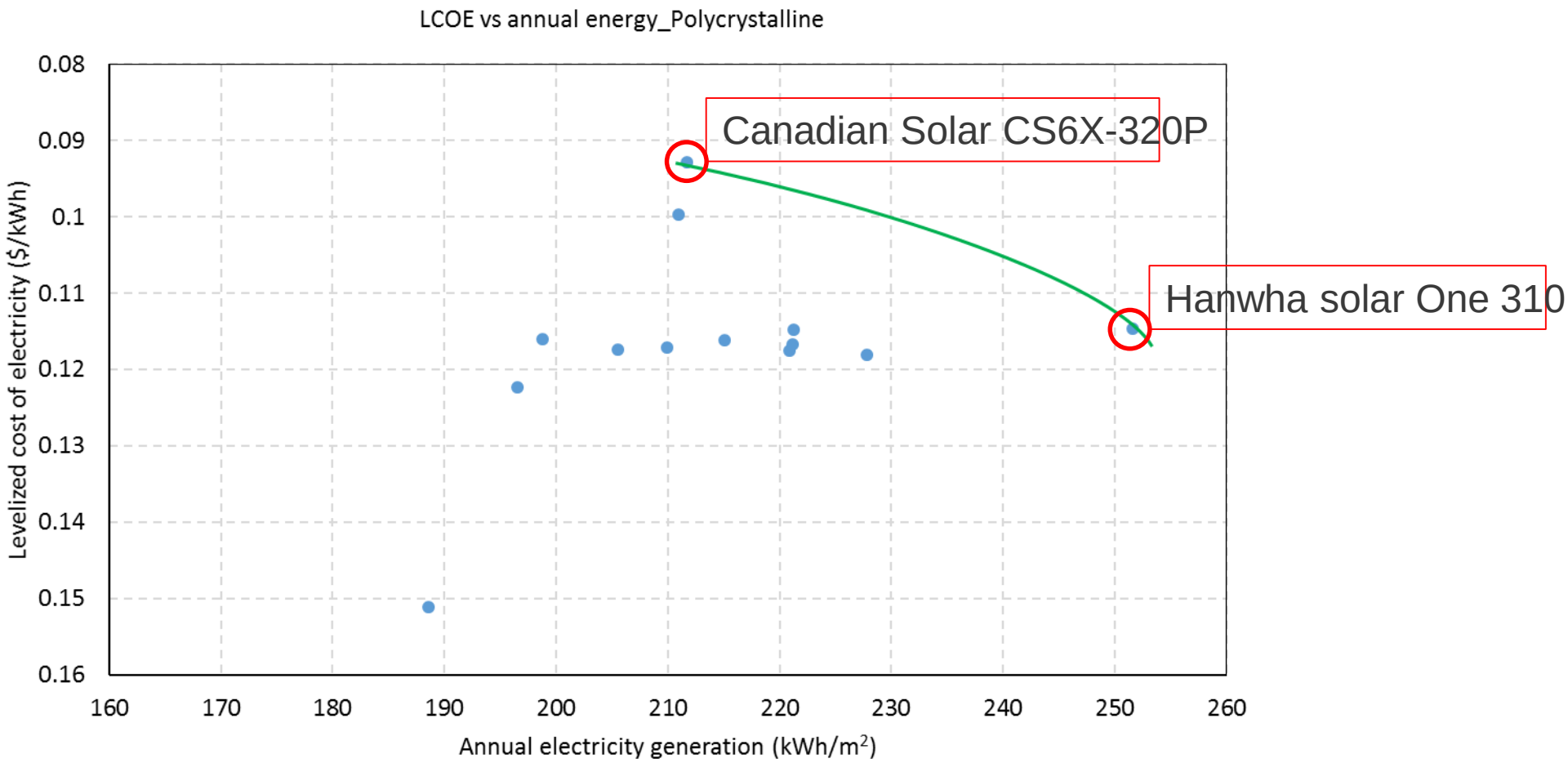
LEVELIZED COST OF ELECTRICITY





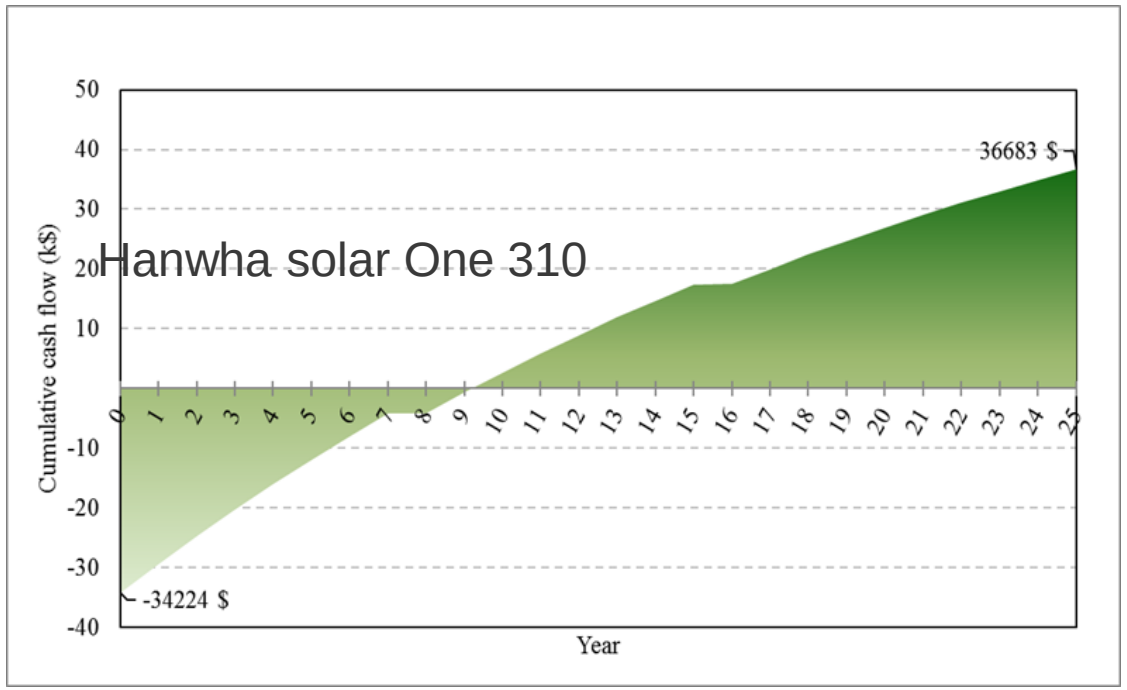
Brand of the best energy performance is not the same one of the best economic performance

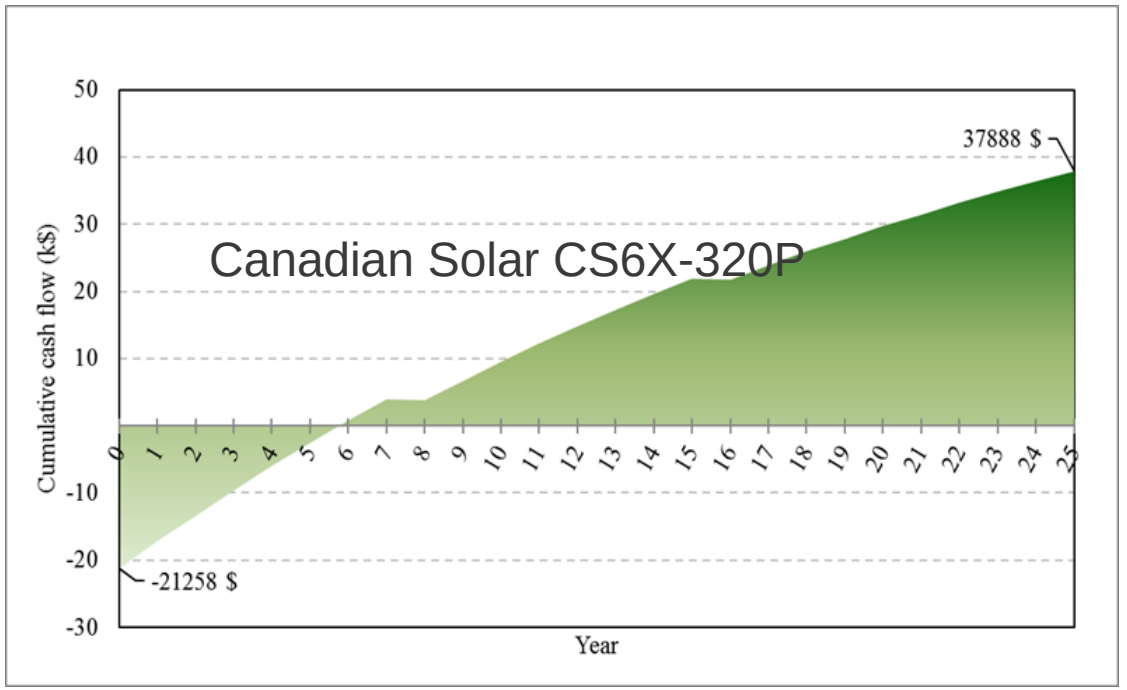
ECONOMIC PERFORMANCE VERSUS ENERGY PERFORMANCE OF PV SYSTEM



COMPARING BETWEEN THE BRANDS OF THE BEST PERFORMANCE

Accumulative cash flow of Hanwha solar One 310 (of the best energy performance) and Canadian Solar CS6X-320P (of the best economic performance) were calculated.



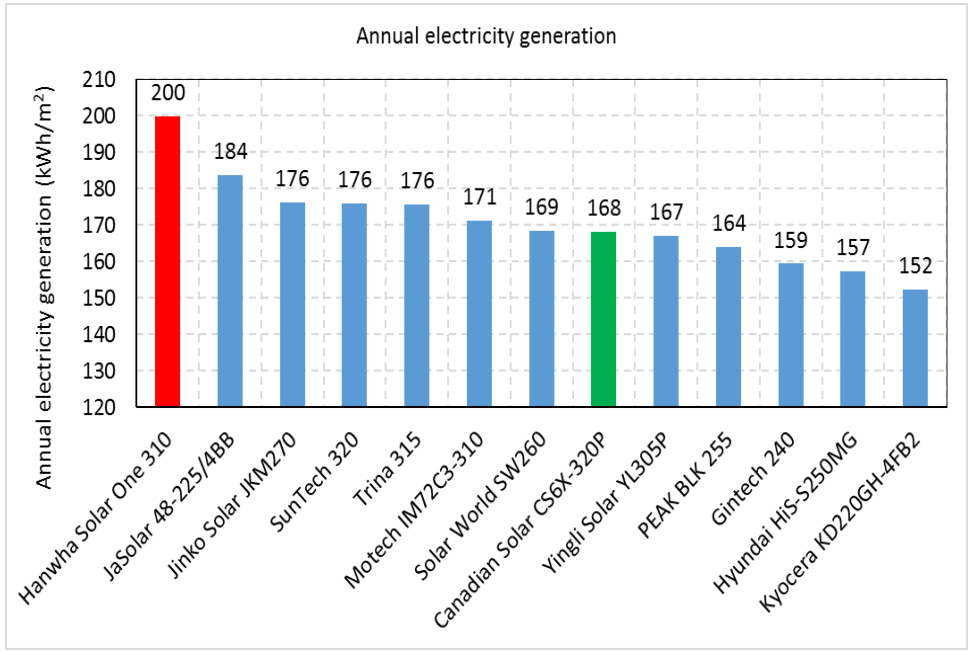


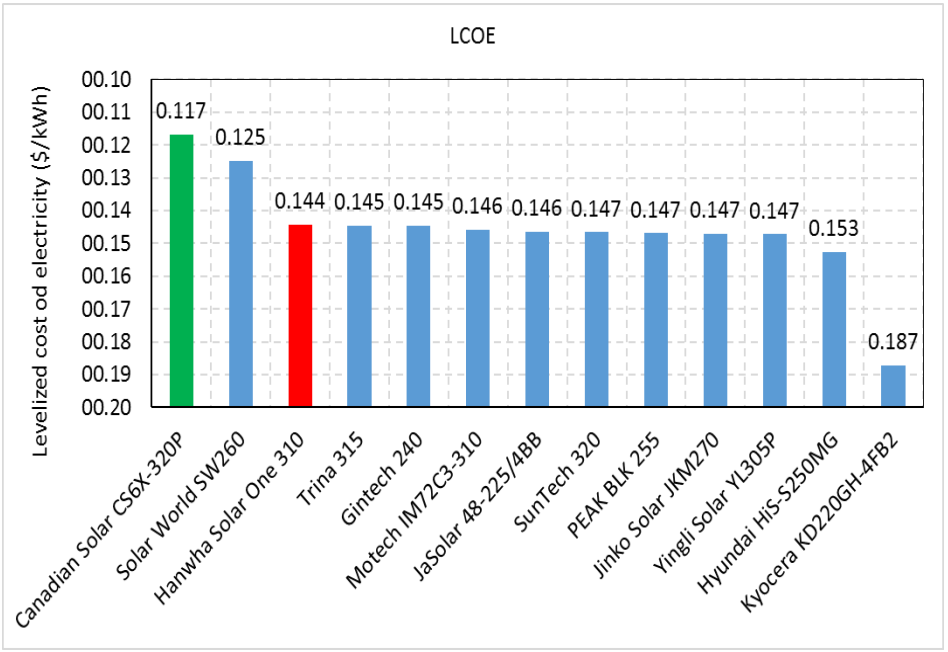
	Annual electricity (kWh/m^2)	Avg. annual efficiency (%)	LCOE (¢/kWh)	Initial cost ($/100m^2)	Payback time (year)
Hanwha Solar One 310	252	16.5	11.5	34224	9.1
Canadian Solar CS6X-320P	212	13.9	9.3	21258	5.9
difference	19%	19%	24%	61%	54%

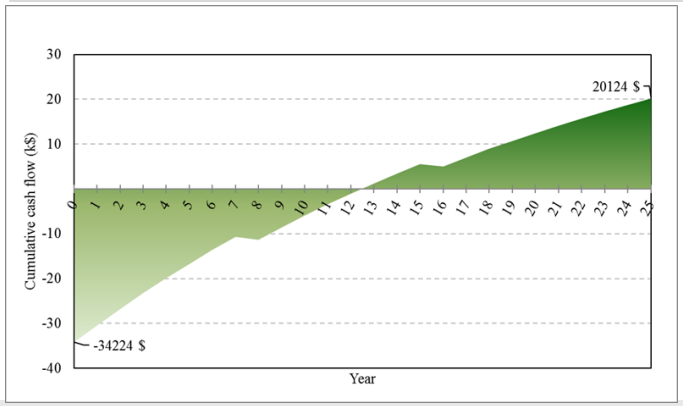
CONCLUSION: POLYCRYSTALLINE ON THE ROOF

- From energy viewpoint, Hanwha solar One 310 PV module seems to be the best among the considered polycrystalline modules.
- From economic viewpoint, Canadian Solar Cs6X-320P looks to be the best among the considered Polycrystalline brands.
- Hanwha solar One 310 PV module gives 19% electricity more than Canadian Solar Cs6X-320P.
- Canadian Solar Cs6X-320P PV module gives electricity at price 19% cheaper than that can be given by Hanwha solar One 310.

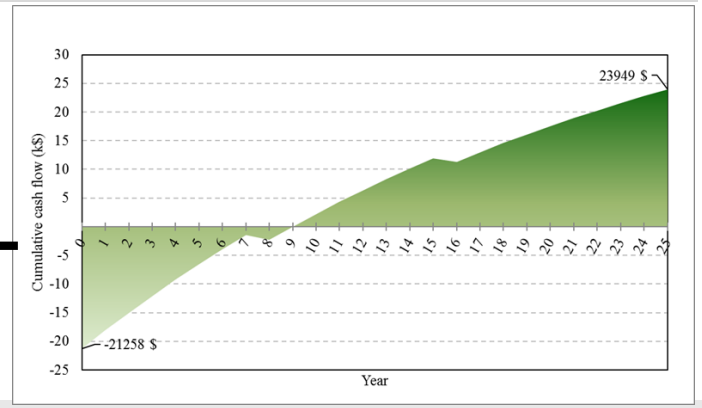
2. POLYCRYSTALLINE MODULE: INSTALLED ON



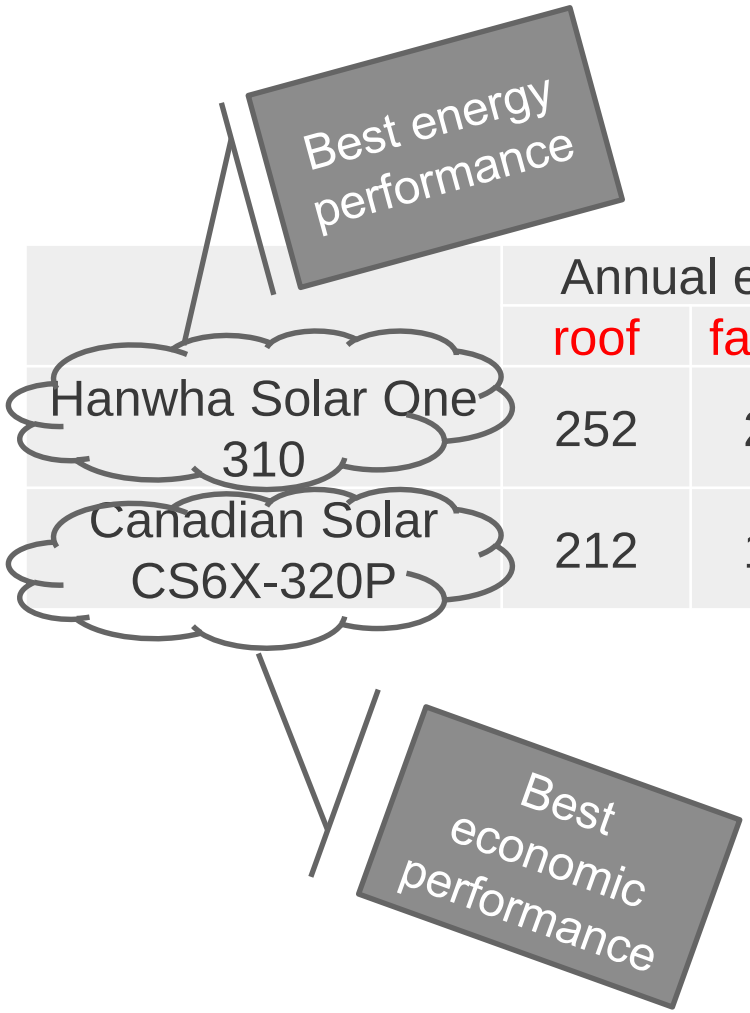




South Facing Façade

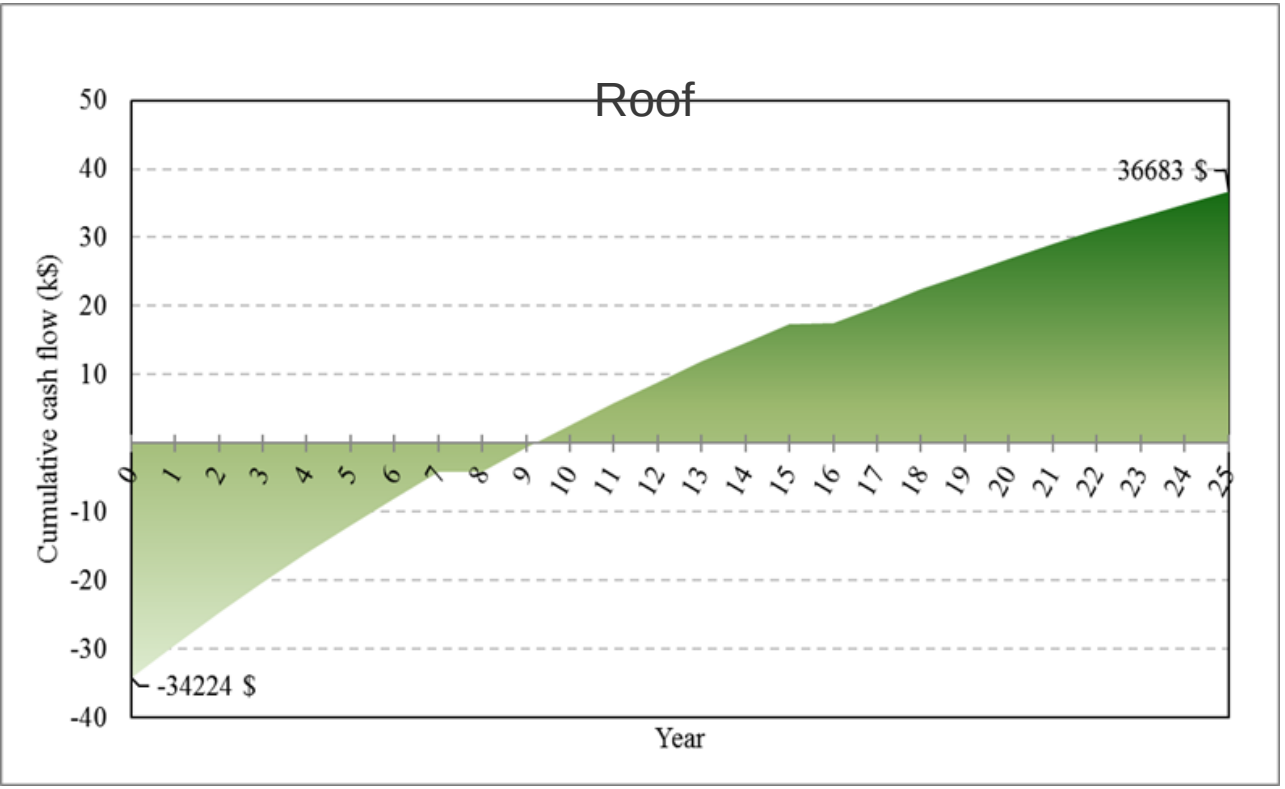


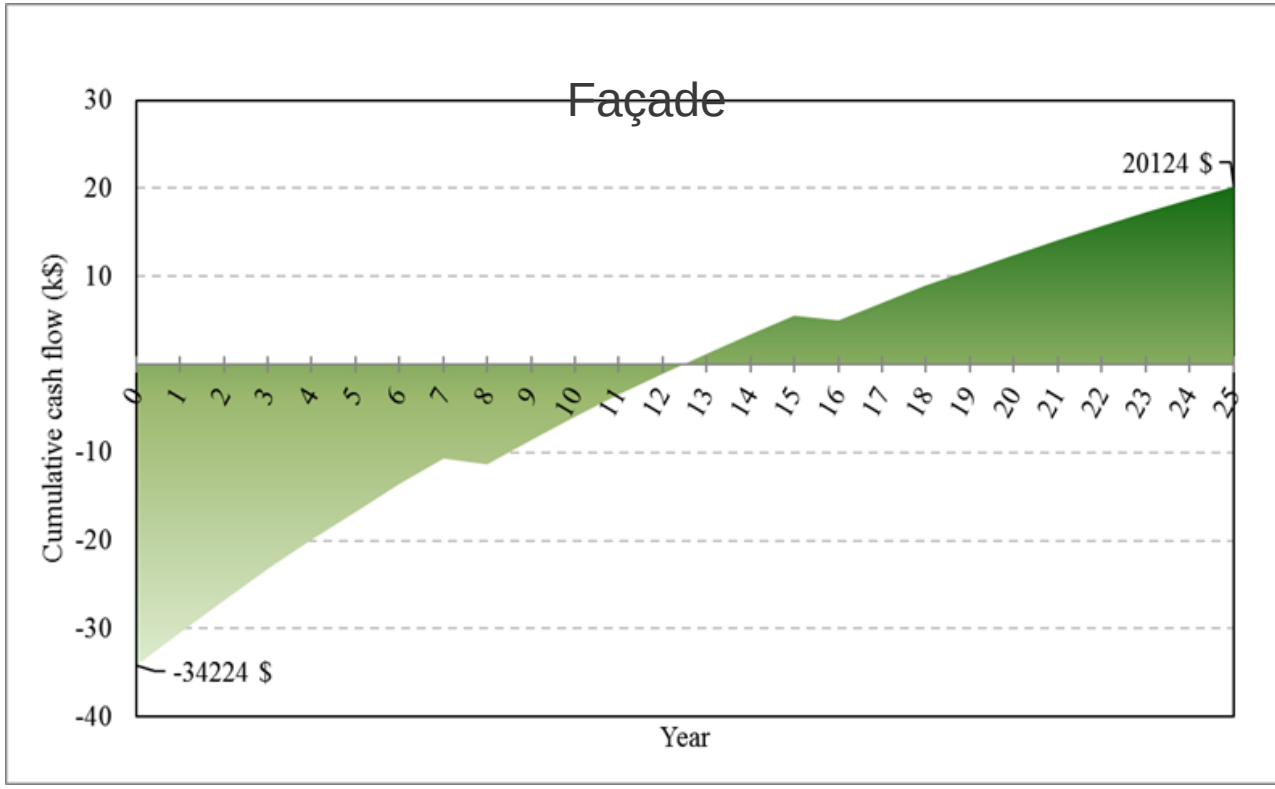
COMPARING BETWEEN SYSTEM ON ROOF AND FAÇADE



	Annual elect. (kWh/m²)			Avg. annual efficiency (%)			LCOE (¢/kWh)		
	roof	facade	difference	roof	facade	difference	roof	facade	difference
Hanwha Solar One 310	252	200	26%	16.5	17	-3%	11.5	14.4	-20%
Canadian Solar CS6X-320P	212	168	26%	13.9	14.3	-3%	9.3	11.7	-21%

COMPARING BETWEEN SYSTEM ON ROOF AND FAÇADE : THE BEST ENERGY PERFORMANCE

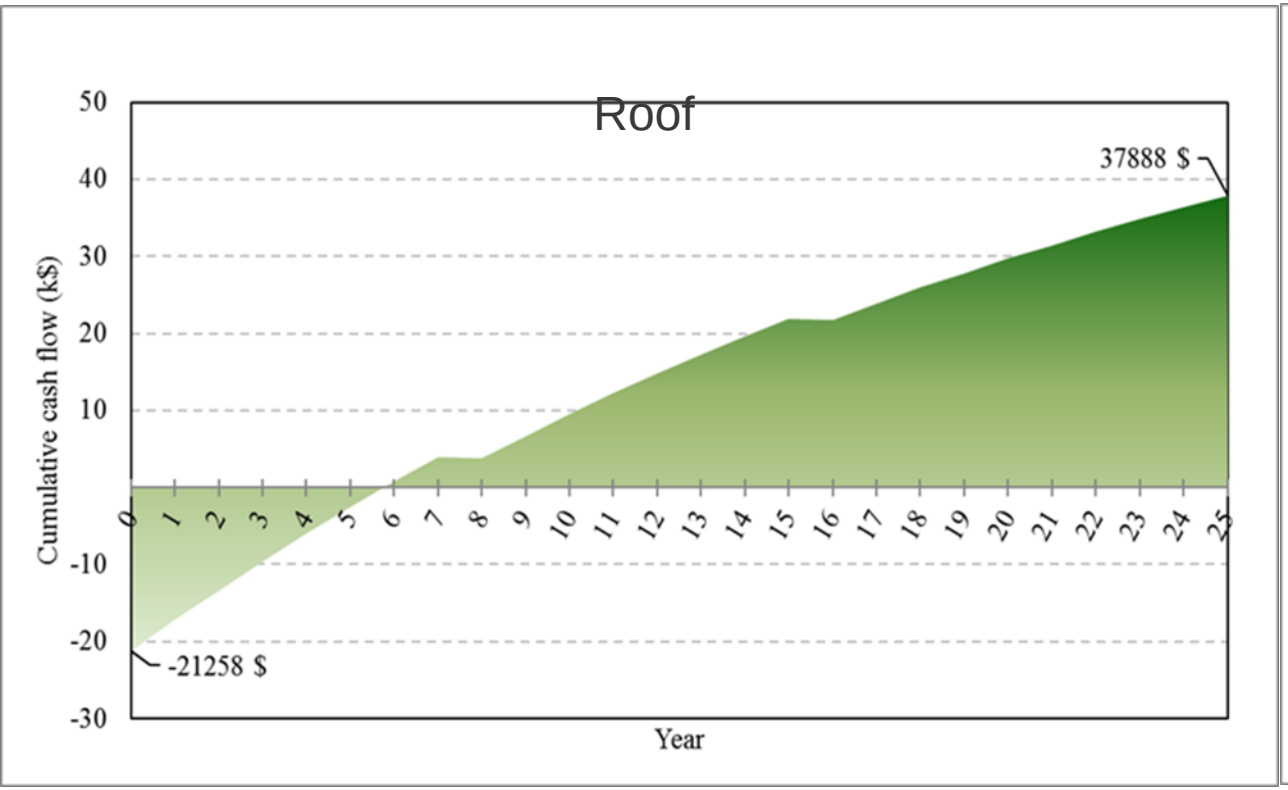


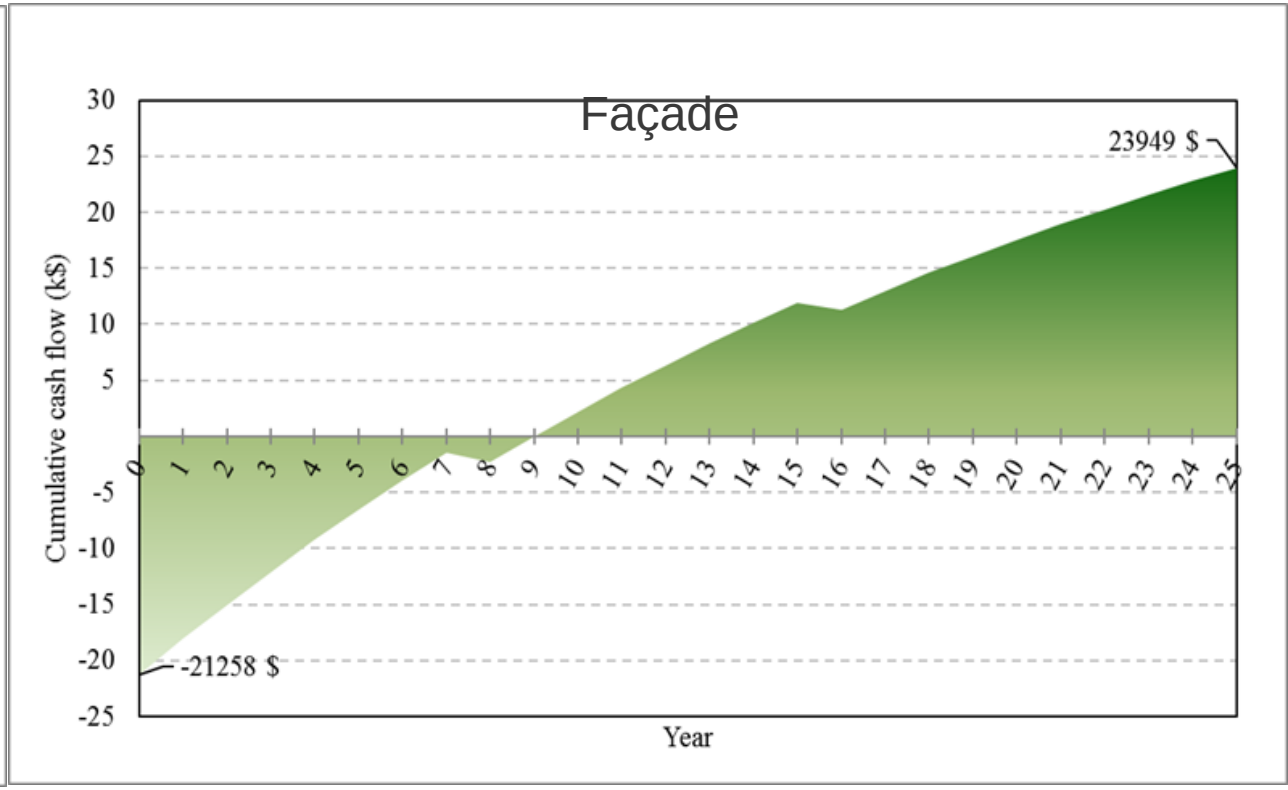


Hanwha solar One 310

	Annual electricity (kWh/m2)		Avg. annual efficiency (%)		LCOE (¢/kWh)	
	on the roof	on facade	on the roof	on facade	on the roof	on facade
Hanwha Solar One 310	252	200	16.5	17.0	11.5	14.4

COMPARING BETWEEN SYSTEM ON ROOF AND FAÇADE : THE BEST ECONOMIC PERFORMANCE





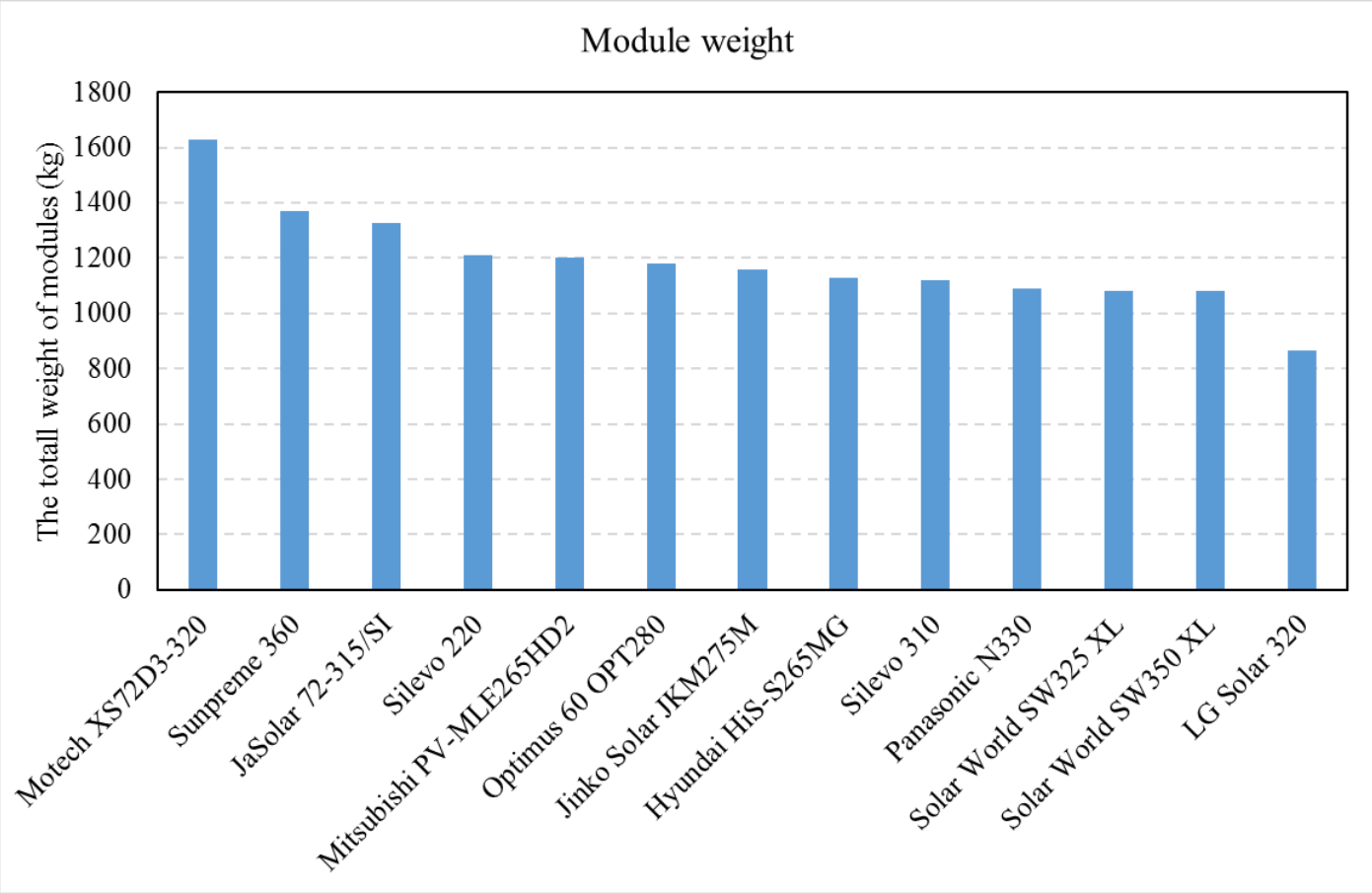
Canadian Solar CS6X-320P

	Annual electricity (kWh/m2)		Avg. annual efficiency (%)		LCOE (¢/kWh)	
	on the roof	on facade	on the roof	on facade	on the roof	on facade
Canadian Solar CS6X-320P	212	168	13.9	14.3	9.3	11.7

RESULTS: 3. MONOCRYSTALLINE

- 13 brands
- Two different systems:
  - On the roof
  - On the facade
- Best brand from energy point of view is defined
- Best brand from economic point of view is defined

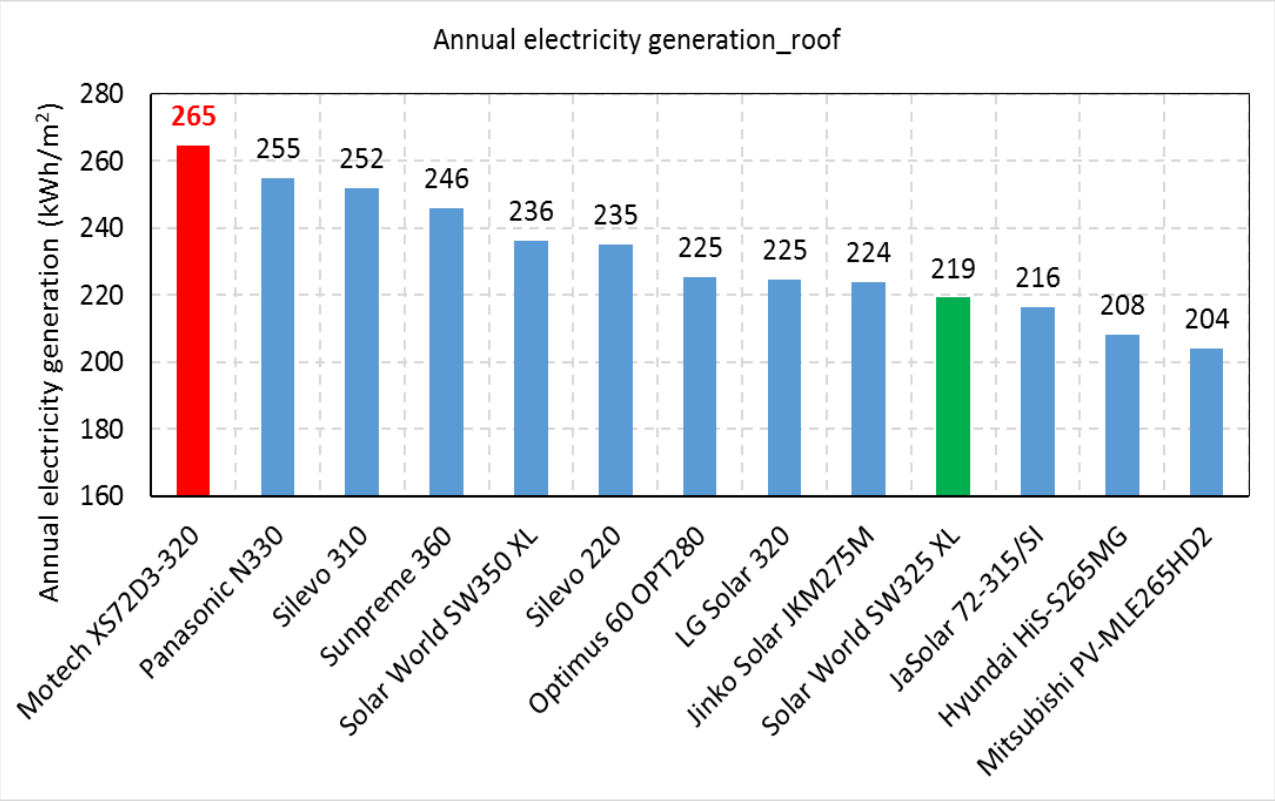
WEIGHT OF 100 M² MONOCRYSTALLINE-BASE PV SYSTEM

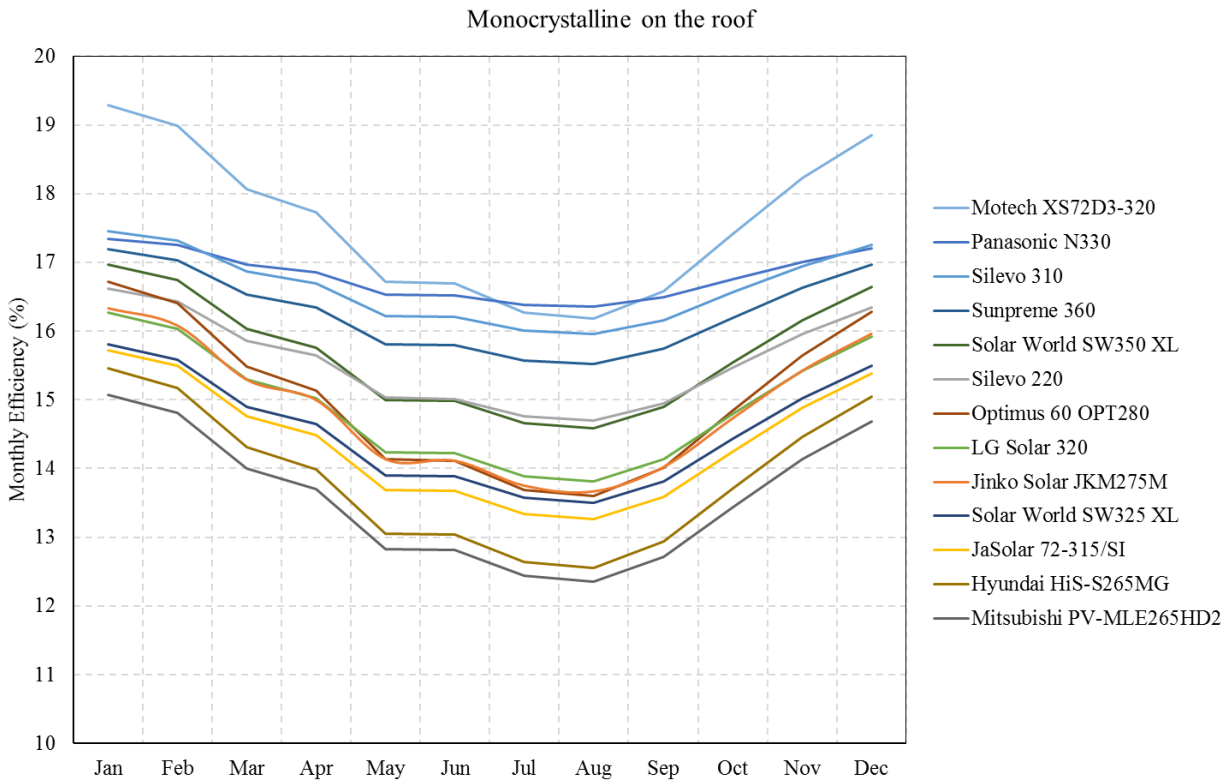


As shown, there is a considered difference in the weight of the moduls on the roof.

ELECTRICAL OUTPUT AND EFFICIENCY OF MONOCRYSTALLINE PV SYSTEM ON ROOF

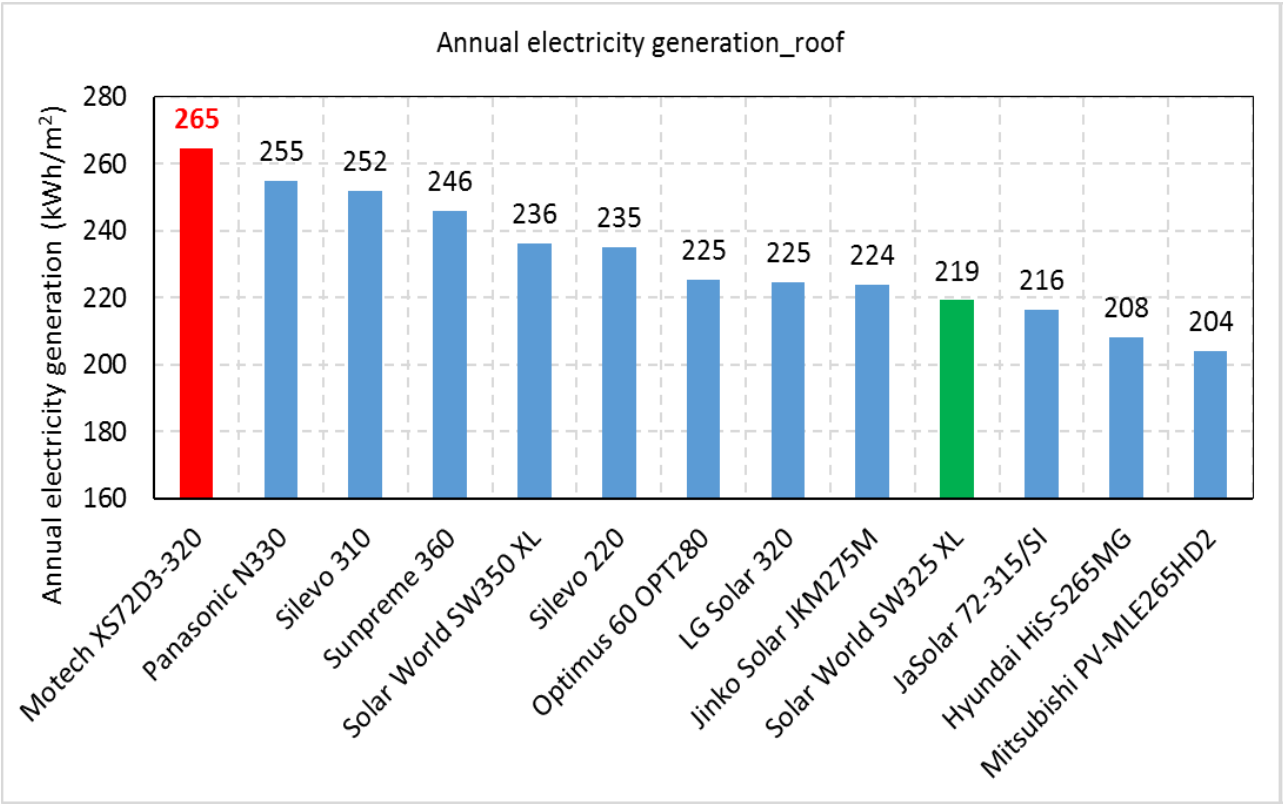
- The simulations show that the electricity output of the system varies from 204 to 265 kWh/m^2.a
- The efficinecy of modules ranged from 12 to 19%
- From energy viewpoint, Motech XS72D3-320 PV module is the best among the considered brands.

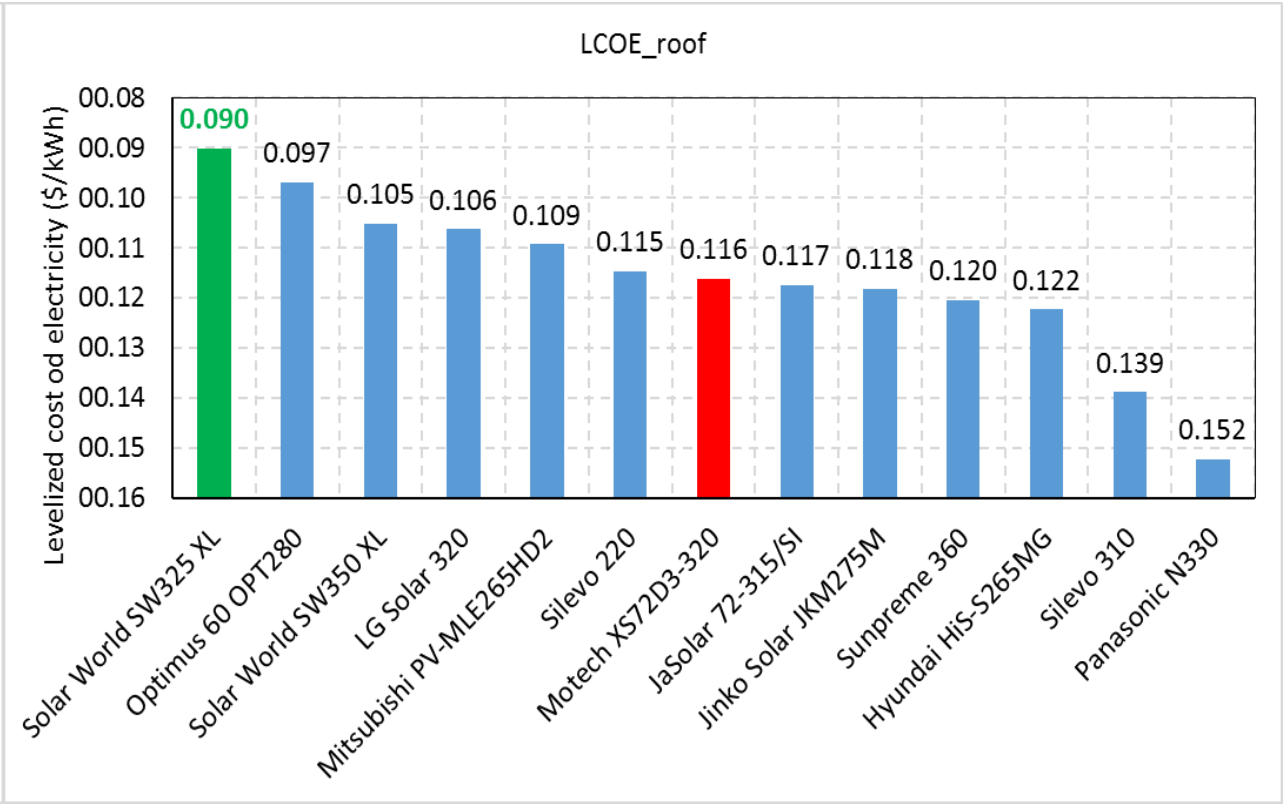




dreeam

LEVELIZED COST OF ELECTRICITY

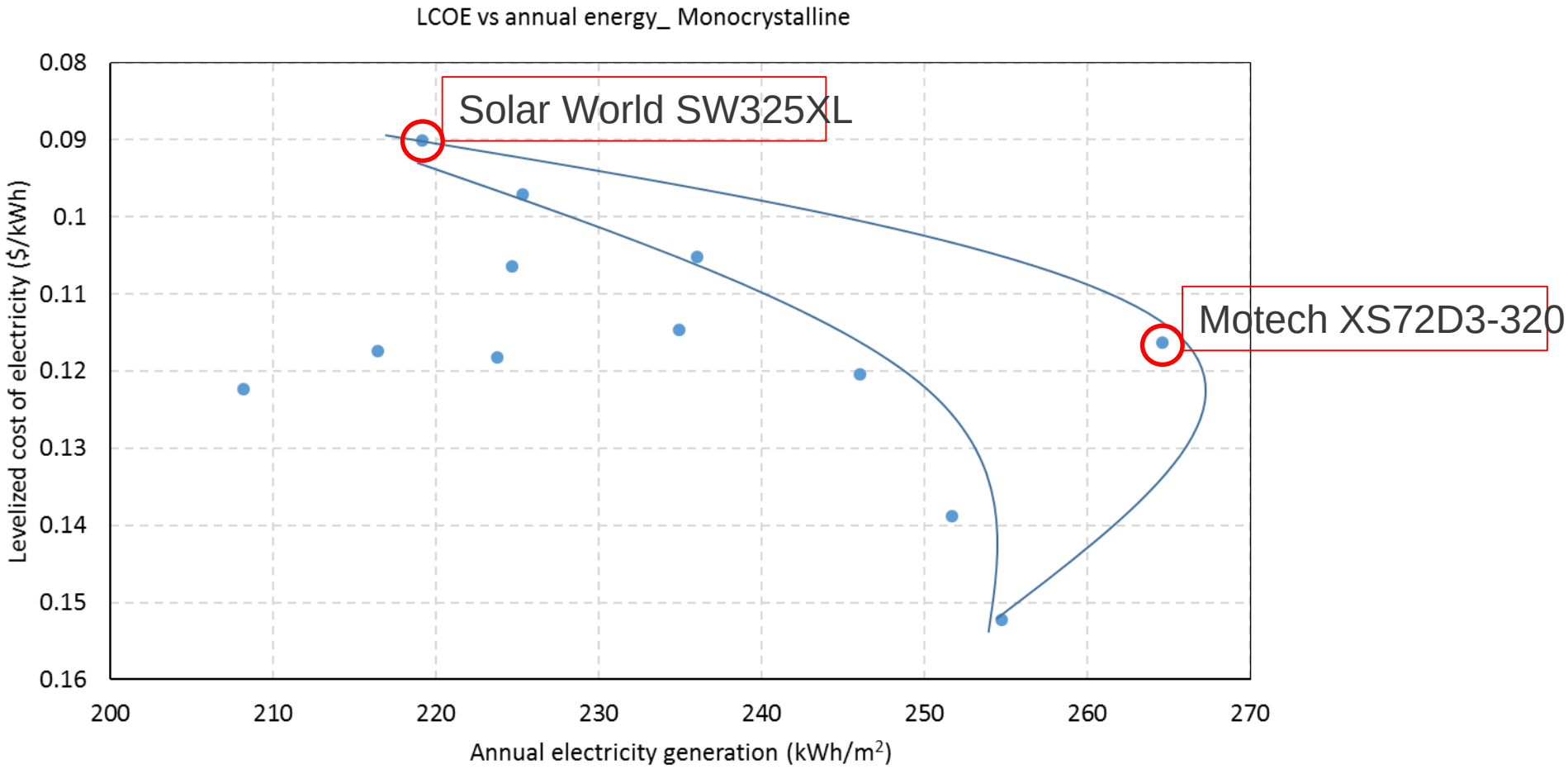




From economic viewpoint, Solar World SW325XL looks to be the best among the considered brands.

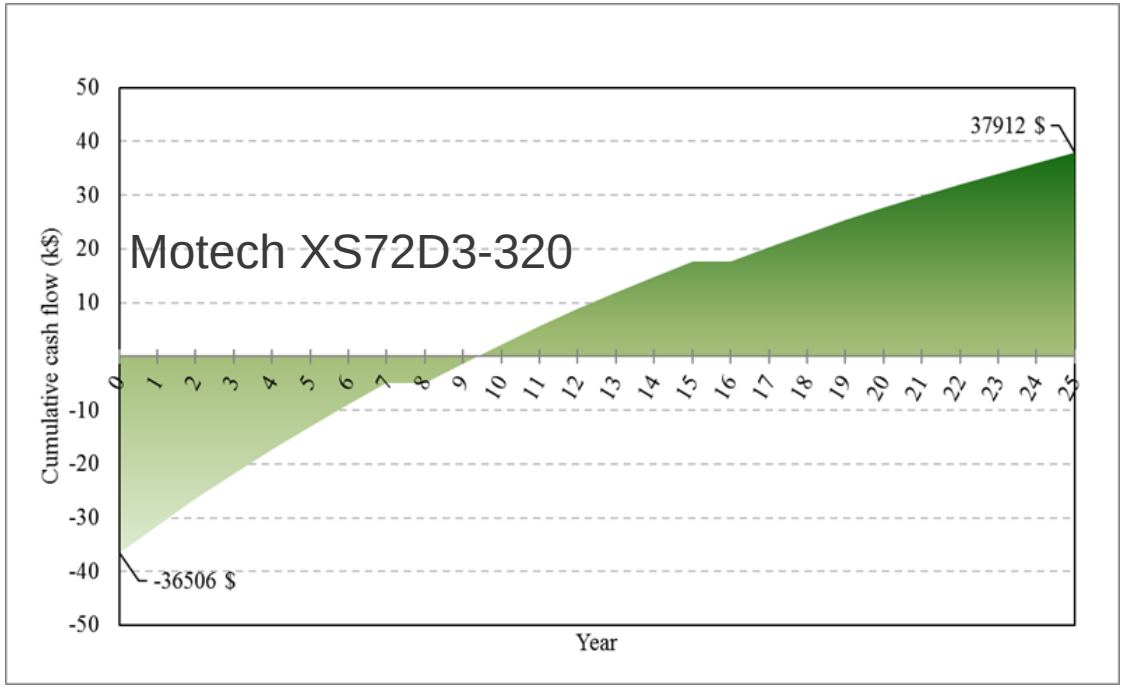
- Brand of the best energy performance is not the same one of the best economic performance

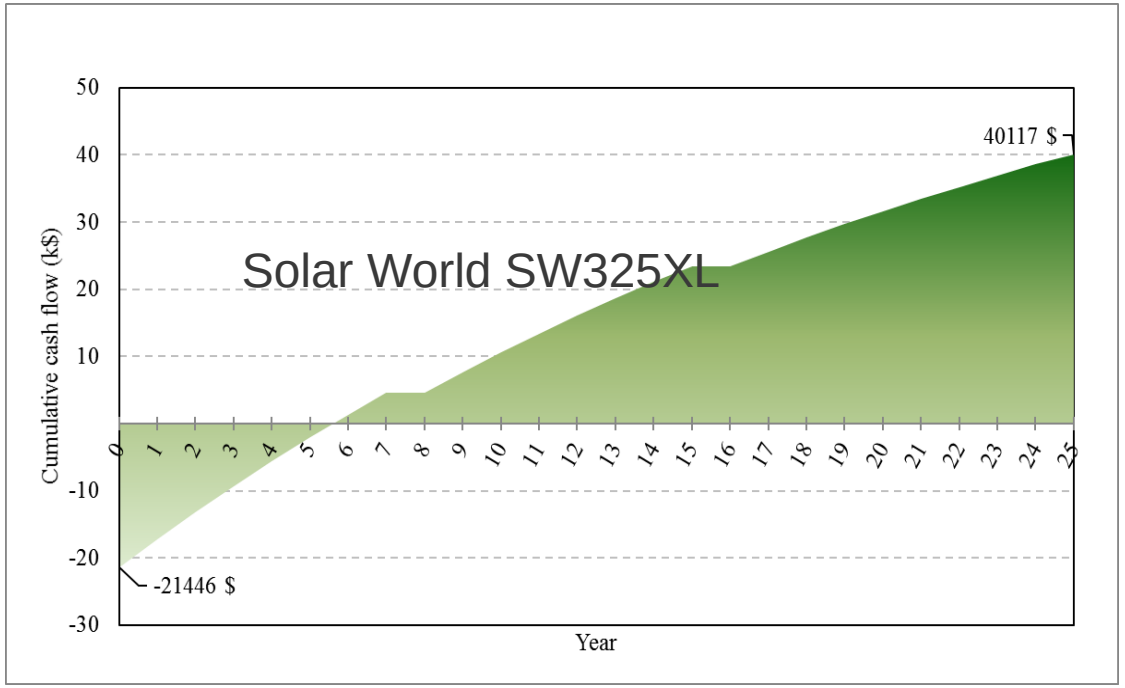
ECONOMIC PERFORMANCE VERSUS ENERGY PERFORMANCE OF PV SYSTEM



COMPARING BETWEEN THE BRANDS OF THE BEST PERFORMANCE

Accumulative cash flow of Motech XS72D3-320 (of the best energy performance) and Solar World SW325 XL (of the best economic performance) were calculated



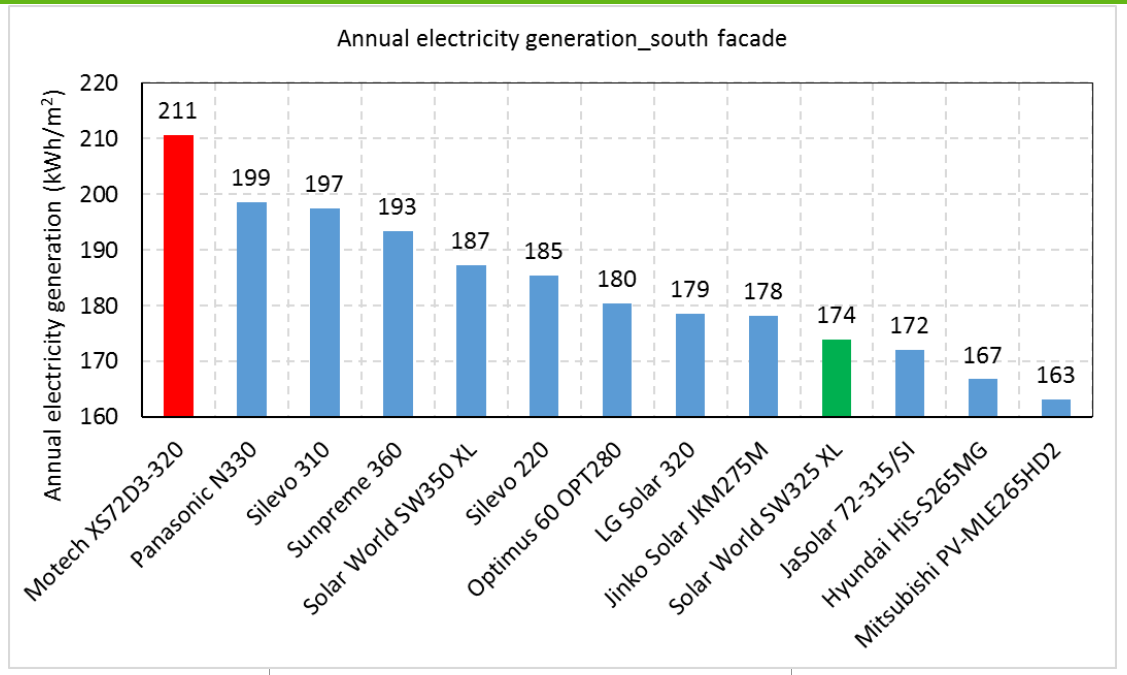


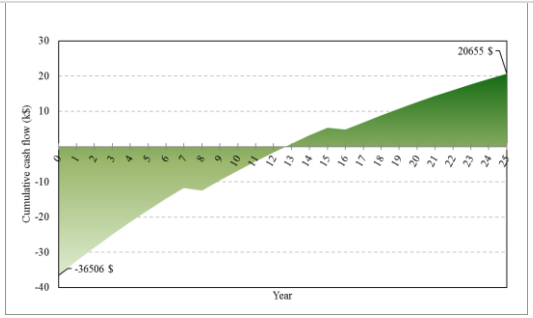
	Annual elect. (kWh/m^2)	Annual efficiency (%)	LCOE (¢/kWh)	Initial cost ($/100m^2)	Payback time (year)
Motech XS72D3-320	265	17.4	11.6	36506	9.5
Solar World SW325 XL	219	14.4	9	21446	5.5
difference	21%	21%	29%	70%	73%

CONCLUSION: MONOCRYSTALLINE

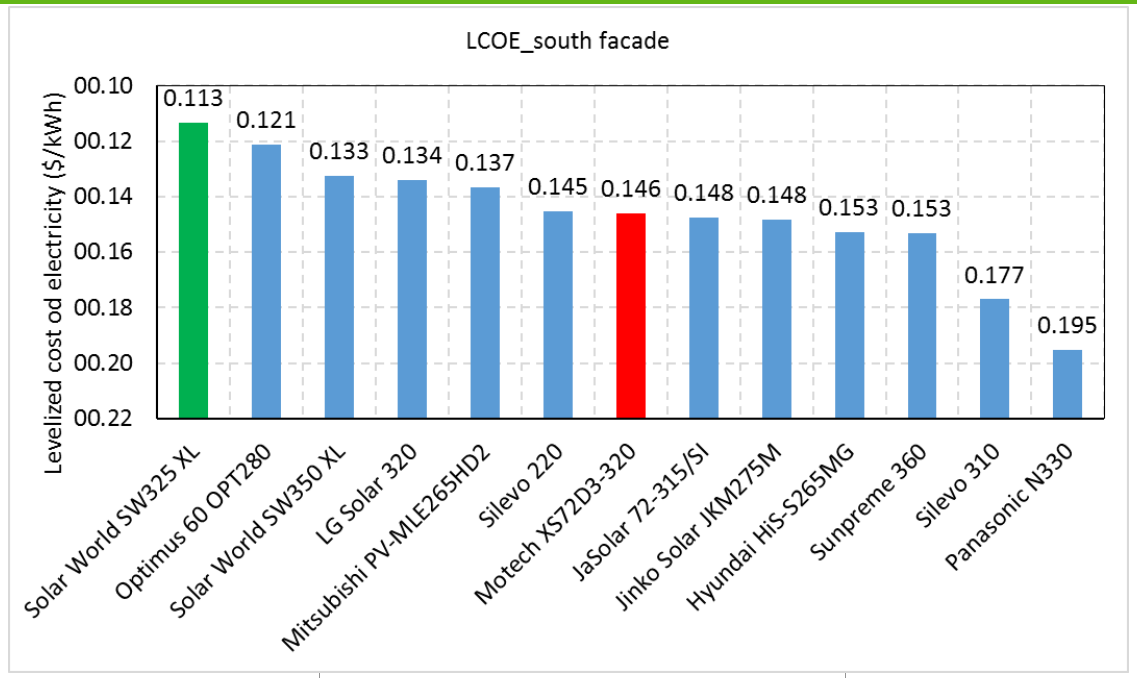
- From energy viewpoint, Motech XS72D3-320 PV module seems to be the best among the considered Monocrystalline modules.
- From economic viewpoint, Solar World SW325XL looks to be the best among the considered Monocrystalline brands.
- Motech XS72D3-320 PV module gives 21% electricity more than Solar World SW325XL
- Solar World SW325XL PV module gives electricity at price 22% cheaper than that can be given by Motech XS72D3-320 .

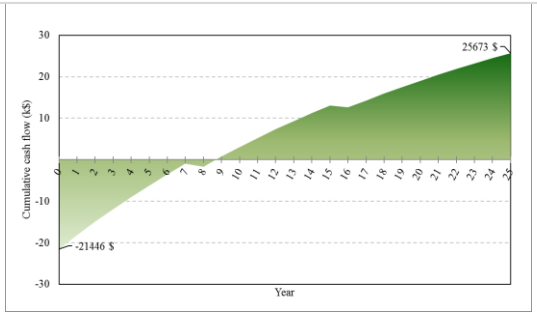
3. MONOCRYSTALLINE MODULE: INSTALLED ON SOUTH FACING FAÇADE





Motech XS72D3-320





Solar World SW325XL

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COMPARING BETWEEN SYSTEM ON ROOF AND FAÇADE

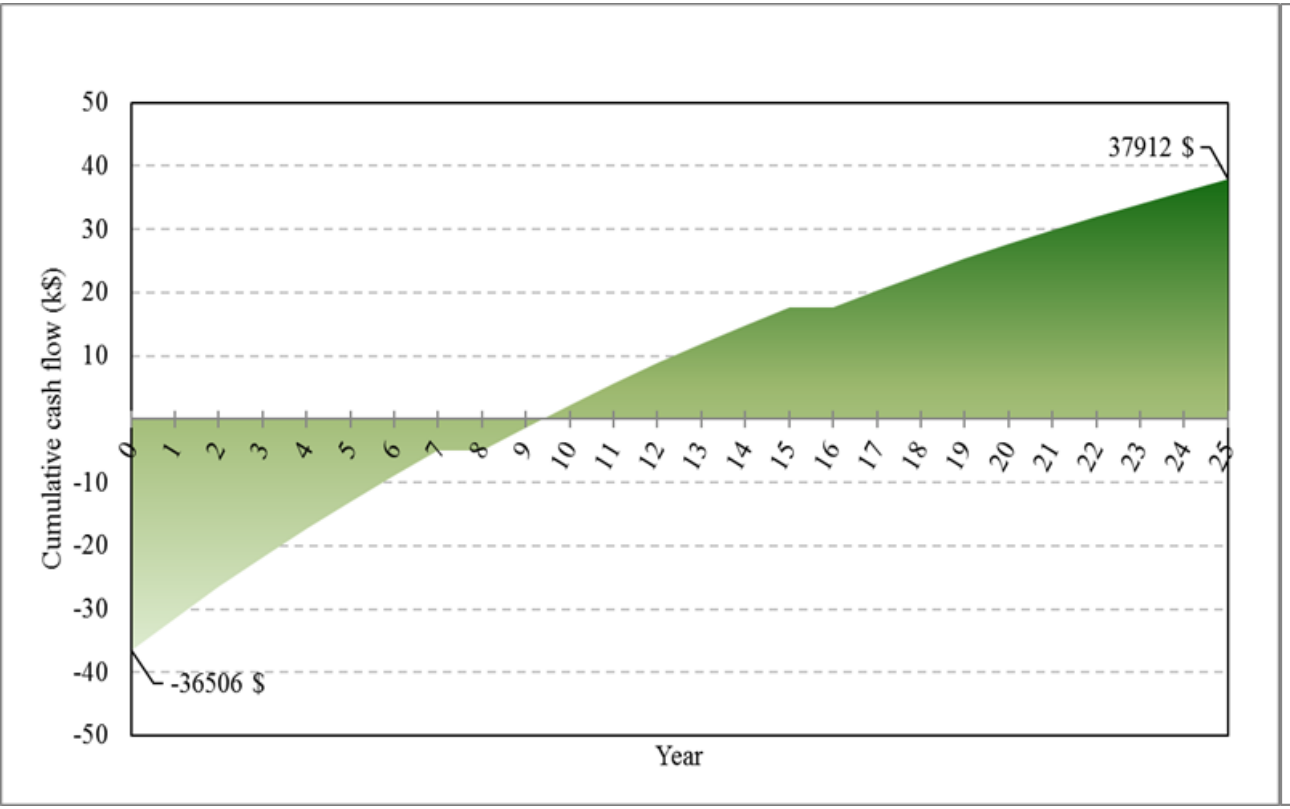
Best energy performance

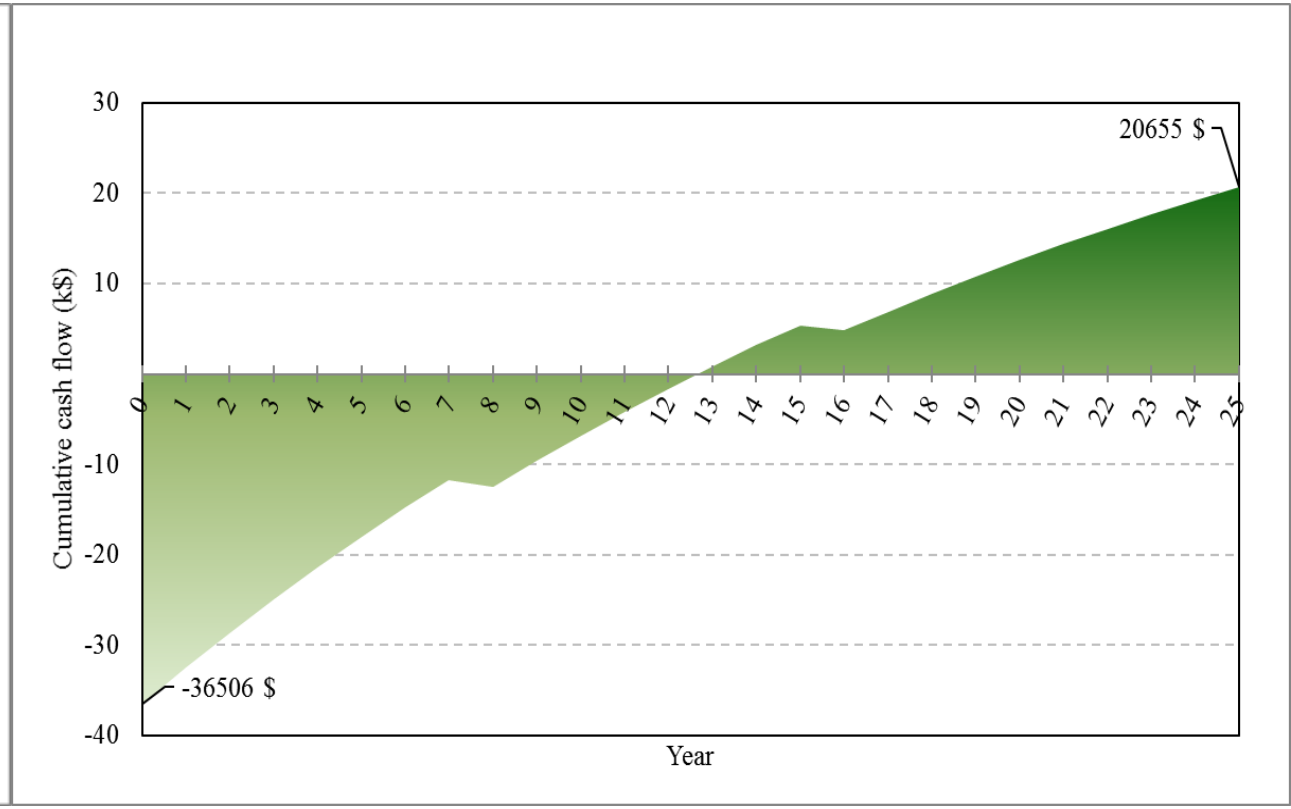
	Annual elect. (kWh/m^2)			Avg. annual efficiency (%)			LCOE (¢/kWh)		
	roof	facade	difference	roof	facade	difference	roof	facade	difference
Motech XS72D3-320	265	211	26%	17.4	17.9	-3%	11.6	14.6	-21%
Solar World SW325 XL	219	174	26%	14.4	14.8	-3%	9	11.3	-20%

Best economic performance

COMPARING BETWEEN SYSTEM ON ROOF AND FAÇADE : THE BEST ENERGY PERFORMANCE

3. Monocrystalline Module





Motech XS72D3-320

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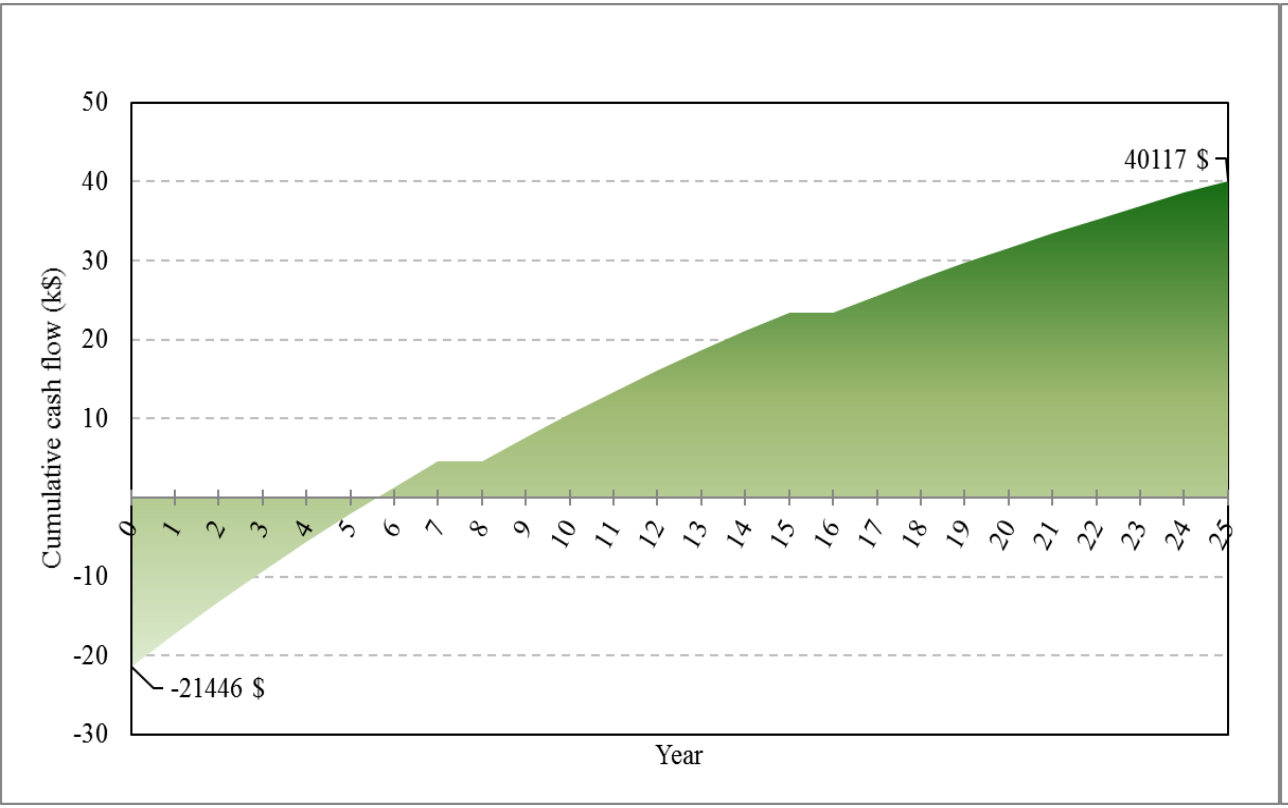
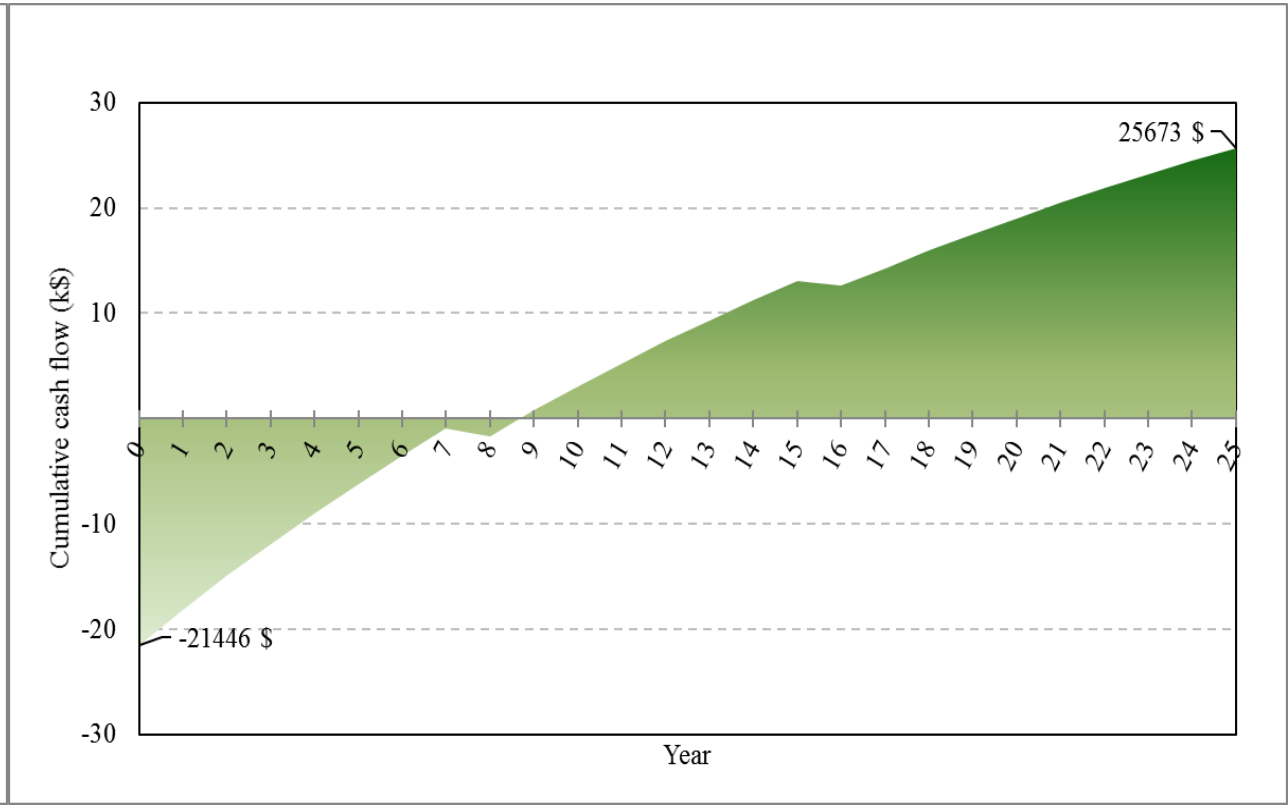
COMPARING BETWEEN SYSTEM ON ROOF AND FAÇADE : THE BEST ECONOMIC PERFORMANCE





Solar World SW325 XL

THE BEST BRAND: MONOCRYSTALLINE, POLYCRYSTALLINE, AND THIN FILM

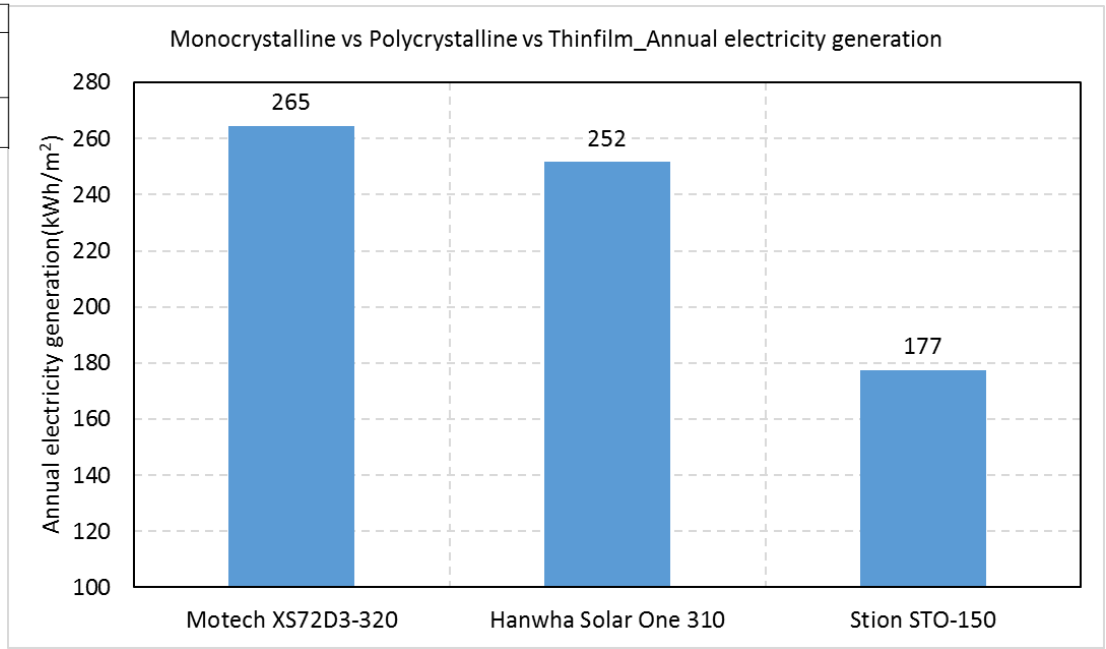
Monocrystalline vs Polycrystalline vs Thin film

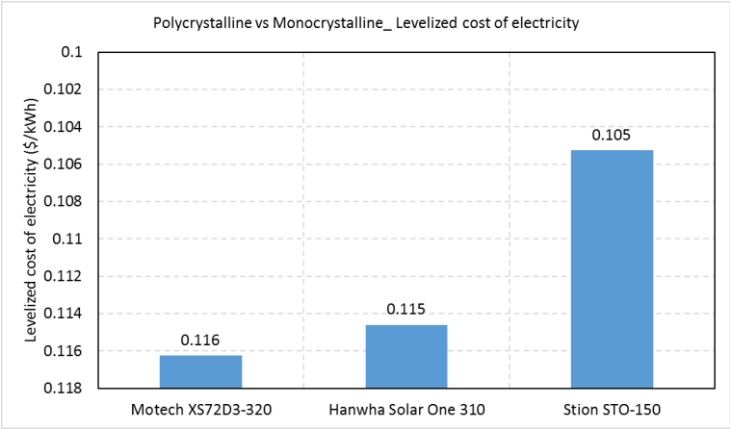
PV Type	Monocrystalline		Polycrystalline		Thin film	
Brand	Motech XS72D3-320	Solar World SW325XL	Hanwha Solar One 310	Canadian Solar CS6X-320P	Stion STO-150	Stion STN-125
Energy performance						
Economic performance						

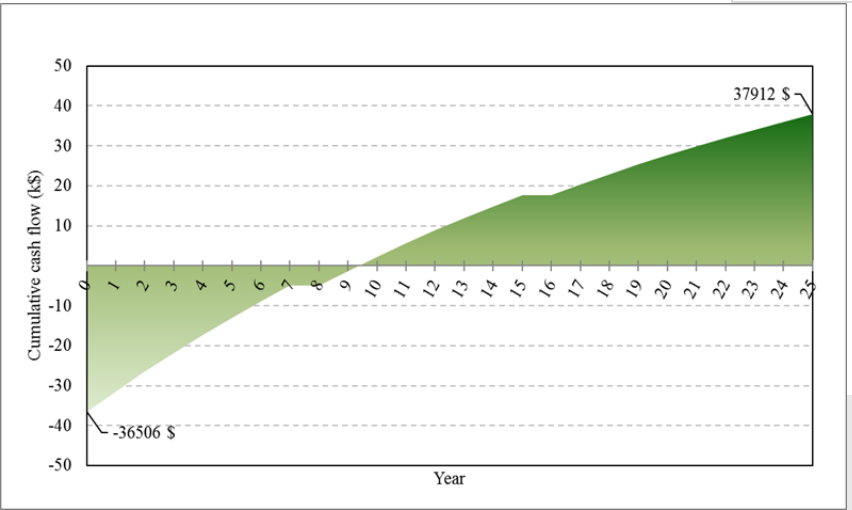
COMPARING MODULES OF THE BEST ENERGY PERFORMANCE

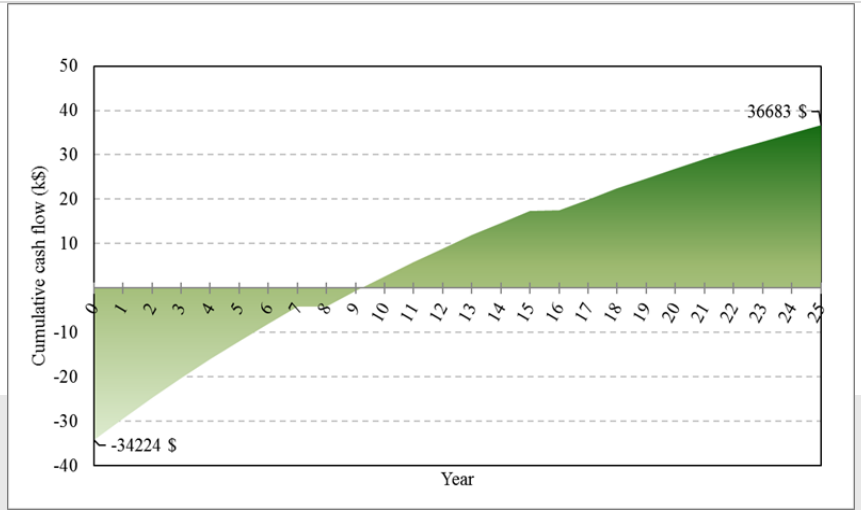
Monocrystalline vs Polycrystalline vs Thin film

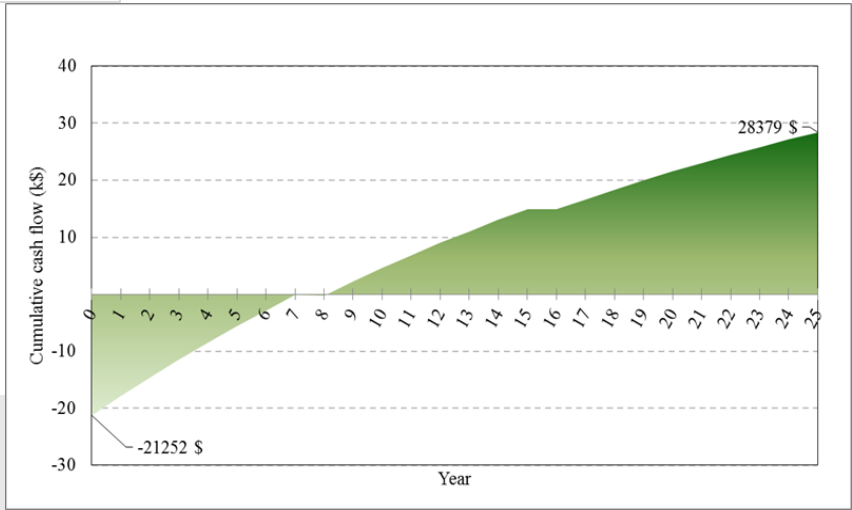
PV Type	Monocrystalline		Polycrystalline		Thin film	
Brand	Motech XS72D3-320		Hanwha Solar One 310		Stion STO-150	
Energy performance						







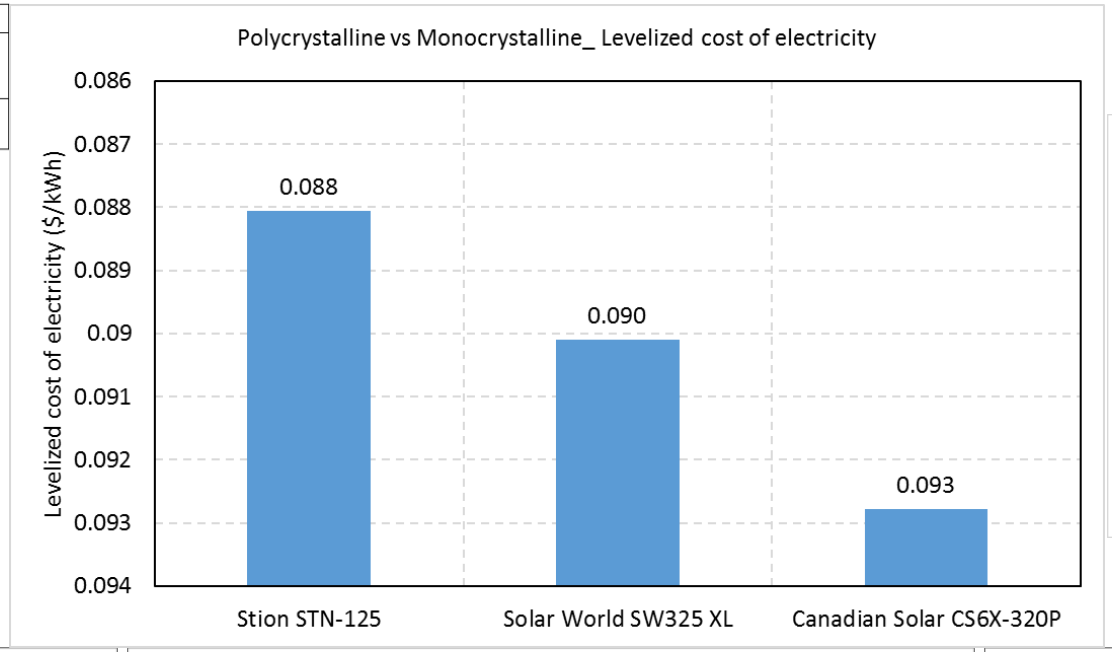


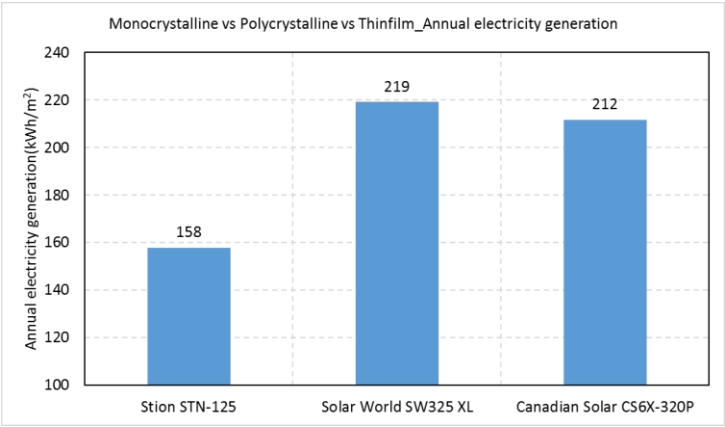


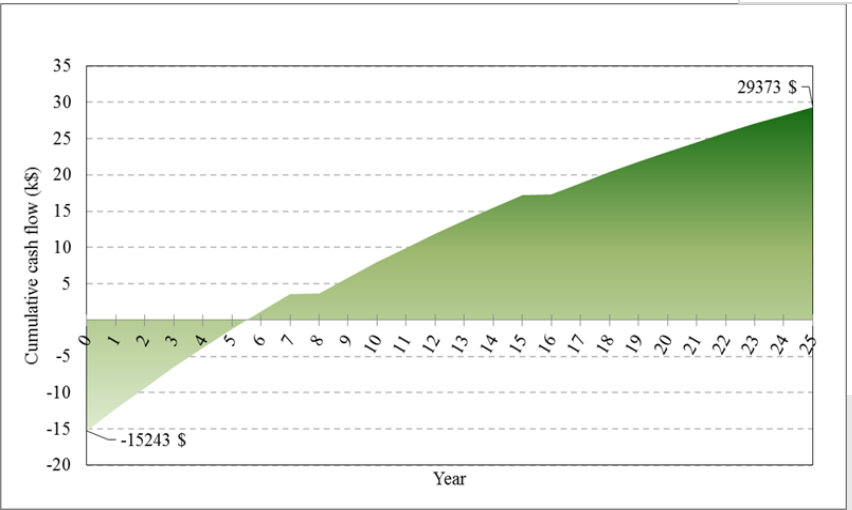
COMPARING MODULES OF THE BEST ECONOMIC PERFORMANCE

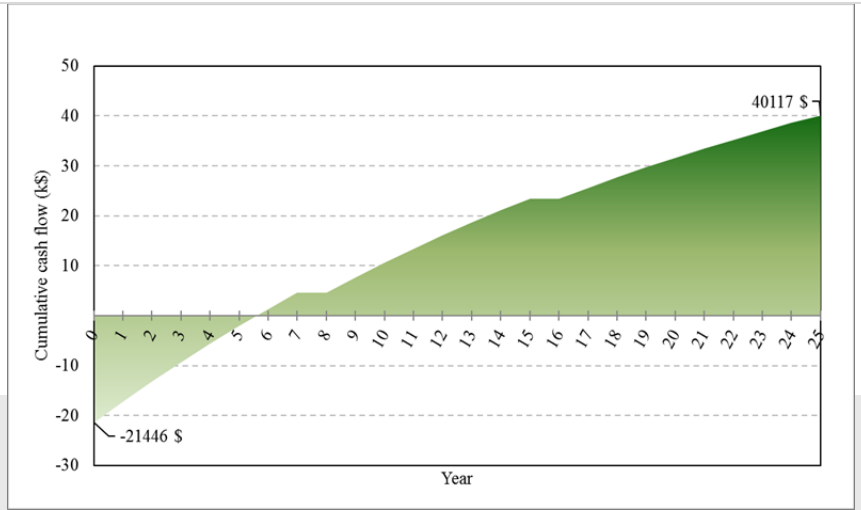
Monocrystalline vs Polycrystalline vs Thin film

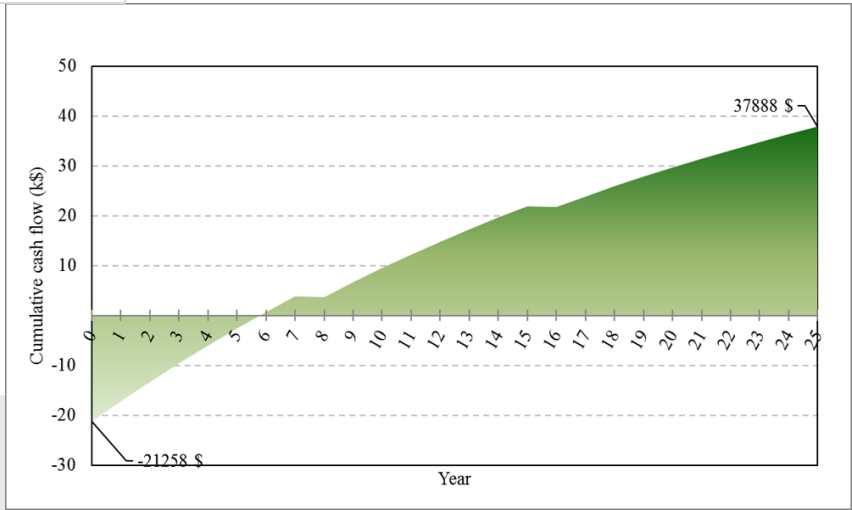
PV Type	Monocrystalline		Polycrystalline		Thin film	
Brand		Solar World SW325XL		Canadian Solar CS6X-320P		Stion STN-125
Economic performance						











CONCLUSION

General Conclusion

- ✓ There is a big potential to use grid-connected PV system
- ✓ Up to 226 kWh/y can be generated per square meter of such system
- ✓ The initial cost of 11.4 kW (thin film) is $15000
- ✓ The initial cost of 19.5 kW (monocrystalline) is $36000
- ✓ Initial cost per installed capacity is:
  - 1.54 $/W thin film based system, or
  - 1.84 $/W monocrystalline based system
- ✓ The payback time of the systems varies from 6 to 10 years

CONCLUSION

Comparison

From energy point of view:

- Monocrystalline can generate 5% more annual electricity than polycrystalline,
- Monocrystalline can generate 49% more annual electricity than Thin film module
- Polycrystalline module can generate 42% more annual electricity than Thin film module

From economic viewpoint:

- Monocrystalline can generate electricity at 3% cheaper than polycrystalline per kWh,
- Thin film can generate electricity at 2% cheaper than Monocrystalline module, and
- Thin film can generate electricity at 5% cheaper than Polycrystalline module

From weight viewpoint:

- Polycrystalline module is the lightest one among the considered brands.
- Monocrystalline is the heaviest one

PART III – INNOVATIONS DEVELOPED IN OTHER EU-FUNDED PROJECTS

OVERVIEW OF THEMATIC AREAS COVERED BY OTHER EU-FUNDED PROJECTS

- High performance insulation systems
- Materials with reduced embodied energy
- Nanotechnologies for HVAC systems
- Novel materials for smart windows
- Nanotechnologies for multifunctional lightweight construction materials
- Technologies and materials for a healthier indoor environment
- ICT and new business models
- Design, decision and support tools for energy efficient buildings, districts and cities
- Energy performance monitoring and management of energy efficient buildings
- Energy performance monitoring and management at district and city levels
- Low carbon and efficient energy generation systems for buildings and districts
- New high performance energy-efficient buildings
- Deep energy renovation of existing buildings
- Deep energy renovation of districts and smart energy efficient solutions for cities

OVERVIEW OF EU-FUNDED PROJECTS SCANNED

HIPIN
AEROCOINs
HomeSkin

LEEMA
SUS-CON
BioBuild
ECO-Binder
ISOBIO

NANO-HVAC
EnE-HVAC
NanoCool

WINSMART
SMARTBLIND
MEM4WIN
HarWin
EELICON
LaWin

ADAPTIWALL
SESBE
ELISSA
Foambuild
MF-RETROFIT

INTASENSE
CETIEB
H-house
BRIMEE
OSIRYS
ECO-SEE

NewBEE
Proficient
Umbrella
DAREED
iURBAN

BESOS
Design4Energy
ECODISTR-ICT
eeEmbedded
FASUDIR
HOLISTEEC
READY4SmartCities
Streamer
OrPHEuS

Energy IN TIME
PERFORMER
TRIBUTE
Built2SPEC
INSITER
ACCEPT

CAMPUS21
AMBASSADOR
EEPOS
EPIC-HUB
IDEAS
NRG4Cast
ODYSSEUS
ORIGINconcept
RESILIENT
SmartKYE
CITYOPT
DIMMER
e-balance
EEbers
SWIMing

HEAT4U
EINSTEIN
CREATE
TESSe2b

BUILDSMART
DIRECTION
NEED4B
NEXT-Buildings

School of the Future
EASEE
MEEFS Retrofitting
HERB
iNSPiRE
RetroKit
A2PBEER
BRICKER
CommONEnergy
EcoShopping
RESSEEPE
E2VENT
BRESAER
Moreconnect

EFFESUS
EU-GUGLE
R2CITIES
URB-Grade
ZenN
CITyFiED
INDICATE
Sinfonia

TRL

In order to classify the different innovations the Technology Readiness Level (TRL) is mentioned, estimating the maturity of each technology.

Please note that the TRL estimation refers to the time of the writing and might have changed in the meantime.

- TRL 5: Component and/or breadboard validation in laboratory environment
- TRL 6: System model or prototype demonstration in relevant environment
- TRL 7: System prototype demonstration in an operational environment
- TRL 8: Actual System complete and qualified through test and demonstration

HIGH PERFORMANCE INSULATION SYSTEMS

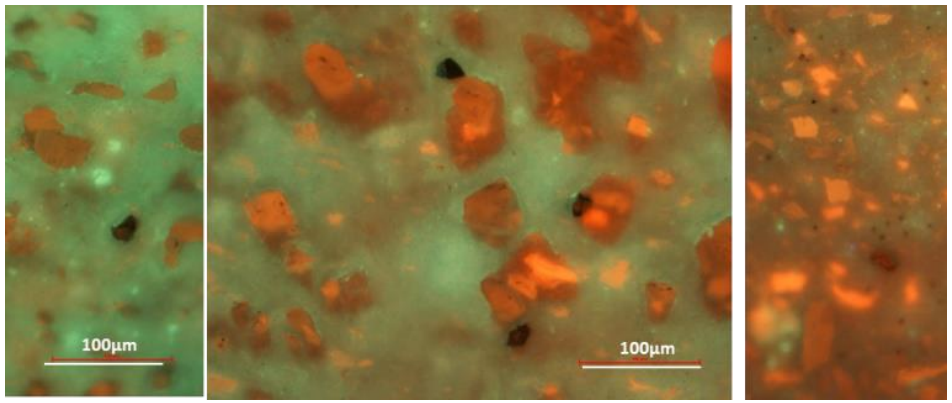
dreeam

HIPIN

TRL = 8

High Performance Insulation Based on Nanostructured Encapsulation of Air.

- Key Points
  - Cheap, robust silica aerogel in form of paint, plaster & panels
  - Heat insulation, sound insulation, fire retardant
  - Low material thickness
  - External & internal application
- Application – building type
  - Refurbishment (especially high density housing)
  - New buildings
- Application – process
  - Disruptive



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AEROCOINs

TRL = 8

Develops silica aerogels on a large scale at a reasonable cost and with good mechanical properties.

- Key Points
  - Strength silica aero-gels by cross-linking with cellulosic polymers or the incorporation of cellulose-based nanofibers
  - Low production costs via ambient drying and continuous production technology
- Application – building type
  - Refurbishment

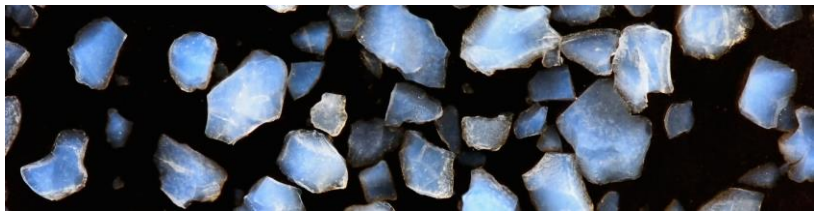
HomeSkin

TRL = 5

Develops a new silica Advanced Aerogel-Based Composite (AABC) material possessing the lowest thermal conductivity of all insulation materials found in the market.

- Key Points
  - High thermal insulation performance
  - Thin, light, non flammable, low CO_2 & VOC emissions
  - External & internal insulation
- Application – building type
  - Refurbishment
  - New building
- Application – process
  - Disruptive

HOME Skin
Thinner Insulation Systems



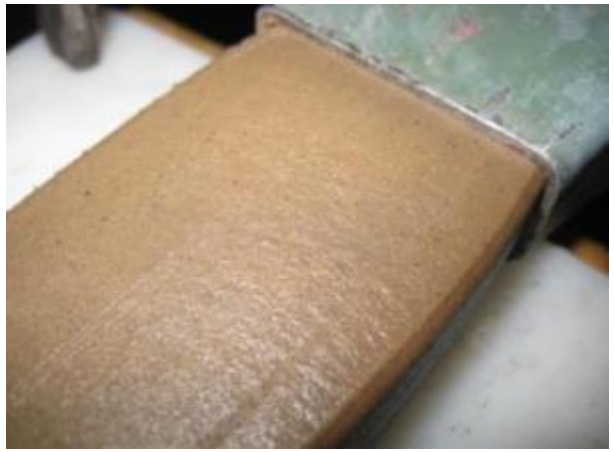
MATERIALS WITH REDUCED EMBODIED ENERGY

LEEMA

TRL = 6-7

Develops a low embodied energy advanced (novel) insulation materials and insulating masonry components for energy efficient buildings

- Key Points
  - Incombustibility and absence of organic/fibrous compounds
  - Use of wastes of industrial minerals exploitation
  - 3I: LFM for cavity walls insulation, EPB Fesco boards, Fibre boards, Perlite filled insulating bricks, Foam boards
- Application – building type
  - Refurbishment
  - New buildings
- Application – process
  - Disruptive or non-disruptive

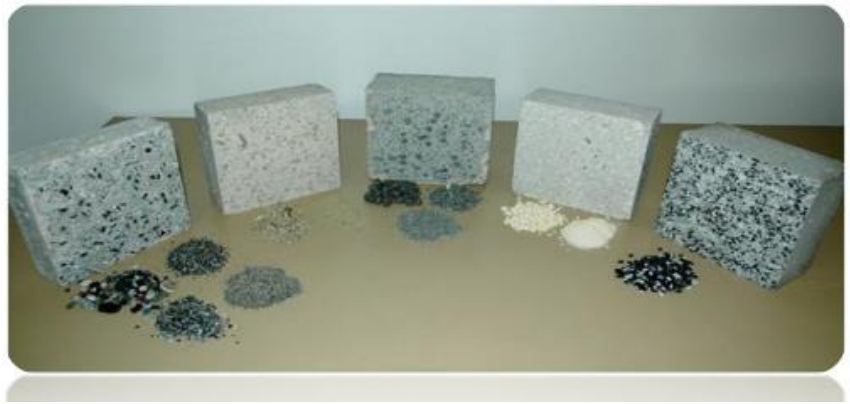


SUS-CON

TRL = 8

Develop a light-weight, eco-compatible & cost-effective construction material, made by all-waste raw materials and characterized by low embodied energy and CO2.

- Key Points
  - Sustainable and energy efficient lightweight concrete
  - Waste recycling
  - Aggregates: MPW from municipal solid wastes & WEEE, rubber tyres, PU foam
  - Binders: waste ashes, ground granulated blast furnace slag, perlite tailings
- Application – building type
  - New buildings
- Application – process
  - Disruptive



BioBuild

TRL = 8

Developed biocomposite materials to reduce the embodied energy with no increase in cost.

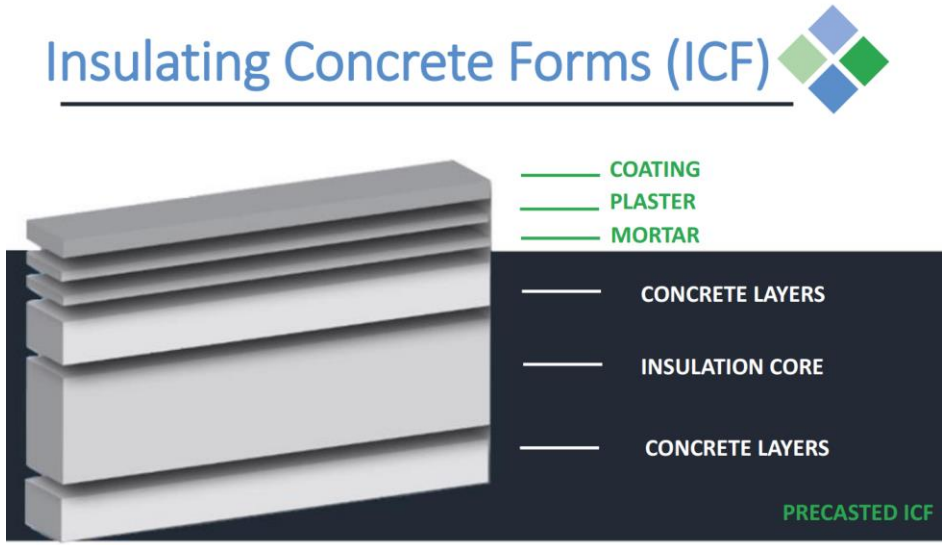
- Key Points
  - A fibre-reinforced polymer where either the reinforcement or matrix or both is derived from biological sources
  - Good vibration- & acoustic damping, resistance to fatigue & fire
  - resistance to moisture absorption and other degrading agents
- Application – building type
  - Refurbishment
  - New buildings
- Application – process
  - Disruptive & non-disruptive

ECO-Binder

TRL = 6-7

Develops innovative Belite-Ye'elimite-Ferrite (BYF) class of low-CO2 binders.

- Key Points
  - Replacing Ordinary Portland Cement (OPC) and OPC based concrete products
  - High performances in terms of safety and comfort
  - Superior dimensional stability
- Application – building type
  - Refurbishment
  - New buildings
- Application – process
  - Disruptive & non disruptive



ISOBIO

TRL = 5

Proposes an innovative strategy to bring bio-based construction materials into the mainstream.

- Key Points
  - Use of pre-treated bio-based aggregates for construction, which include insulation materials, hygrothermal and moisture buffering materials, binders, sol-gel and resins
- Application – building type
  - Refurbishment
  - New buildings
- Application – process
  - Disruptive & non-disruptive

NANOTECHNOLOGIES FOR HVAC SYSTEMS

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NANO-HVAC

TRL = 8

Develops an innovative approach for ducts insulation while introducing new cleaning and maintenance technologies, all enabled by cost-effective application of nanotechnology.

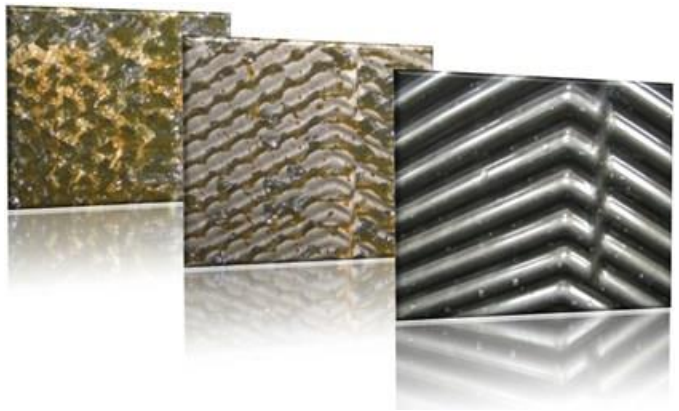
- Key Points
  - Application on circular & square ducts
  - Sprayable aeroclay-based insulating foam (extremely thin)
  - Cost-effective pathogen and allergenic removal during operation and maintenance
- Application – building type
  - Refurbishment
  - New buildings
- Application – process
  - Non-disruptive & Disruptive

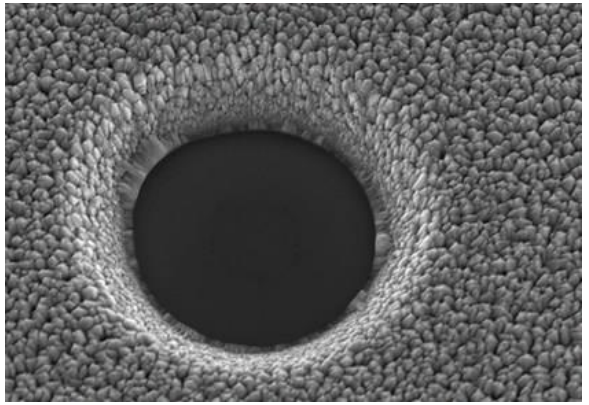
EnE-HVAC

TRL = 6-7

Develops energy efficient heat exchangers for HVAC applications.

- Key Points
  - New technologies:
  - Nanostructured coatings including Sol-gels and PVD coatings for increasing heat transfer.
  - Nanotechnological coatings with anti-freezing properties to limit over icing of heat exchangers.
  - Nanofluids for the improvement of heat transport.
- Application – building type
  - Refurbishment
  - New buildings
- Application – process
  - Non-disruptive & Disruptive

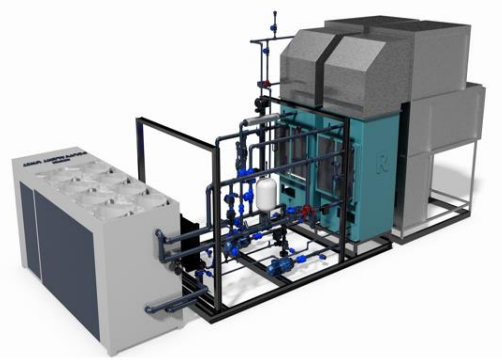




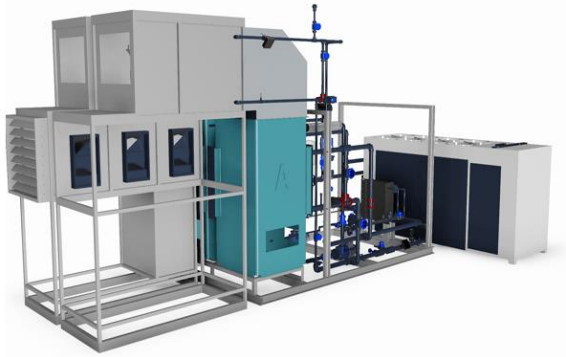
NanoCool

TRL = 8

Developed an innovative Hybrid Liquid Desiccant (HLD) Air Conditioning System with independent temperature and humidity control.



- Key Points
  - Latent load: Removed by a liquid desiccant dehumidifier
  - Sensible load: Removed by a conventional air conditioning system
- Application – building type
  - Refurbishment
  - New buildings
- Application – process
  - Disruptive



NOVEL MATERIALS FOR SMART WINDOWS

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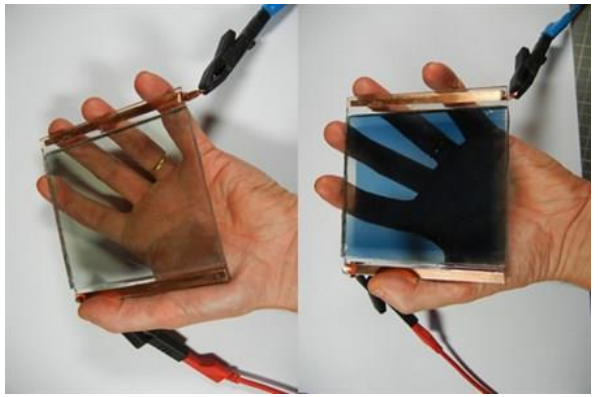
WINSMART

TRL = 5

Develops a new vacuum insulation glazing (VIG) solution combined with a robust switchable glazing system mounted in durable and energy efficient sash and frame.

- Key Points
  - Higher insulation performance
  - Slim & lightweight solution
  - Control functions including switchable optical properties and exterior surface protection (anti-fogging, easy to clean, scratch resistant etc.)
- Application – building type
  - Refurbishment
  - New buildings
- Application – process
  - Disruptive



SMARTBLIND

TRL = 8

Develops a window including a hybrid film constituted of an electrochromic LC film & a photovoltaic film both printed on the same long-lasting flexible substrate.

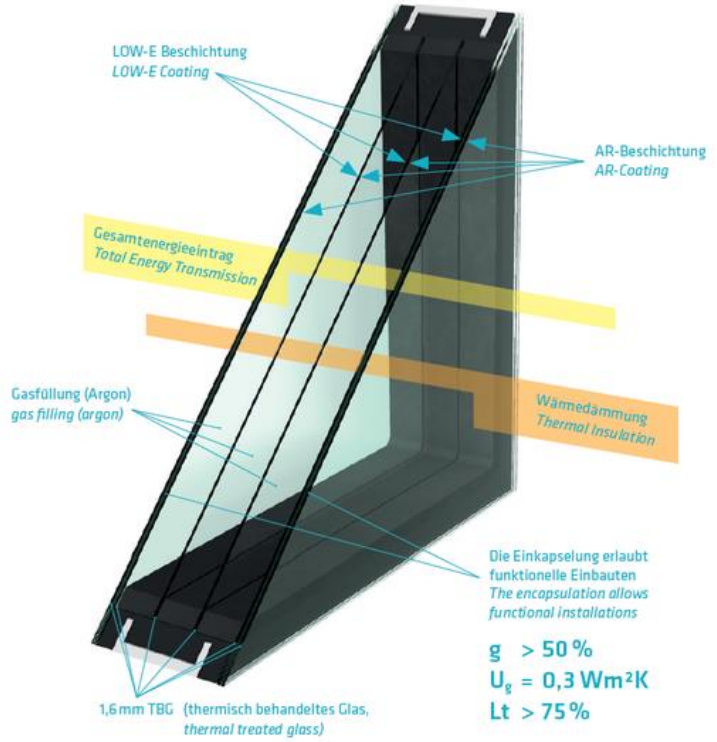
- Key Points
  - Electrochromic and photovoltaic inks especially formulated to be ink-jet printed
  - Lightweight windows
  - Integrated electronic control system with an embedded power source
- Application – building type
  - Refurbishment
  - New buildings
- Application – process
  - Disruptive

MEM4WIN

TRL = 8

Developed quadruple glazing with ultra-thin glass membranes.

- Key Points
  - anti-reflective coating
  - OPV ink for direct printed organic photovoltaic cells
  - micro mirror arrays for control of solar radiation and light guidance
  - solar-thermal collector
- Application – building type
  - Refurbishment
  - New buildings
- Application – process
  - Disruptive



Schnittmuster der neuartigen IG-Einheit | *section of the novel IG-unit*

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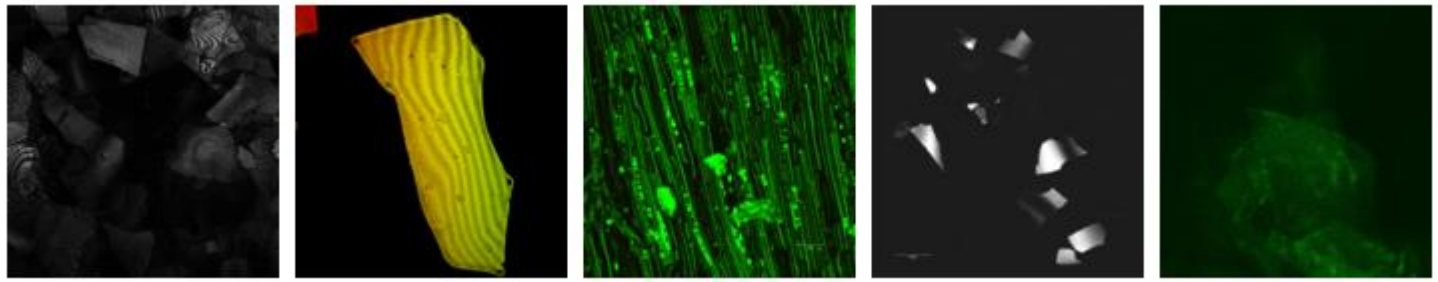
HarWin

TRL = 8

Develops multifunctional glass-polymer windows that harvest solar energy.

- Key Points
  - Lightweight
  - Less thermal conductivity, energy consumption and material usage
  - Additional functionality: window integrated functional coatings with intelligent phase changing materials, novel glass-polymer composites with wavelength management capability
- Application – building type
  - Refurbishment
  - New buildings
- Application – process
  - Disruptive

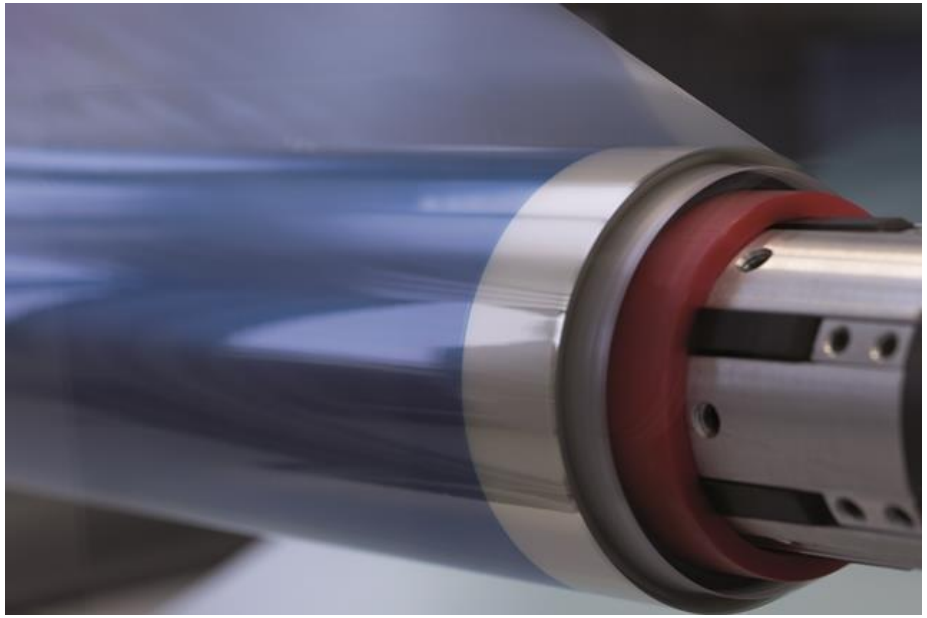


EELICON

TRL = 8

Develops a conductive polymer nanocomposite coating for glass with electro-optical properties that can change its optical absorption properties within seconds.

- Key Points
  - Well suited for the high-throughput production of mechanically flexible and light-weight electrochromic film devices with low energy consumption and fast response, opening the possibility to retrofit existing windows with a dimmable plastic film
- Application – building type
  - Refurbishment
  - New buildings
- Application – process
  - Disruptive



LaWin

TRL = 8

Develops windows that provide highly efficient solar energy harvesting and heat exchange through an active building envelope.

- Key Points
  - Large-area microfluid devices
  - 4 new materials: A structured base glass sheet comprising an array of microchannels, a thin and mechanically robust cover glass, a bonding process and a functional liquid circulating within the microchannels
- Application – building type
  - Refurbishment
  - New buildings
- Application – process
  - Disruptive

http://cordis.europa.eu/result/rcn/192855_en.html

NANOTECHNOLOGIES FOR MULTIFUNCTIONAL LIGHTWEIGHT CONSTRUCTION MATERIALS AND COMPONENTS

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ADAPTIWALL

TRL = 7

Develops a climate adaptive multi-functional lightweight prefab panel suitable for cost-efficient, rapid & energy efficient retrofitting of facades.

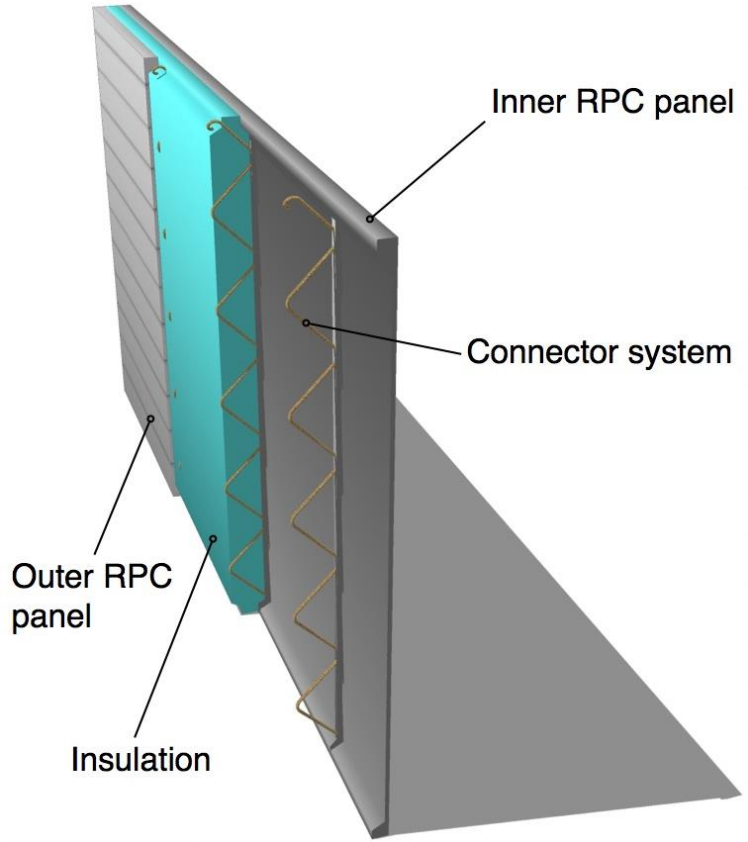
- Key Points
  - Thin, easy and quick to install, lightweight & multi-functional
  - High thermal resistance values in relation to thickness (3D non-wovens and flexible foams)
  - Ventilation system including a heat exchanger component is integrated in the prefab panel
- Application – building type
  - Refurbishment (eventually New Buildings)
- Application – process
  - Non-disruptive

SESBE

TRL = 6-7

Develops thin and low-weight façade elements with integrated insulation for new buildings and for renovation.

- Key Points
  - Sandwich element: Non-flammable, lightweight, mineral based materials, functionalized materials
  - Super hydrophobic surface and alternatively self-cleaning by a photocatalytic, oleophobic layer
  - heat reflective layer
- Application – building type
  - Refurbishment
  - New Buildings



ELISSA

TRL = 8

Develops nano-enhanced lightweight steel skeleton/dry wall systems with improved thermal, vibration/seismic and fire performance.

- Key Points
  - Short building time
  - Light & thin construction
  - high seismic, fire & thermal behaviour of buildings
- Application – building type
  - New Buildings
- Application – process
  - Disruptive

foambuild

TRL = 8

Develops next generation External Thermal Insulation Composite Systems (ETICS) for new builds and retrofitting applications.

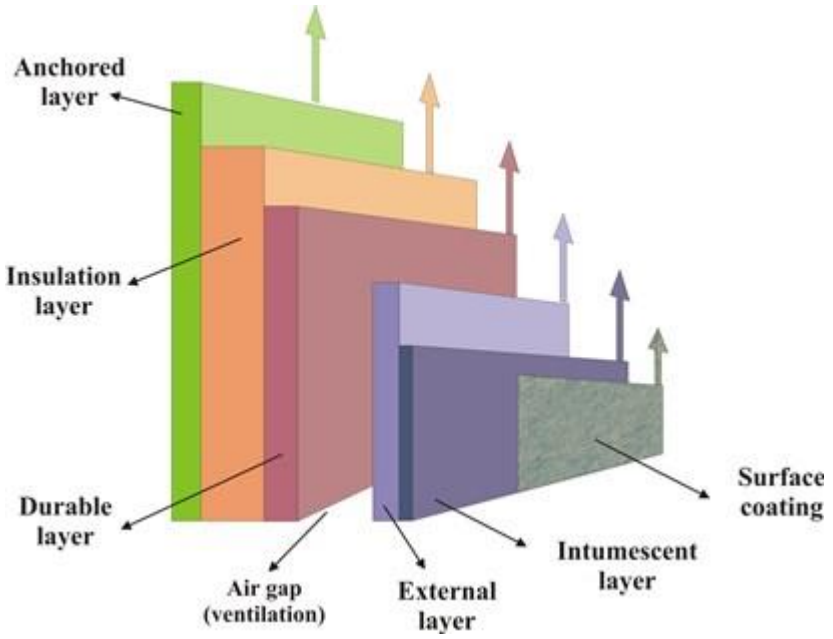
- Key Points
  - Active moisture monitoring and control system
  - Lightweight and highly insulating nano-cellular foams
  - Non-halogenated nano-based flame retardants
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Disruptive

MF-RETROFIT

TRL = 6-7

Develops a light-weight, durable, cost effective and high performance panel.

- Key Points
  - High thermal and acoustic insulation, excellent mechanical properties, up to standards flame retardancy and photocatalytic activity
  - Recycled materials and biomass foams
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Disruptive



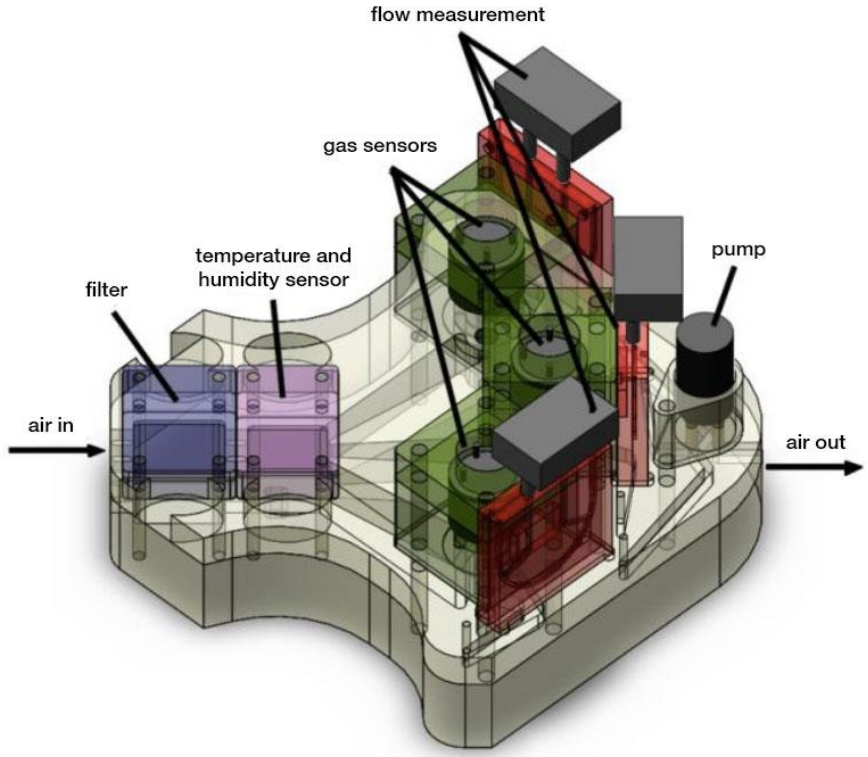
TECHNOLOGIES AND MATERIALS FOR A HEALTHIER INDOOR ENVIRONMENT

INTASENSE

TRL = 8

Develops an indoor air quality monitoring tool to support the efficient use of heating, ventilation and air-conditioning systems.

- Key Points
  - Low cost comprehensive monitoring of key airborne pollutants
  - Intelligent interface with existing ventilation and air treatments systems
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Non-disruptive

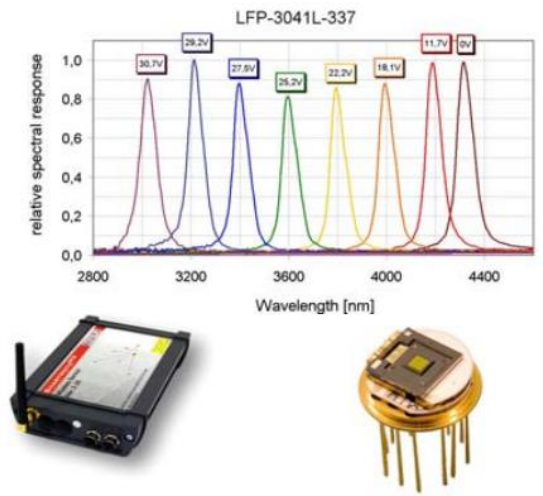


CETIEB

TRL = 8

Develops cost-effective tools for better indoor environment in retrofitted energy efficient buildings.

- Key Points
  - Monitoring platform for advanced sensors (CO2, thermal comfort, light, climate, etc.)
  - VOC and TVOC sensors for smaller concentrations
  - Intelligent control platforms
- Application – building type
  - Refurbishment
- Application – process
  - Non-disruptive

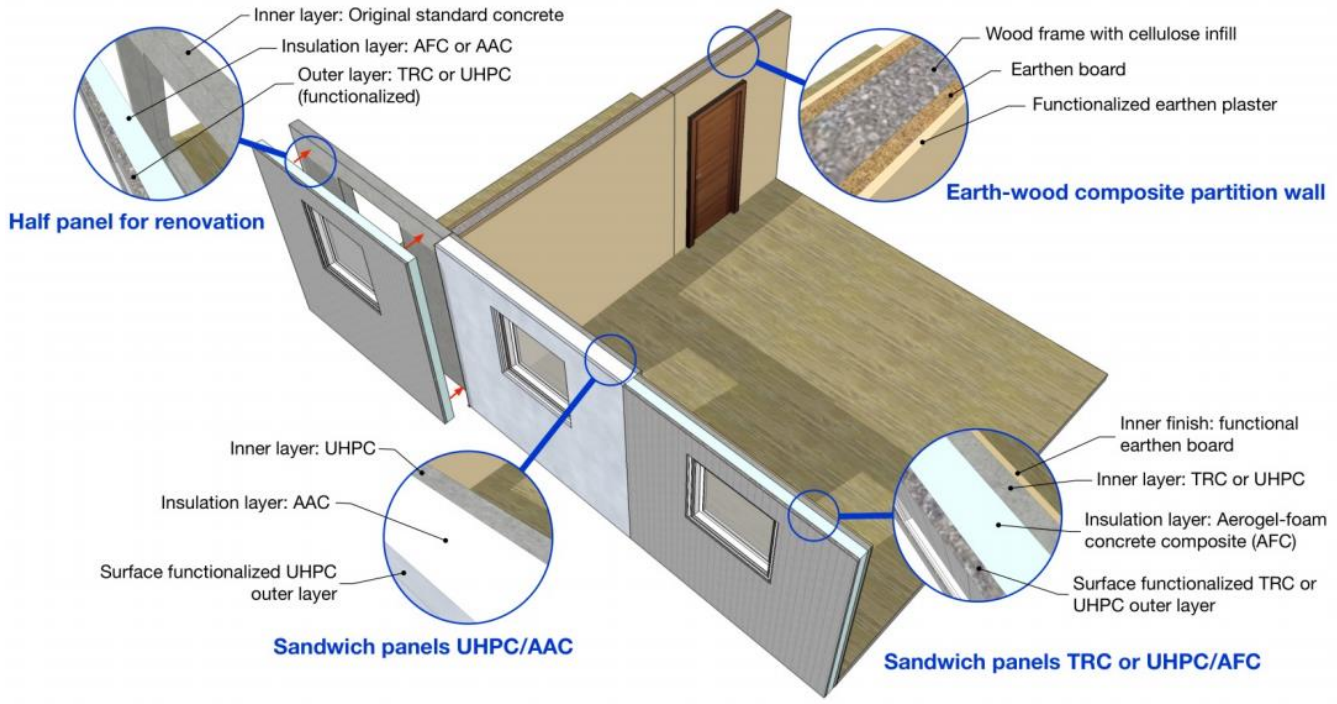


H-house

TRL = 6

Develops new eco-innovative materials and focuses on building components for a healthier indoor environment.

- Key Points
  - Building envelope and the interior
  - Based on earthen materials, optimised cementitious materials with modified surfaces and wooden/cellulose materials
- Application – building type
  - Refurbishment
  - New Buildings



BRIMEE

TRL = 6-7

Develops cost-effective and sustainable bio-renewable indoor materials with high potential for customization and creative design in energy efficient buildings.

- Key Points
  - Nano-Crystalline Cellulose (NCC) based foam, strengthened with natural derived resins → can be profitably extracted from the waste streams of the pulp and paper industry
- Application – building type
  - Refurbishment
- Application – process
  - Disruptive
  - Non-disruptive

OSIRYS

TRL = 6-7

Develops new eco-innovative materials and focuses on building components for a healthier indoor environment.

- Key Points
  - Forest based composites for façades and interior partitions to improve indoor air quality in new builds and restoration → Photocatalytic coatings to improve indoor environment, Biocomposites with good outdoor durability, Graphene additives in biopolymers to improve mechanical and fire performance, Cork insulation for biocomposite panels
- Application – building type
  - Refurbishment
- Application – process
  - Non-disruptive & disruptive

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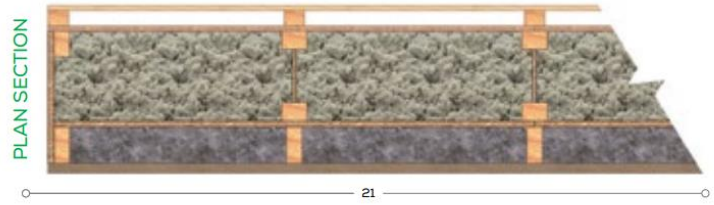
ECO-SEE

TRL = 8

Developed hygrothermal coatings to passively regulate relative humidity levels, modified bio-based insulation materials to capture VOCs and photocatalytic coatings to remove indoor organic pollutants using visible light sources.

- Key Points
  - Natural materials
  - Breath through panel products: interior and exterior
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Disruptive



ICT AND NEW BUSINESS MODELS

NewBEE

TRL = 8

Develops a novel business model generator for energy efficiency in construction and retrofitting.

- Key Points
  - Integration of all actors in the energy-efficiency value chain in the construction industry with ICT tools
  - Financial and organizational aspects can link risk and profitability with performance
  - Wiki, Pre Assesement tool
- Application – building type
  - Refurbishment
- Application – process
  - Non-disruptive

Proficient

TRL = 8

Develops large business opportunities for SMEs in the construction sector.

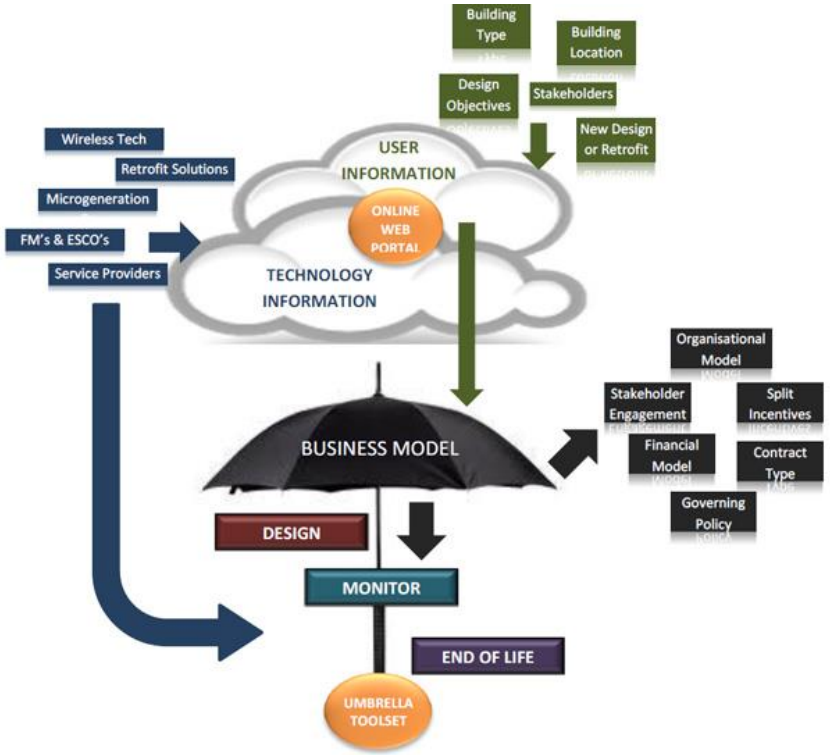
- Key Points
  - Greater certainty of total cost of ownership & lifecycle performance
  - Operation on multiple network levels across the EU
  - Value-chain integration
  - Flexible collaboration with the end-user
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Non-disruptive

Umbrella

TRL = 8

Develops a web-based decision-support application, which provides independent evaluation tools built around adaptable business models.

- Key Points
  - Decision-support tool (Design & Monitoring)
  - Innovative business models
  - The enhanced web-portal database (integrates the energy efficiency measures, the business models and the life stage of your building)
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Non-disruptive



dreeam

DAREED

TRL = 8

Develops an ICT service platform to foster energy efficiency and low carbon activities at neighbourhood, city and district levels.

- Key Points
  - Citizen become active subjects and decisiveness
  - Helps energy companies to define and validate their business strategies and pricing schemes, making them economically viable and, at the same time promote good practice in the use of energy
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Non-disruptive

Decision support
Advisor for innovative business models and useR engagement for smart Energy Efficient Districts

iURBAN

TRL = 8

Develops a software platform that will integrate ICT energy management systems in two European cities.

- Key Points
  - Local Decision Support System (LDSS) will engage consumers and prosumers by capturing near real-time data from installed Distributed Energy Resources
  - Centralized Decision Support System (CDSS) will aggregate data from all LDSSs to provide city-level decision support
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Non-disruptive

iURBAN

Cheaper, cleaner energy services

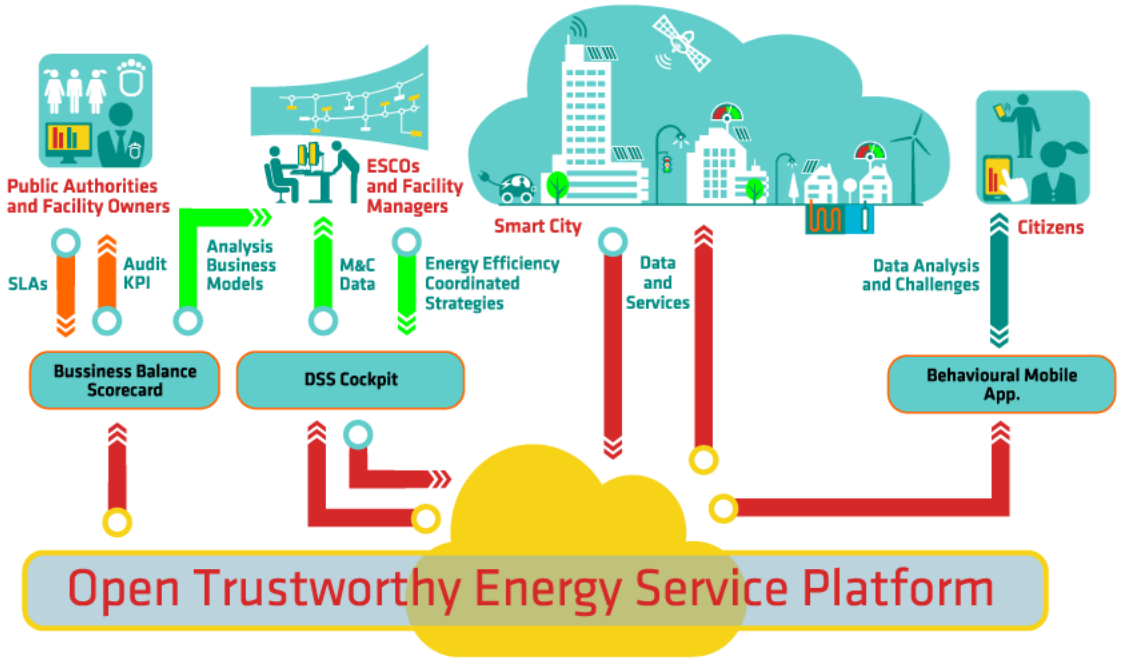
DESIGN, DECISION AND SUPPORT TOOLS FOR ENERGY EFFICIENT BUILDINGS, DISTRICTS AND CITIES

BESOS

TRL = 8

Develops an advanced, integrated, management system which enables energy efficiency in smart cities from a holistic perspective.

- Key Points
  - Share data and services through and open trustworthy platform
  - Processes real-time data and generates valuable analysis
- Application – building type
  - New Buildings
  - Refurbishment
- Application – process
  - Non-disruptive



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Design4Energy

TRL = 7-8

Develops a building life-cycle evolutionary design methodology able to create energy-efficient buildings flexibly connected with the neighborhood energy system.

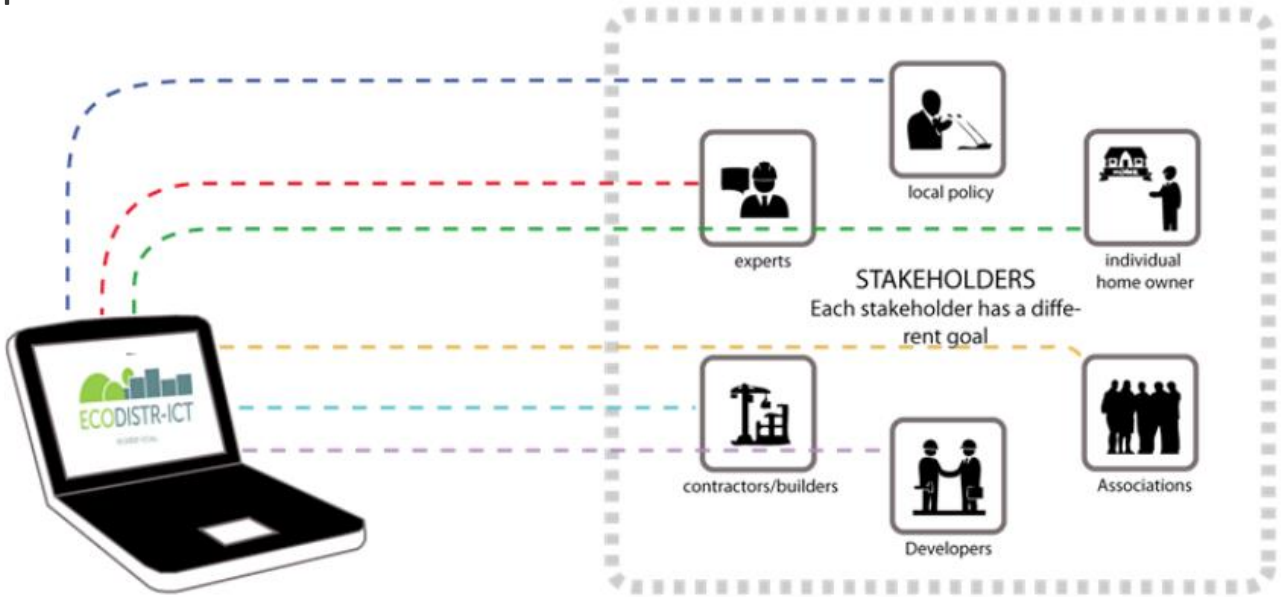
- Key Points
  - Mapping of the building design solutions
  - Includes energy attributes of building components, deterioration of building components and systems, neighborhood energy systems, energy related parameters, energy simulation tools and current usage parameters of the tenants → qualified choices as early as possible
- Application – building type
  - New Buildings
  - Refurbishment
- Application – process
  - Non-disruptive

ECODISTR-ICT

TRL = 8

Developed a modular, open source software platform to support decision-making processes for district renovation.

- Key Points
  - Integration of district energy solutions, important social, economic and environmental considerations into the process
  - Multiple stakeholders on multiple scales
- Application – building type
  - Refurbishment
- Application – process
  - Non-disruptive

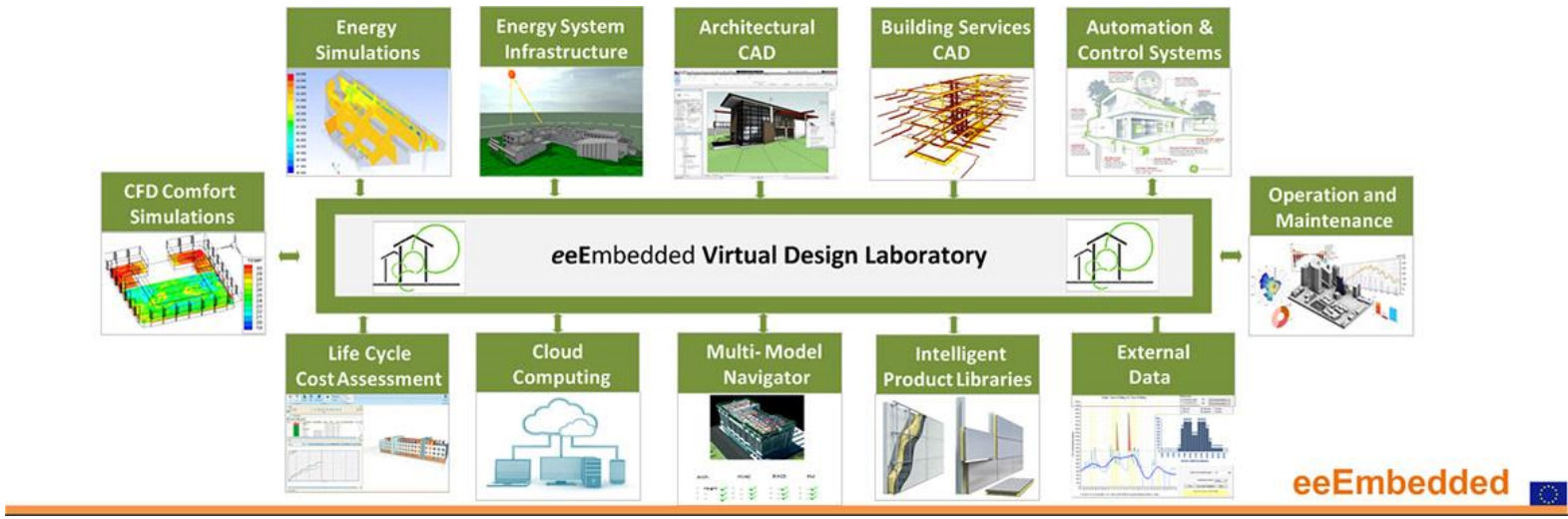


eeEmbedded

TRL = 8

Develops an open BIM-based holistic collaborative platform, methodology, energy system information model and an integrated information management framework.

- Key Points
  - For designing energy-efficient buildings and their optimal energetic embedding in the neighbourhood of surrounding buildings and energy systems
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Non-disruptive

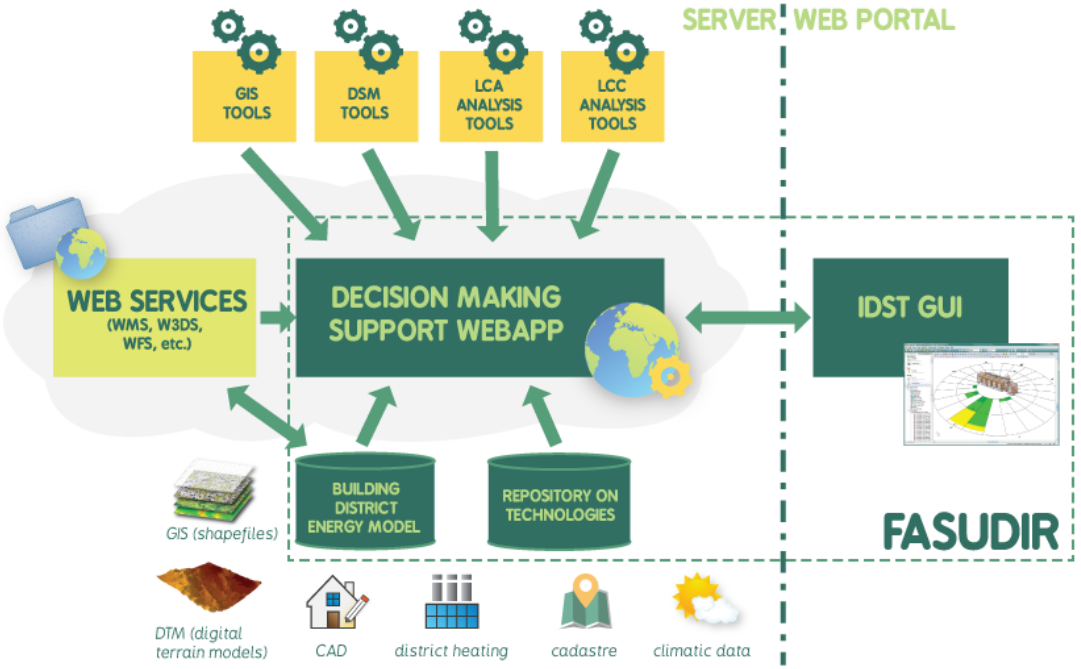


FASUDIR

TRL = 8

Develops new business models and financial supporting tools.

- Key Points
  - Integration of the Integrated Decision Support Tool → on-line calculations concerning the possible retrofitting technologies and mechanisms on building/district level by taking into consideration different technological scenarios
- Application – building type
  - Refurbishment
- Application – process
  - Non-disruptive



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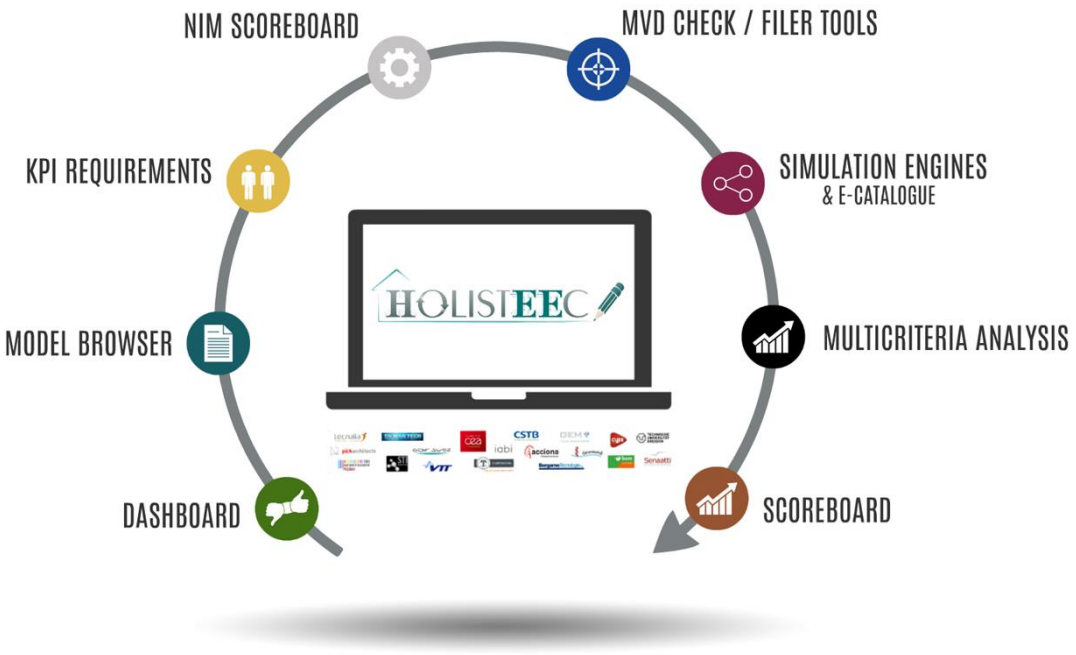
HOLISTEEC

TRL =

Develops, designs and demonstrates a BIM-based, on-the-cloud, collaborative building design software platform.

- Key Points
  - Integration of the Integrated Decision Support Tool → on-line calculations concerning the possible retrofitting technologies and mechanisms on building/district level by taking into consideration different technological scenarios
- Application – building type
  - Refurbishment
- Application – process
  - Non-disruptive



READY4SmartCities

TRL =

Develops, designs and demonstrates a BIM-based, on-the-cloud, collaborative building design software platform.

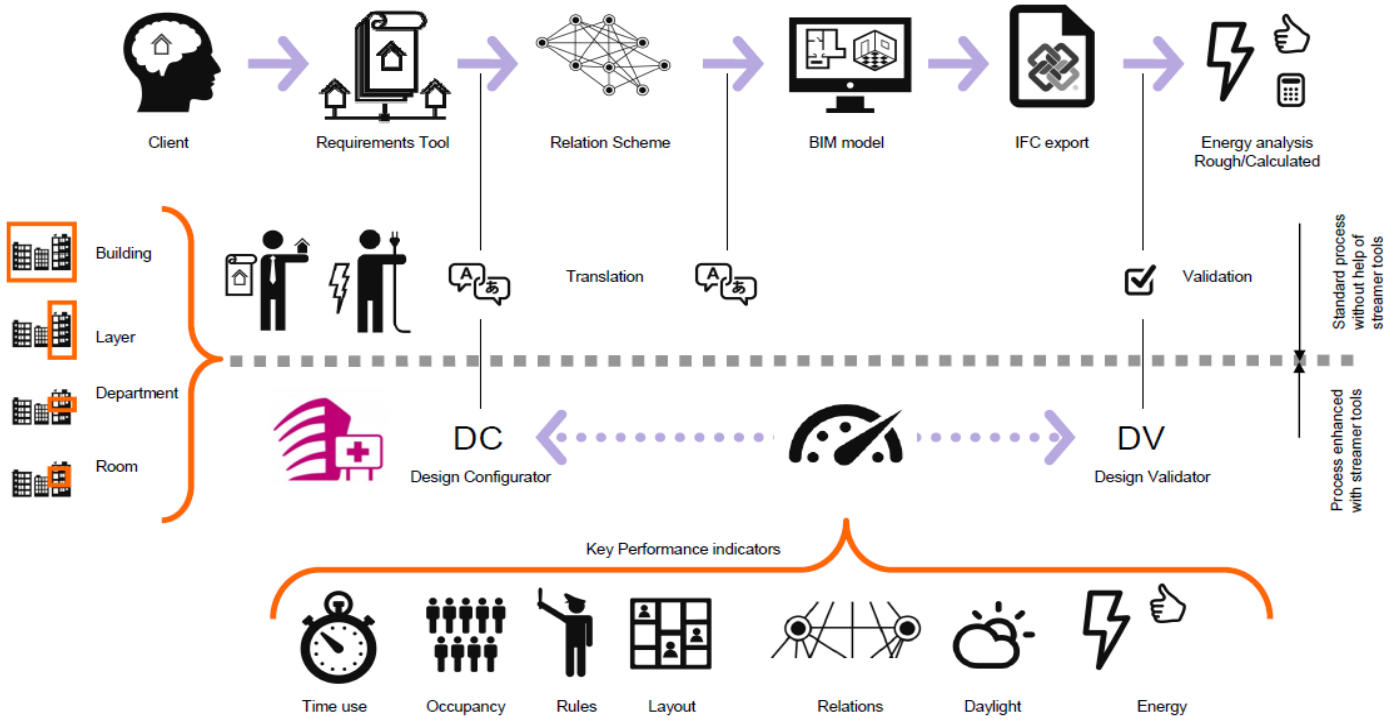
- Key Points
  - Integration of the Integrated Decision Support Tool → on-line calculations concerning the possible retrofitting technologies and mechanisms on building/district level by taking into consideration different technological scenarios
- Application – building type
  - Refurbishment
- Application – process
  - Non-disruptive

Streamer

TRL = 7-8

Develops a design decision-support tool for new EeB & refurbishments in a healthcare district.

- Key Points
  - Interoperable BIM and GIS model
  - Analysis of energy performance; lifecycle-cost; functional optimization; stakeholder's & user's requirements, decision criteria and priorities
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Non-disruptive

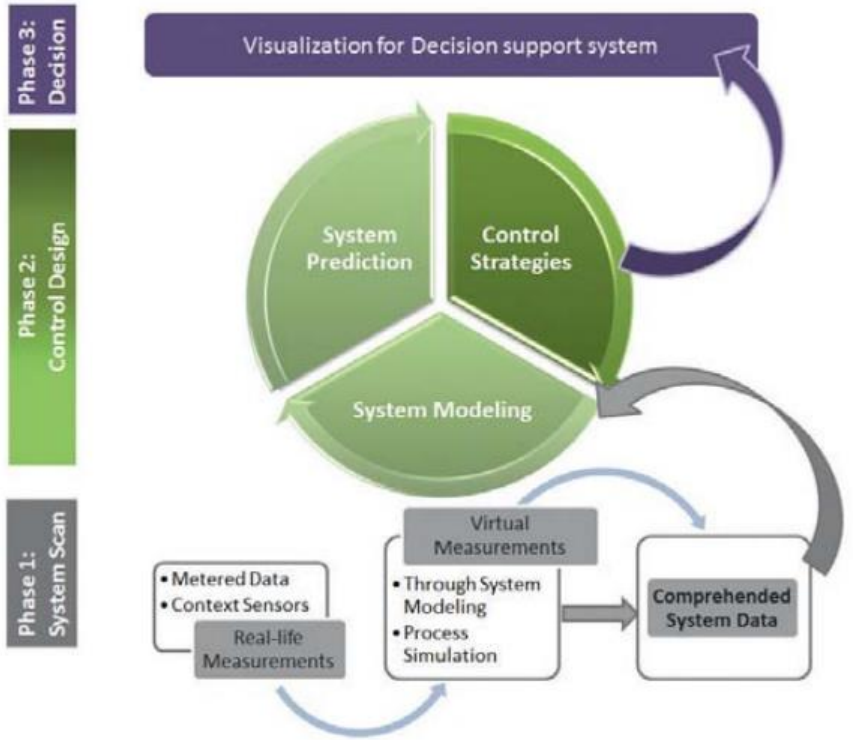


OrPHEuS

TRL = 8

Develops solutions for optimizing the interaction among multiple energy grids which are connected through coupling points and defined as hybrid energy grids.

- Key Points
  - Five main energy hybridization scenarios
  - Extended hybrid energy network modelling of cities' hybrid energy networks
- Application – building type
  - Refurbishment
- Application – process
  - Non-disruptive



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ENERGY PERFORMANCE MONITORING AND MANAGEMENT OF ENERGY EFFICIENT BUILDINGS

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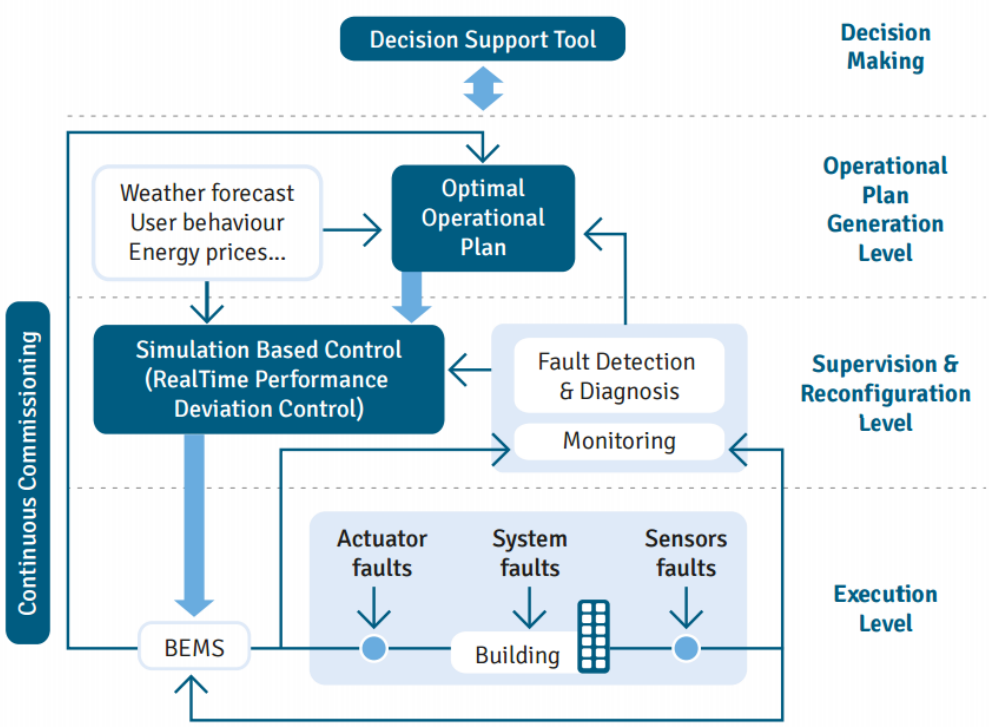
Energy IN TIME

TRL = 7-8

Develops a Smart Energy Simulation Based Control method which will reduce the energy consumption.

- Key Points
  - Real-time control of energy system performance deviations & adjustment of the operational plan execution
  - Remote and automatic operation of the HVAC systems
  - Automatic generation of optimal operational plans for the HVAC systems
- Application – building type
  - Refurbishment (non-residential)
- Application – process
  - Non-disruptive



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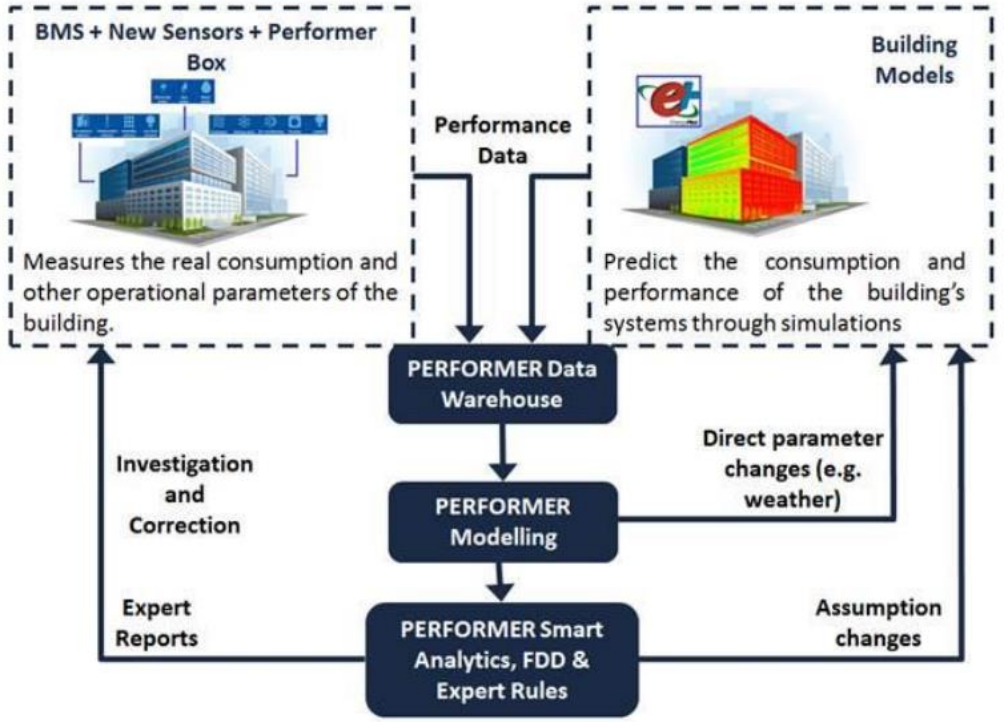
PERFORMER

TRL = 7-8

Develops an innovative and comprehensive solution towards improved building energy management & guaranteed energy performance.

- Key Points
  - Energy Instrumentation Kit → Establishment of energy performance accounts during operation and retrofit / post-retrofit stages
  - Secure and monitored data storage and simulation facility for in-house or outsourced
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Non-disruptive



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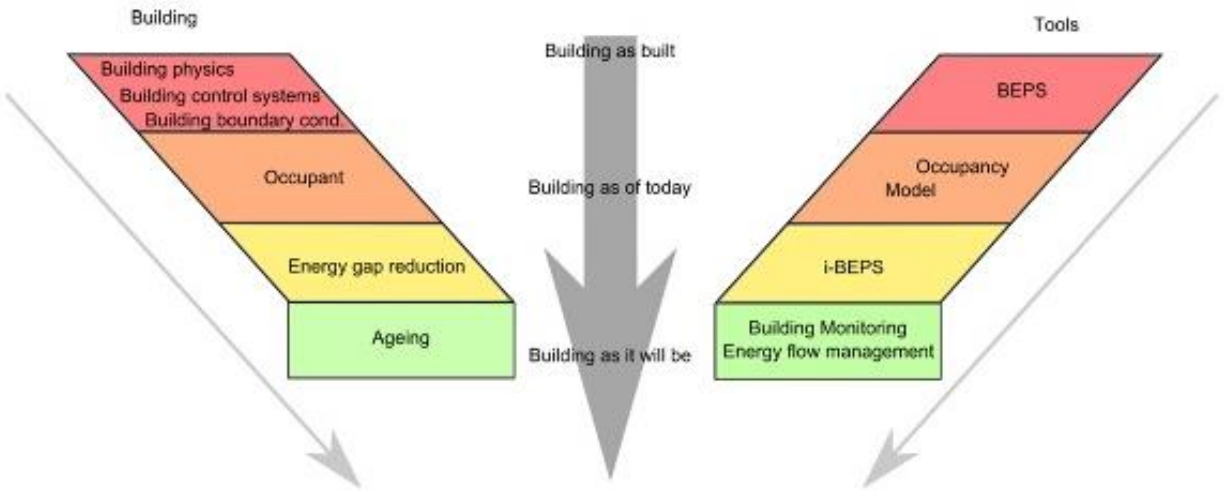
TRIBUTE

TRL = 7-8

Improves the predictive capability of a commercial BEPS by minimizing the gap between computed and measured energy performances.

- Key Points
  - Unique level of repeatability and reliability of i-BEPS
    → Setting up a new European legislative framework
  - Significantly fast and precise retrofit decision tool
  - Improved energy flow management
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Non-disruptive



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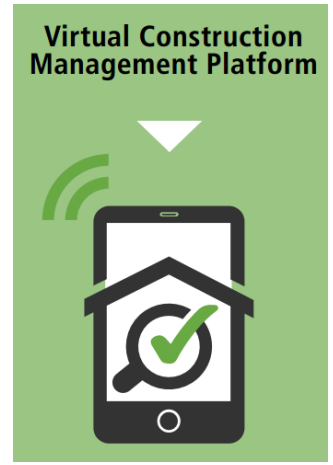
Built2SPEC

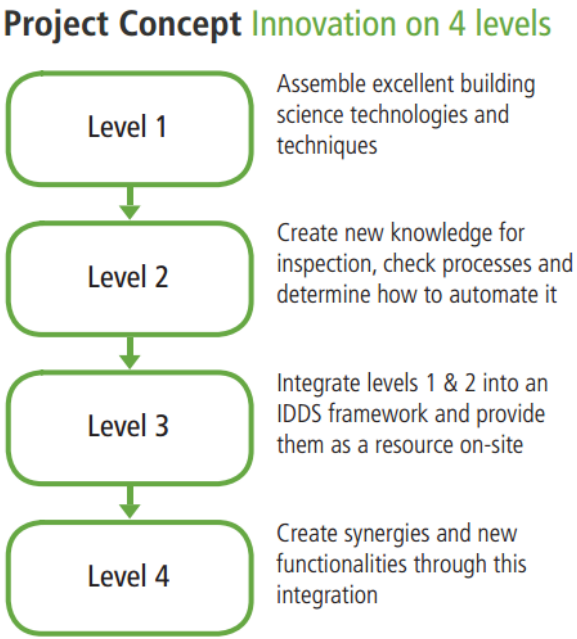
TRL = 7-8

Develops a new and innovative on-site quality assurance tools.

- Key Points
  - Technological advances: 3D and Imagery Tools, Building Information Modeling (BIM), Smart Building Components, Energy Efficiency Quality Checks, Indoor Air Quality Tools, Airtightness Test Tools with air-pulse checks, Thermal Imaging Tools, Acoustic Tools

  → Connected in a Virtual Construction Management Platform
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Non-disruptive





INSITER

TRL = 6-7

Develops an intuitive and cost-effective Augmented Reality that connects the virtual model and the physical building in real-time.

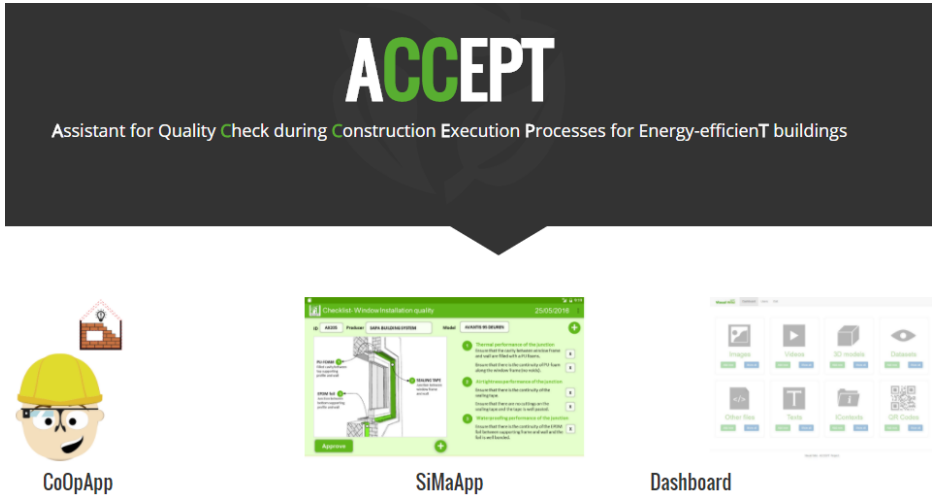
- Key Points
  - Self inspection during construction, refurbishment, maintenance and commissioning
  - Ensures that the targeted performance in the design model is realized
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Non-disruptive

ACCEPT

TRL = 6

Develops an intuitive and cost-effective Augmented Reality that connects the virtual model and the physical building in real-time.

- Key Points
  - CoOpApp: collects data and actively provides guidance to the worker on site during the building process
  - SiMaApp: allows to remotely coordinate the working process as well as collect additional data on site by different sensors
  - An interactive web-based Dashboard as a monitoring and quality assurance solution
- Application – building type
  - New Buildings
- Application – process
  - Non-disruptive



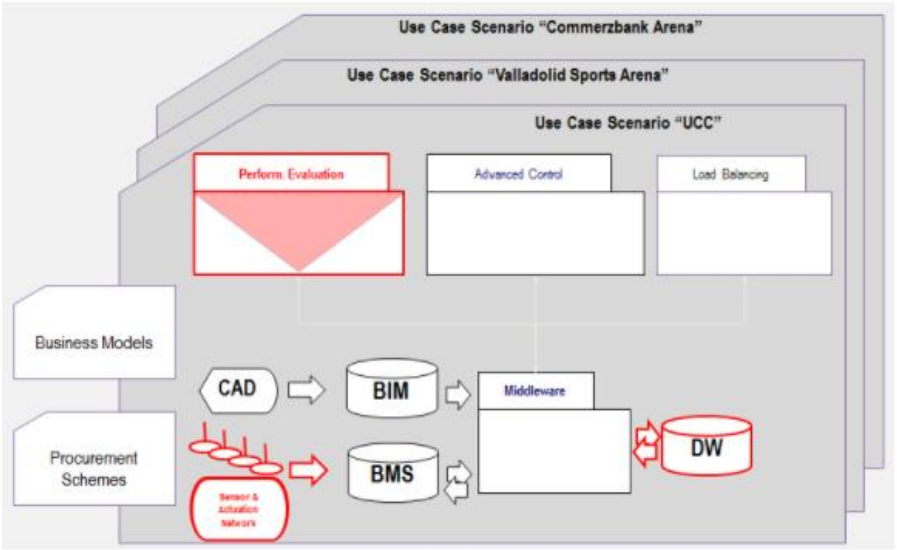
ENERGY PERFORMANCE MONITORING AND MANAGEMENT AT DISTRICT AND CITY LEVELS

CAMPUS21

TRL = 8

Develops a Hardware-Software Platform for the integration of existing ICT-subsystems.

- Key Points
  - Supports energy, building, and security systems management
  - Cross-sectorial, interdisciplinary innovation convergence: Germany, Ireland, Austria & Spain
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Non-disruptive



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AMBASSADOR

TRL = 8

Develops systems and tools that will optimize the energy usage of a district by managing the energy flows and predicting energy consumption & production.

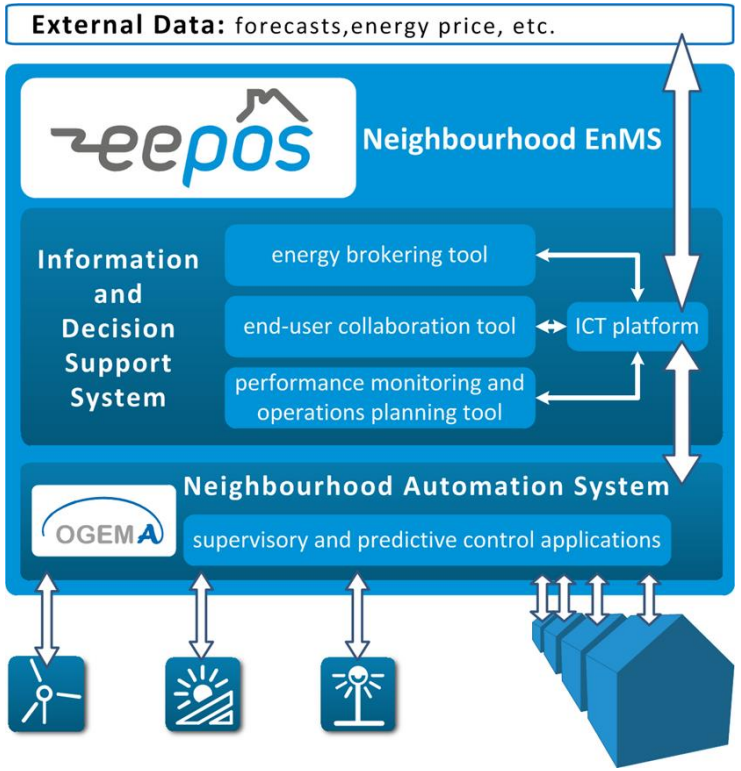
- Key Points
  - District Energy Management and Information System: Coordinates each actor of the district, in order to implement a new mission for the whole district
  - Flexibility embedded into the systems is exploited on priority
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Non-disruptive

EEPOS

TRL = 8

Develops tools for energy optimisation and end user involvement to improve the management of energy generation and consumption on the neighbourhood level.

- Key Points
  - The Information and Decision Support System which supports stakeholders with additional management tools
  - The Neighbourhood Automation System for automated control and management of loads
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Non-disruptive



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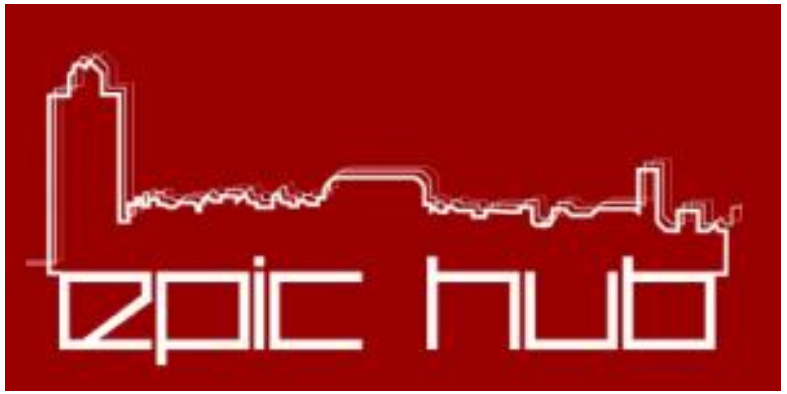
EPIC-HUB

TRL = 8

Develops a new methodology, an extended architecture and services able to provide improved Energy Performances to Neighbourhoods (NBH).

- Key Points
  - “Neighbourhood-aware" energy trading platform
  - Combination of powerful Energy-Hub-based Energy Optimization capabilities with seamless integration of pre-existing and new ICT systems
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Non-disruptive



IDEAS

TRL = 8

Provides tools for optimising energy management, energy trading and urban planning within Energy Positive Neighbourhoods.

- Key Points
  - Neighbourhood energy management tool
  - User interfaces: Tool to engage communities and individuals in the operation
  - Decision support urban planning tool
  - Business models: Models to underpin energy positive neighbourhoods
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Non-disruptive

NRG4Cast

TRL = 8

Developed an open dynamic system for holistic energy management of the dynamics of energy supply, demand and storage in urban areas.

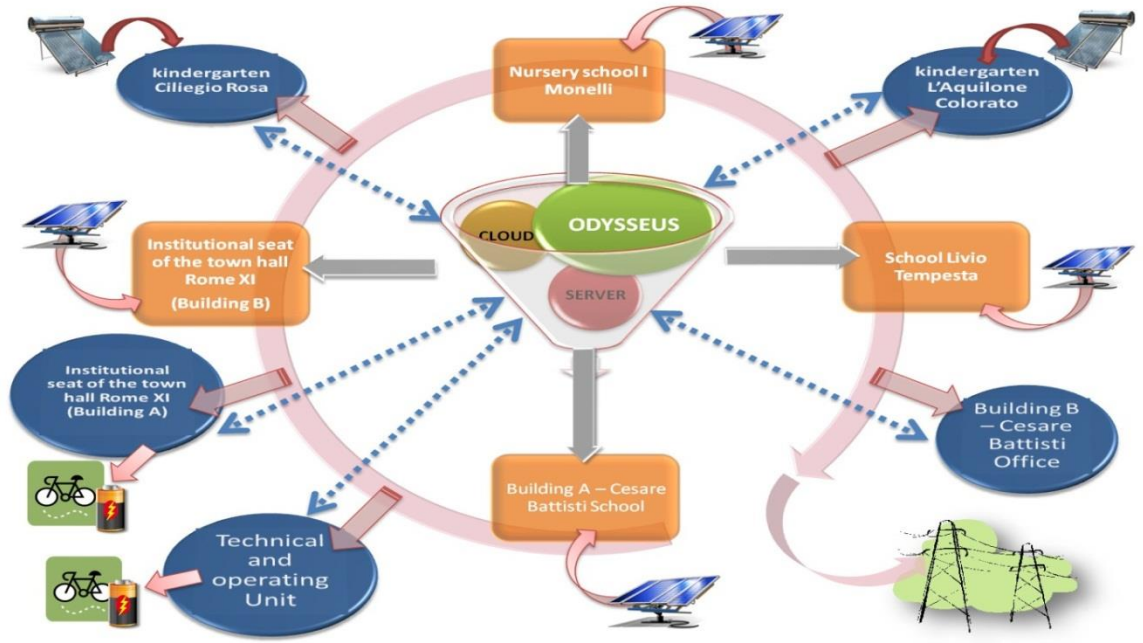
- Key Points
  - Holistic energy management
  - Monitoring of energy nodes
    → long-term decision support
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Non-disruptive

ODYSSEUS

TRL = 8

Developed an open dynamic system for holistic energy management of the dynamics of energy supply, demand and storage in urban areas.

- Key Points
  - Holistic energy management
  - Monitoring of energy nodes
    → long-term decision support
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Non-disruptive



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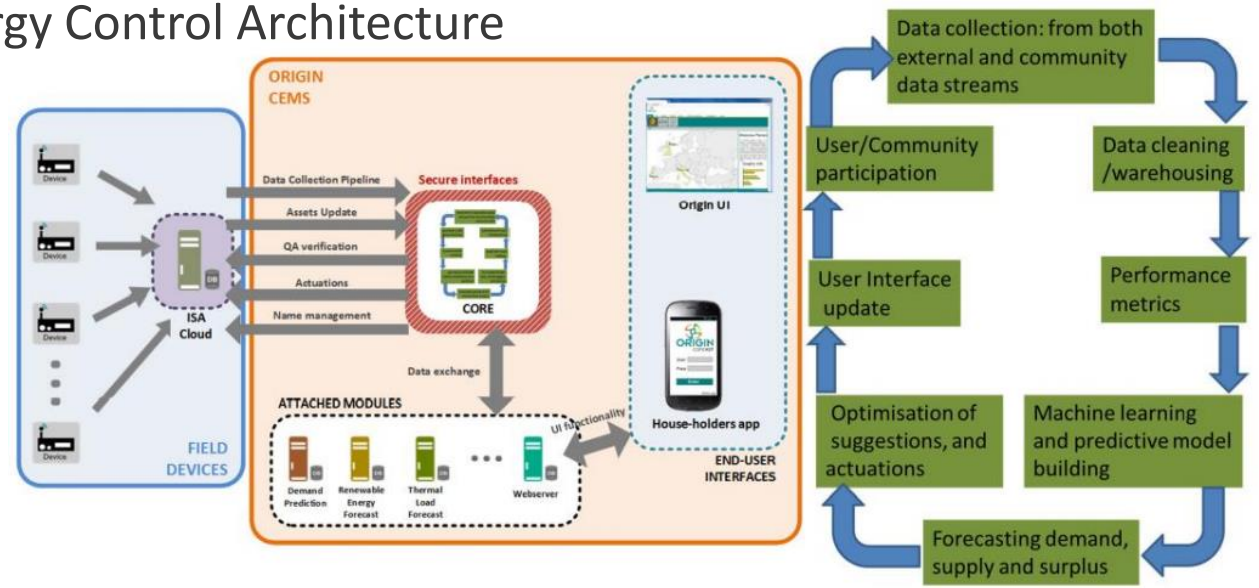
ORIGINconcept

TRL = 8

Developed a sophisticated intelligent ICT system for the management of energy in a community.

- Key Points
  - New software technology for achieving demand-response from community-level actions
  - New software technology for accurate localized short-term weather forecasting
  - End-to-end operation of a new breed of Energy Control Architecture
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Non-disruptive



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RESILIENT

TRL = 8

Developed a new integrated concept of interconnectivity between buildings, DER, grids and other networks at a district level.

- Key Points
  - Smart ICT components
  - Optimized energy generation and storage technologies
  - Real time accounts of energy demand and supply at a district level
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Non-disruptive

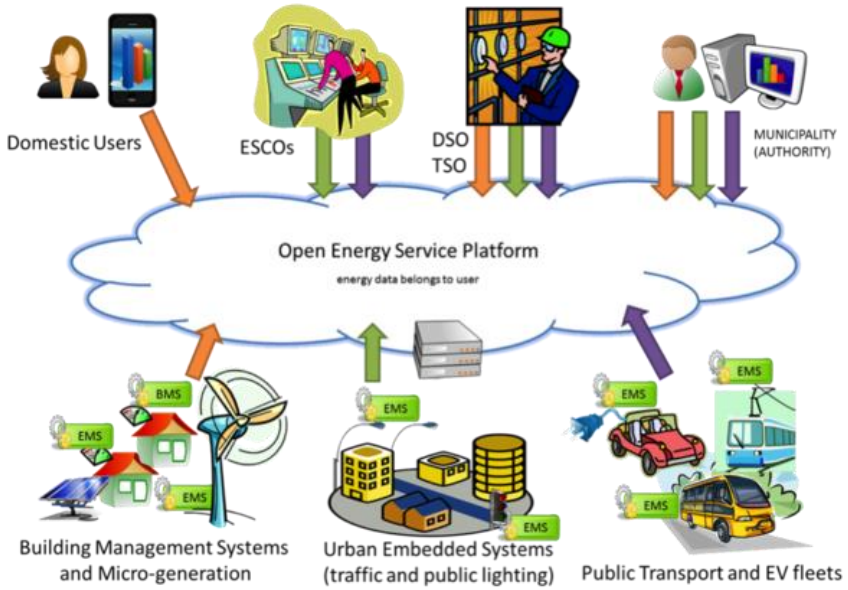
RESILIENT

SmartKYE

TRL = 8

Developed a system for the future smart grid neighbourhood that will enable better business decisions to be made based on real-time fine-grained data.

- Key Points
  - Service oriented architecture information model and interface
  - Open energy services platform integration with the different energy management systems
  - Business and monitoring & control oriented cockpit
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Non-disruptive



CITYOPT

TRL = 8

Developed a set of applications and guidelines that support efficient planning, detailed design and operation of energy systems in urban districts.

- Key Points
  - Planning tool: support analysing, simulating, optimizing and communicating city planning alternatives
  - Operational tool: increase optimisation opportunities related to user behaviour, like residential demand response schemes for inhabitants to participate in online-optimization
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Non-disruptive

CITYOPT

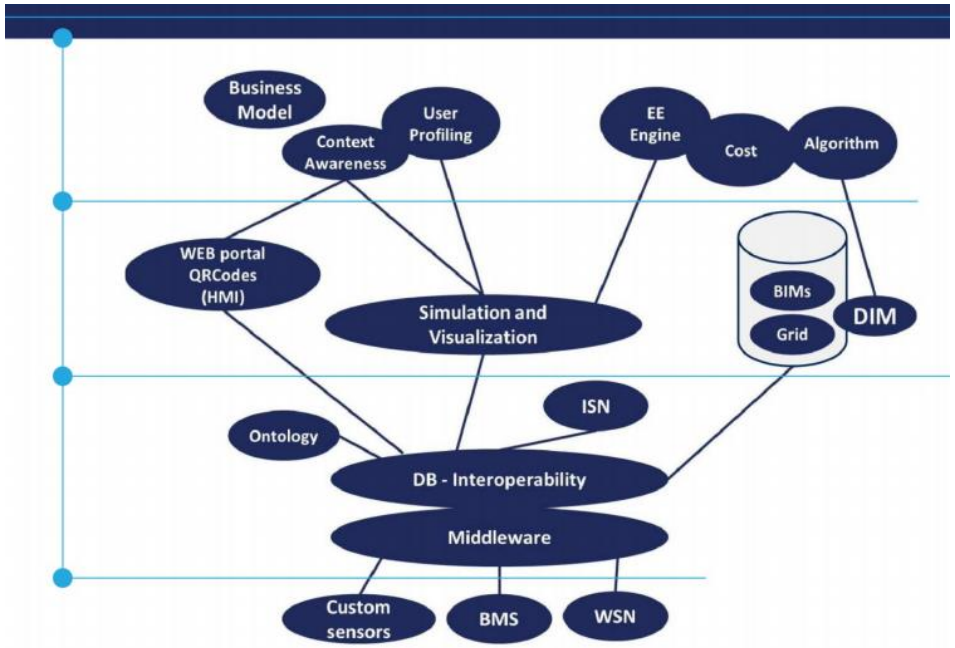
Holistic simulation & optimisation of energy systems in Smart Cities

DIMMER

TRL = 8

Developed a tool to analyze and correlate buildings utilization and provide real-time feedback about energy-related behaviors.

- Key Points
  - Integration of BIM and district level 3D models with real-time data from sensors and user feedback
  - Tools: benchmarking tool, dashboard, district visualizer
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Non-disruptive



e-balance

TRL = 7-8

Aims to address environmental problems by considering the different aspects of the energy efficiency in present and future smart cities.

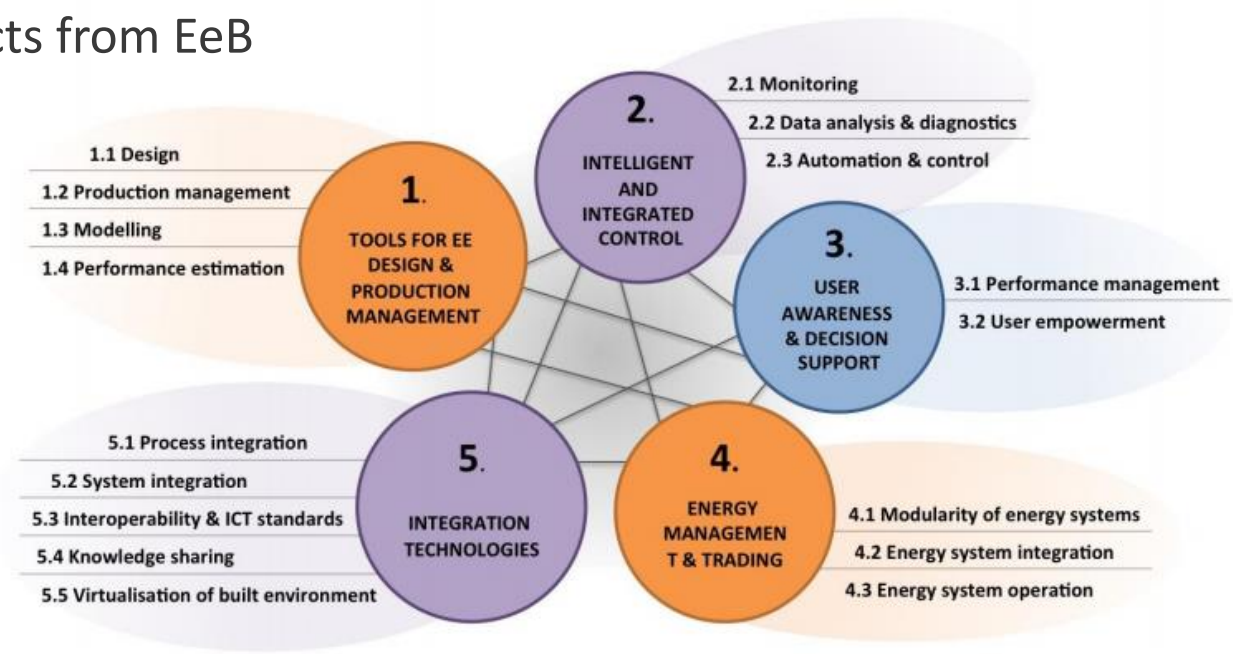
- Key Points
  - Flexible and holistic technical solution
  - Integration of: Distributed energy resources; Fractal-like system, fractal-like solutions; Security and Privacy technology; Business models for smart-grids; Social analysis: smart-grids for people
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Non-disruptive

EEbers

TRL = 8

Identify opportunities for synergies in Information and Communication Technologies related Research Technology Development in the EeB domain.

- Key Points
  - Mapping of EeB domains
  - Consolidation of results and expected impacts from EeB projects
  - Recommendations for future EeB priorities
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Non-disruptive



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SWIMing

TRL = 8

Develops a new linked open data based BIM cloud to manage the data generated across the building life cycle of relevance to building energy management.

- Key Points
  - Tools: LBD Wiki, Use Case Classification Overview, BIM*Q Tool
  - Analyse of more than 100 EeB Projects → guidelines and milestones in future work in EeB
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Non-disruptive

LOW CARBON AND EFFICIENT ENERGY GENERATION SYSTEMS FOR BUILDINGS AND DISTRICTS

dreeam

HEAT4U

TRL = 8

Implements the gas absorption heat pump technology in the area of single-family detached residential homes.

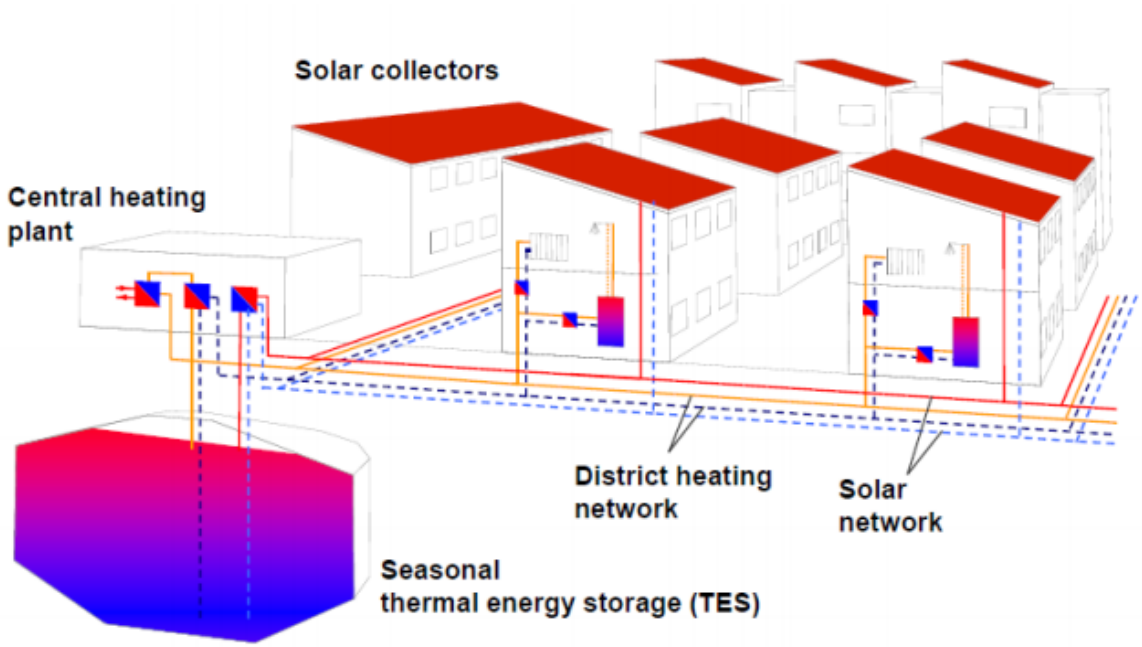
- Key Points
  - Absorption heat pump powered by natural gas and air-source renewable energy (GAHP)
- Application – building type
  - Refurbishment
  - New Buildings
- Application – process
  - Non-disruptive

EINSTEIN

TRL = 8

Develops a low energy heating system based STES systems in combination with Heat Pumps (DHW) requirements for existing buildings.

- Key Points
  - Integration between Seasonal Thermal Energy Storage (STES) systems & Heat Pumps for space heating and domestic hot water (DHW)
  - Decision Support Tool (DST) for selection, design and evaluation of STES
- Application – building type
  - Refurbishment (existing buildings)
- Application – process
  - Non-disruptive



CREATE

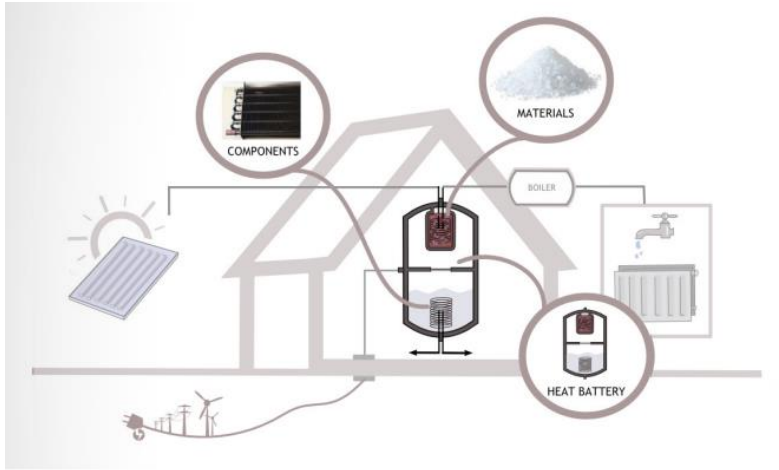
TRL = 5

Develops a heat battery based on Thermo-Chemical Materials (TCMs), that enables economically affordable, compact and loss-free storage of heat.

- Key Points
  - Decentral thermal energy storage bridging supply and demand of renewable thermal energy
  - Decentral grid-connected storage for increasing energy efficiency and introducing flexibility in the electricity grid, e.g. using a heat pump
- Application – building type
  - Refurbishment (existing buildings)
- Application – process
  - Non-disruptive

CREATE©

Compact REtrofit Advanced Thermal Energy storage



TESSe2b

TRL = 5

Develops a thermal storage technology based on solar collectors and geothermal heat pumps for heating, cooling and domestic hot water (DHW) production.

- Key Points
  - Optimize performance for high efficiency PCM TES tank and enhanced PCM borehole heat exchangers
  - New nano-composite enhanced paraffin PCM
- Application – building type
  - Refurbishment (existing buildings)
- Application – process
  - Non-disruptive

NEW HIGH PERFORMANCE ENERGY-EFFICIENT BUILDINGS

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BUILDSMART

TRL = 8

Demonstrates and mainstreams cost effective techniques and methods for constructing very low energy buildings in European.

- Key Points
  - Varies climates: north, central and south
  - Large scale deployment of the used methods can be implemented in the recast of the EPBD II
- Application – building type
  - New Buildings
- Application – process
  - Non-disruptive

DIRECTION

TRL = 8

Aims at demonstrating how the use of very innovative & cost-effective energy efficiency technologies can lead to the achievement of low energy new buildings.

- Key Points
  - Enhancing building Envelope and architectural solutions
  - New control algorithms in order to improve the "intelligence" of building energy management system (BEMS)
  - Optimized IDP (Integration Design Process) procedures
- Application – building type
  - New Buildings
- Application – process
  - Non-disruptive

DIRECTION
DEMONSTRATION OF VERY LOW ENERGY NEW BUILDINGS

NEED4B

TRL = 7

Demonstrates cost-effective and energy efficient technologies and methods for the design, construction and operation of very low energy new buildings.

- Key Points
  - Broadly applicable in Europe
  - Open methodology for designing, constructing and operating very low energy new buildings
- Application – building type
  - New Buildings
- Application – process
  - Non-disruptive

NEXT-Buildings

TRL = 7-8

Demonstrates very low-energy buildings, where in all demonstrations, the ambition is net zero carbon/energy or better (active or plus-energy house).

- Key Points
  - large scale implementation of energy neutral buildings/neighbourhood
  - 1. Reduce demand; 2. Sustainable heat; 3. Local renewables for residual demand
- Application – building type
  - New Buildings
- Application – process
  - Non-disruptive

DEEP ENERGY RENOVATION OF EXISTING BUILDINGS

School of the Future

TRL = 7-8

Develops designs and disseminates good examples of high performance buildings.

- Key Points
  - Holistic retrofits of the building envelope & service systems
  - Integration of renewables and management systems
- Application – building type
  - Refurbishment (Public)
- Application – process
  - Disruptive

EASEE

TRL = 7-8

Develops a tool-kit for envelope retrofitting.

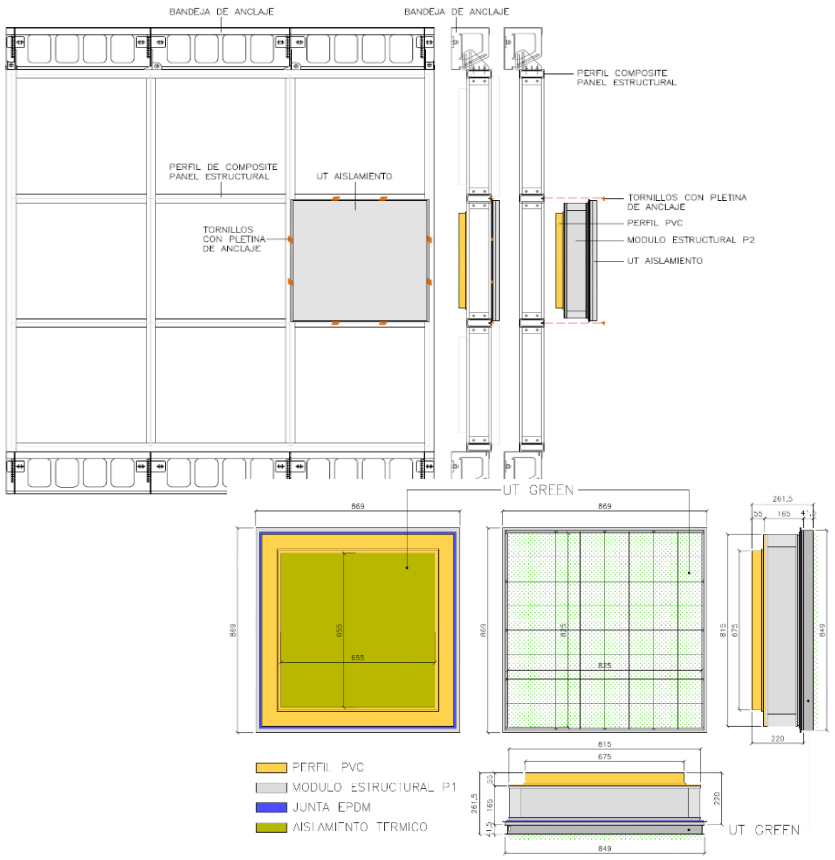
- Key Points
  - 3 main components: Outer façade, cavity walls and interiors
  - Innovative design & technical solutions
  - Novel assessment strategies
  - Scaffolding-free installation approach
  - Reducing duration and optimizing the worksite in general
- Application – building type
  - Refurbishment (Residential built between 1925-1975)
- Application – process
  - Non-disruptive

MEEFS Retrofitting

TRL = 8

Develops, evaluates and demonstrates a multi-functional facade system.

- Key Points
  - Structural Panel in Composite (Included Anchorage System)
  - Structural Module (Base system for the Technological Units)
  - Technological Units (Certified: thermal insulation panel/ ventilated facade/ green facade/ solar protection facade/ advanced passive solar protector and energy absorption unit/ advanced passive solar collector and ventilation unit)
- Application – building type
  - Refurbishment (Residential)
- Application – process
  - Non-disruptive



HERB

TRL = 7-8

Creates framework for demonstration and dissemination of very innovative retrofit technologies.

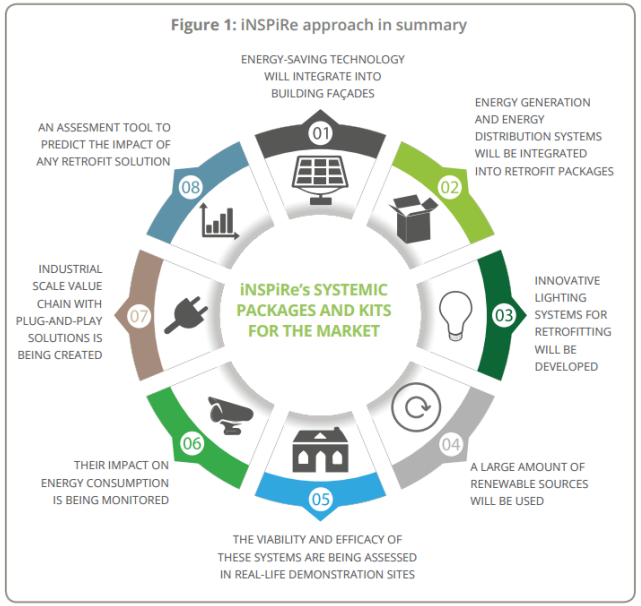
- Key Points
  - Optimisation and modelling of best-suited renovation concepts
  - Technologies: Vacuum Tube Window, Self Cleaning Coating, Phase Change Materials, Aerogel VIPs, Passive zenithal light guides, PV Systems-Façade, Solar Thermal Heating Systems, Air to Water Heat Pump
  - Computer models: For optimization of components for each technology and solution, for dynamic simulation of energy demand and supply & for simulation of the indoor environment
- Application – building type
  - Refurbishment (Residential)

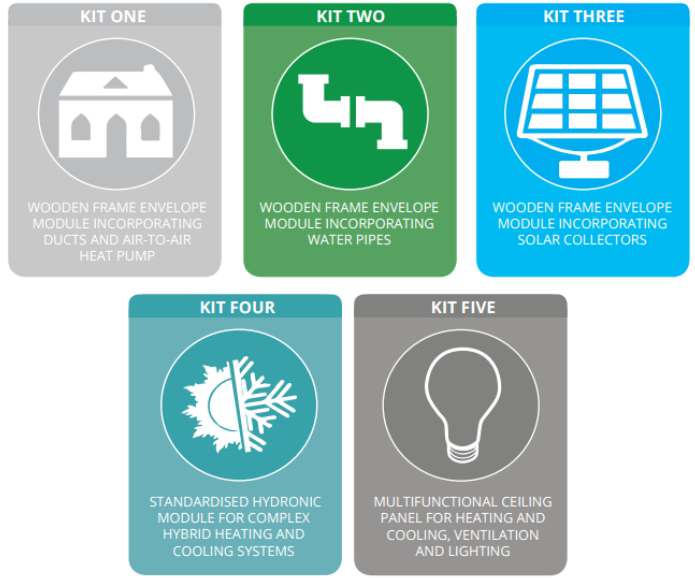
iNSPiRE

TRL = 8

Develops systemic renovation packages, applicable in different climates.

- Key Points
  - Large replication potential
  - Multifunctional renovation kits (innovative envelope technologies, energy generation systems, energy distribution)
- Application – building type
  - Refurbishment (Residential)
- Application – process
  - Disruptive





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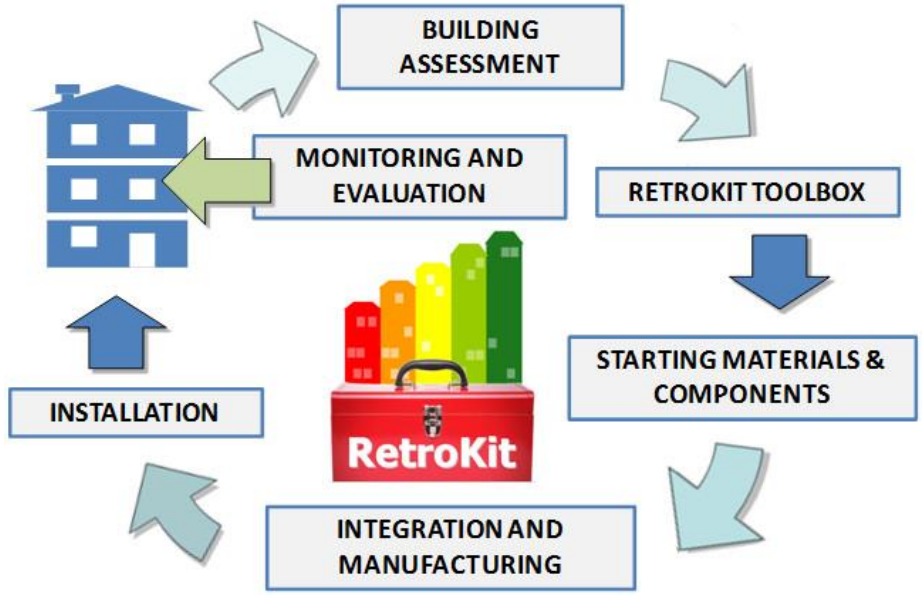
RetroKit

TRL = 7-8

Develops multifunctional, modular, low cost and easy to install prefabricated modules.

- Key Points
  - Multifunctional façade and roof elements
  - Window element accompanied with a technical box taking in HVAC and interfaces for building services
- Application – building type
  - Refurbishment (Residential “multi-family” built between 1925-1980)
- Application – process
  - Disruptive

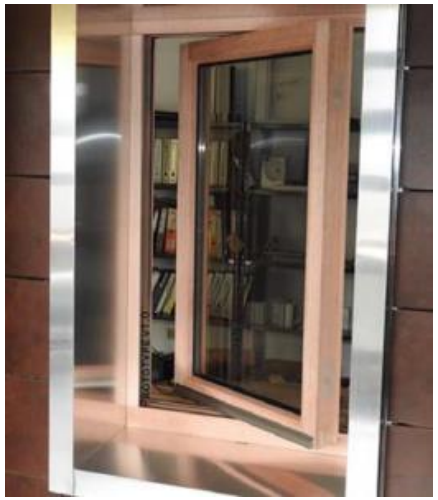


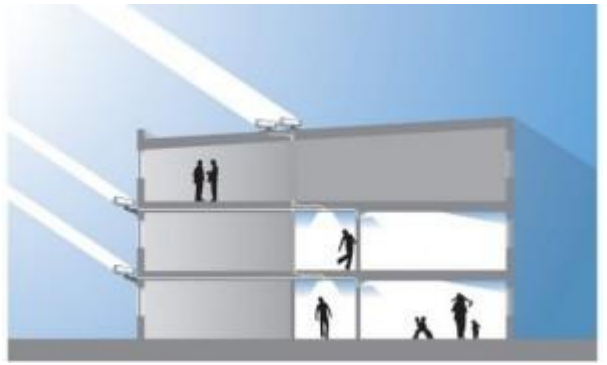
A2PBEER

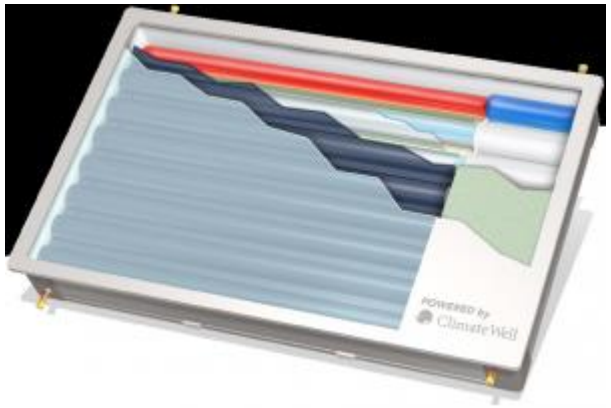
TRL = 7-8

Develops a cost-effective energy-efficient retrofit methodology for public buildings

- Key Points
  - Combination of standard and innovative technologies (affordable and adaptable)
  - High energy performance facades
  - Smart windows and advanced technologies using LED and fibre optic lighting
  - Dual heating and cooling technologies
- Application – building type
  - Refurbishment (Public built before 1980)







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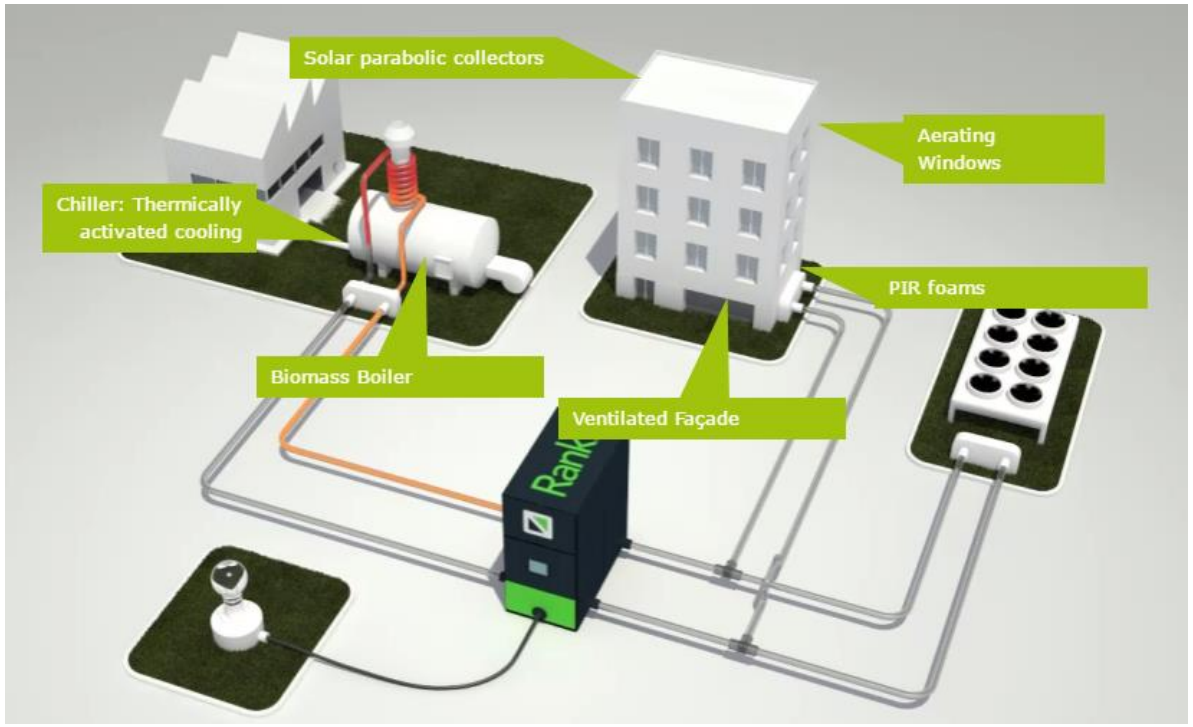
BRICKER

TRL = 6

Develops retrofitting solution packages for public-owned, non-residential buildings.

- Key Points
  - Envelope (made-to-measure façades, innovative insulation materials and high performance windows)
  - Zero emissions energy production technologies
  - Integration and operation strategies
- Application – building type
  - Refurbishment (Public)



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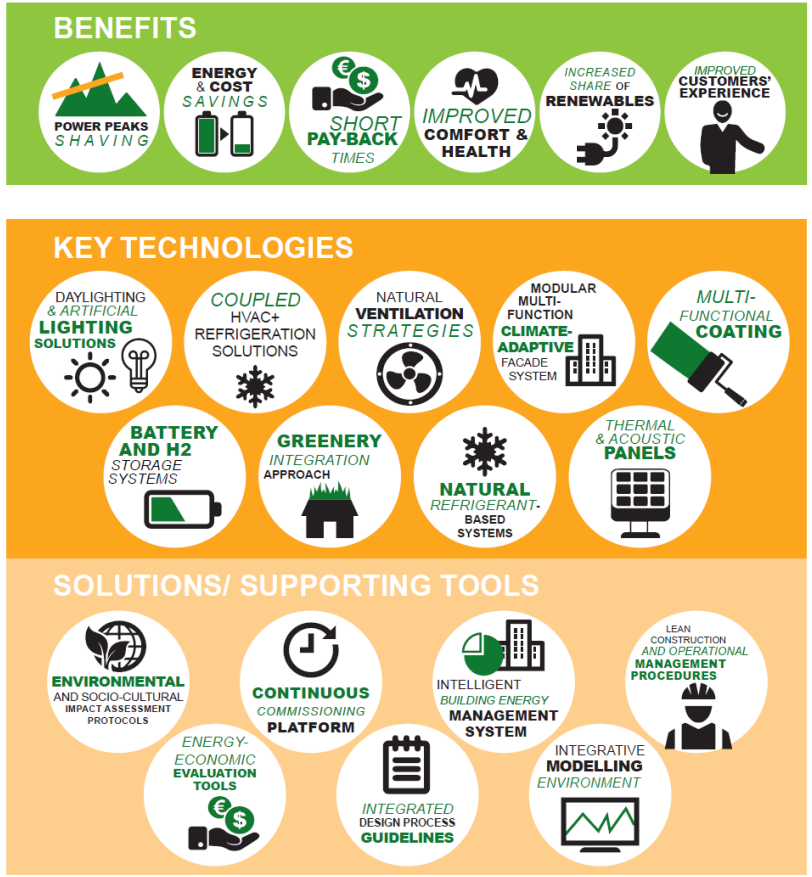
CommONEnergy

TRL = 6

Turning high consuming shopping centers into temples for energy conservation.

- Key Points
  - Deep retrofitting
  - 10-20 systemic solution sets
  - Integrative modelling environment, lean management, power peaks balancing, increased share of RES, technical-economic evaluation
- Application – building type
  - Refurbishment (Commercial)
- Application – process
  - Disruptive



EcoShopping

TRL = 6

Develops holistic retrofitting approaches for commercial buildings, by addressing different elements of the building and increasing the share of renewables by 50%.

- Key Points
  - Novel thermal insulation solutions
  - Easy to install and cascadable daylighting technologies based on the NLIS system
  - Integrated HVAC kit solution based on RES
  - Intelligent Automation Unit (IAU)
- Application – building type
  - Refurbishment (Commercial)
- Application – process
  - Disruptive

RESSEEPE

TRL = 7

Retrofitting Solutions and Services for the enhancement of Energy Efficiency in Public Edification

- Key Points
  - Envelope Retrofitting: Ventilated Facades, Aerogel-based Superinsulating mortar, Wooden Insulating Wall Panel and VIP Panel
  - Integration of RES: PV Energy, Thermal Collectors
  - Energy Storage Systems: Thermal storage and PCMs
  - Nanotechnologies and smart materials: EC/PV Windows
  - ICT: Strategies at building and district level
  - Intelligent Building Controls: HVAC systems
- Application – building type
  - Refurbishment (Commercial)

RESSEEPE

TRL = 7

Real time occupancy monitoring (single and networked version)

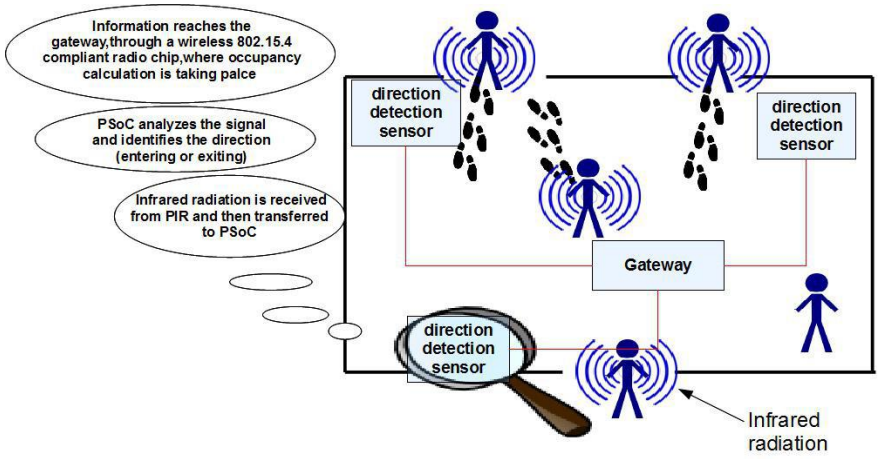
- Key Points
  - Space occupancy sensor: Estimation of the space occupancy/population, i.e., the number of people in a space
  - A direction detection sensor includes:

    - Single PIR element (piroelectric infra-red) that receives infra-red radiation from moving people

    - PSoC (programmable system on chip) processor which receives the signal from a PIR element, analyses it and identifies the direction of the movement

    - Wireless, 802.15.4 compliant radio chip

    - One direction detection sensor is installed in all entrance points

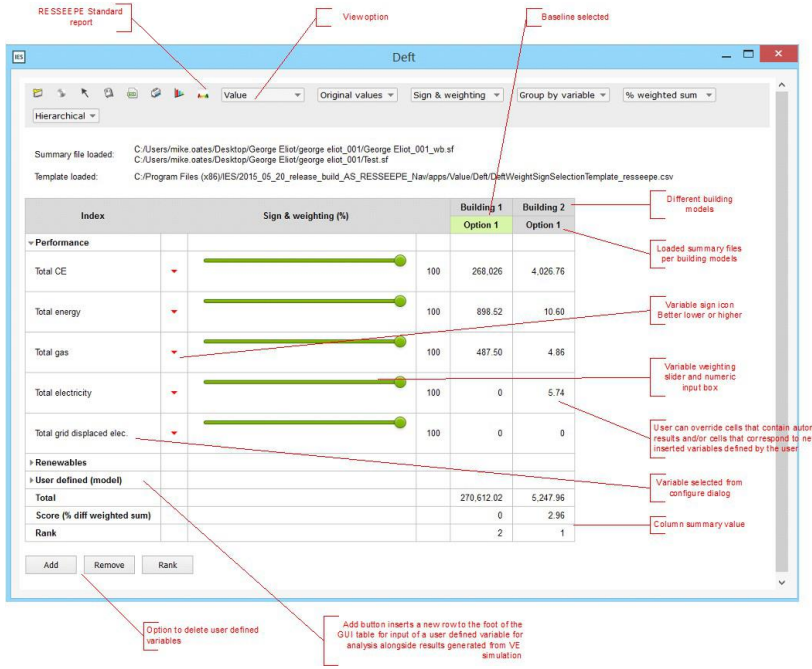


RESSEEPE

TRL = 7

Retrofit planner ”Building level analysis”

- Key Points
  - The Retrofit Planner allows facilities managers to assess the effectiveness of selected technologies for a particular public building based on installation location, energy efficiency, and cost.
  - The Retrofit Planner incorporates holistic evaluation of technology options; contributes towards the overall assessment of the expected energy performance including multivariate parametric assessments for each Demo Site; and outputs a report on building performance focusing on multivariate results analysis.



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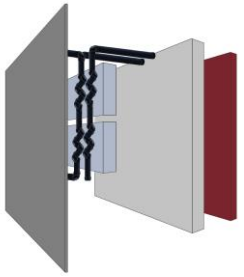
E2VENT

TRL = 6

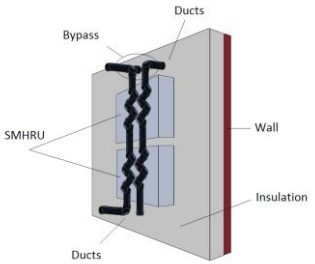
Develops a cost effective, high energy-efficient, low CO_2 emissions, replicable, low intrusive, systemic approach for retrofitting of residential buildings through the integration of an innovative adaptive ventilated façade system.

- Key Points
  - Smart modular heat recovery
  - Smart building management
  - PCM → Thermal storage
  - Cost-effective & easy to install products for external thermal insulation

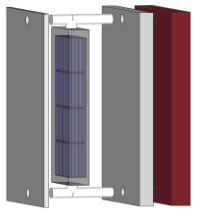
- Application – building type
  - Refurbishment (Residential multi-storey building built in the 60s-70s)



E2VENT system



SMHRU Smart Modular Heat Recovery Unit



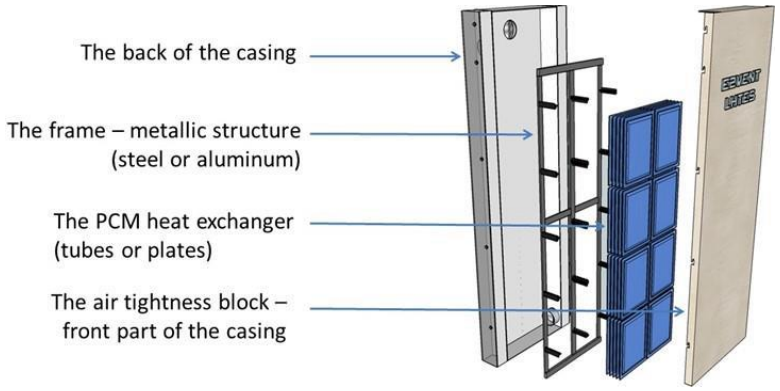
LHTES Latent Heat Thermal Energy Storage

E2VENT

TRL = 6

Latent Heat Thermal Storage System embedded in a renovation module for façades

- Key Points
  - Embedded into the E2VENT module and based on a air to PCM exchanger
  - The Smart Modular Heat Recovery Unit (SMHRU) will provide the air renewal, the LHTES will not provide new air, but will allow to store thermal energy in order to use it for cooling or heating → Complementary system with high performance for heating and cooling especially aiming at reducing the peak loads and improving indoor thermal comfort
- Application – building type
  - Refurbishment (Commercial)

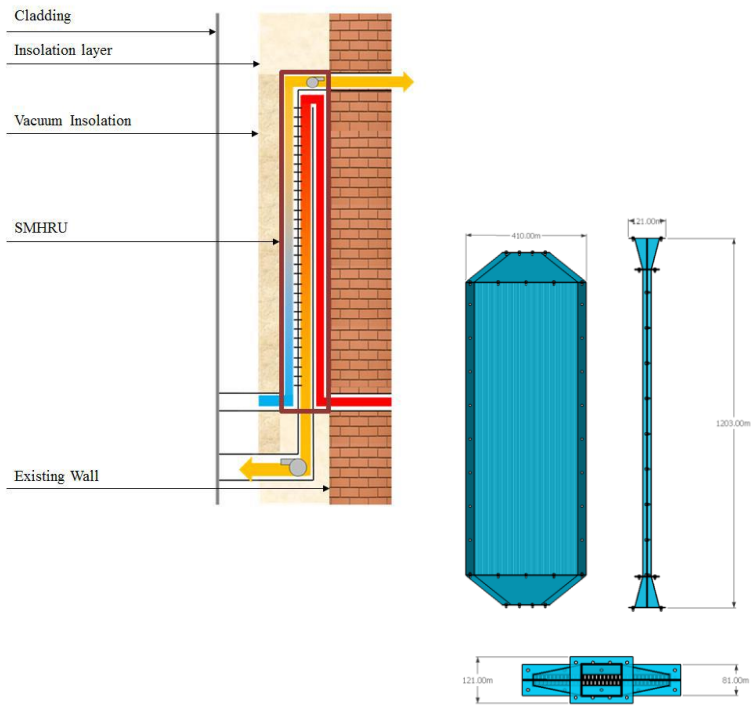


E2VENT

TRL = 6

Heat Recovery Unit embedded in a renovation module for façades

- Key Points
  - Smart Modular Heat Recovery Unit (SMHRU) for the air renewal allows the heat recovery from the extracted air using a double flux exchanger
  - Indoor Air Quality is ensured while limiting the energy losses
  - Can be integrated in the insulation layer, while having a high energy recovery coefficient allowing a high efficiency
  - Made with aluminum plates



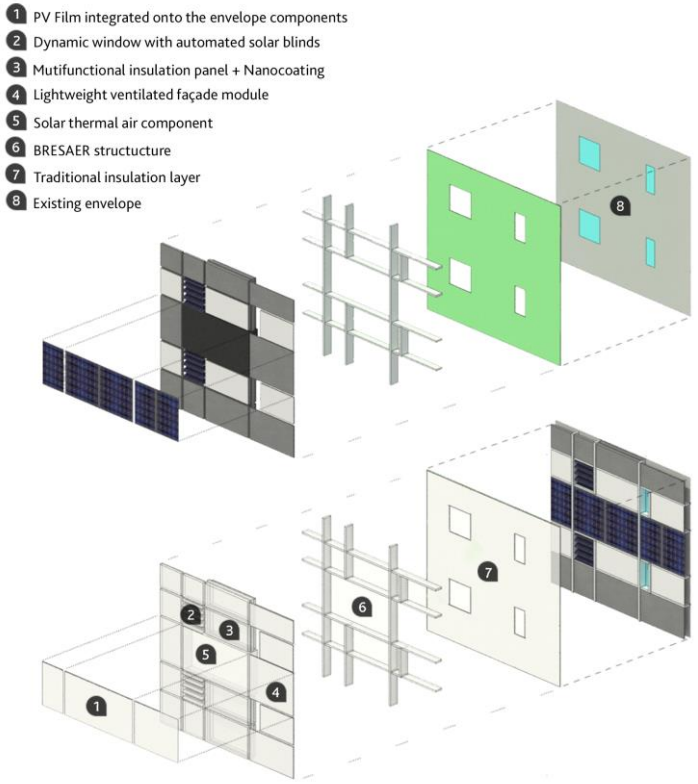
- Application – building type
  - Refurbishment (Commercial)

BRESAER

TRL = 6-7

Develops an adaptable, cost-effective and industrialized envelope system.

- Key Points
  - Facade and roof
  - Integration of active (RES generation) and passive prefabricated solutions
  - Innovative Building Energy Management System
  - NZEB
  - Cutting-edge Building Energy Management System: Measures and controls both the envelope and hungry consuming devices
- Application – building type
  - Refurbishment (Residential, Commercial, Public)



Moreconnect

TRL = 7-8

Develops prefabricated, multifunctional renovation elements for the total building envelope (façade & roof) and installation/building services.

- Key Points
  - Selection/combination/configuration of elements by end-users
  - Cost optimal deep renovation solutions towards nZEB concepts with the possibility of extra customize features
  - Prefabricated multifunctional modular renovation elements in series of 1 concepts, in a mass production process
  - Fully automated production lines for multifunctional modular renovation elements
  - One-stop-shop market models for end-users
- Application – building type
  - Refurbishment (Residential)

DEEP ENERGY RENOVATION OF DISTRICTS AND SMART ENERGY EFFICIENT SOLUTIONS FOR CITIES

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EFFESUS

TRL = 8

Develops technologies and systems for the improvement of the energy efficiency of European historic urban districts.

- Key Points
  - Strategies for energy assessment of historic urban districts
  - Innovations: Advanced blown-in insulation aerogel, New insulating mortar for external and internal application, Radiant reflective coating for outdoor application
  - Decision Support for energy interventions in historic urban districts
- Application – building type
  - Refurbishment (buildings built before 1945)

EFFESUS

TRL = 8

Advanced blown-in insulation aerogel:

- Key Points
  - thin, highly efficient insulation for walls with a solid construction and lath & plaster finishes
  - Space filling

New insulating mortar (ISOCAL):

- Key Points
  - External & internal
  - NHL-based finish plaster
  - Applicable on mineral substrates such as natural stone, brick, ceramic block, old intact mineral render/plaster and concrete

EU-GUGLE

TRL = 7

Demonstrate the feasibility of nearly-zero energy building renovation models in view of triggering large-scale, Europe-wide replication in smart cities and communities by 2020.

- Key Points
  - Combine the research results that are relevant at district level
  - Adaption of the results to local needs in a balanced mix of technical, socio-economic and financial solutions
  - Monitoring and evaluation of all aspects of the renovation process
- Application – building type
  - Refurbishment
- Application – process
  - Disruptive & non-disruptive

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R2CITIES

TRL = 7

Develops and demonstrates replicable strategies for designing, constructing and managing large scale district renovation projects for achieving NZE cities.

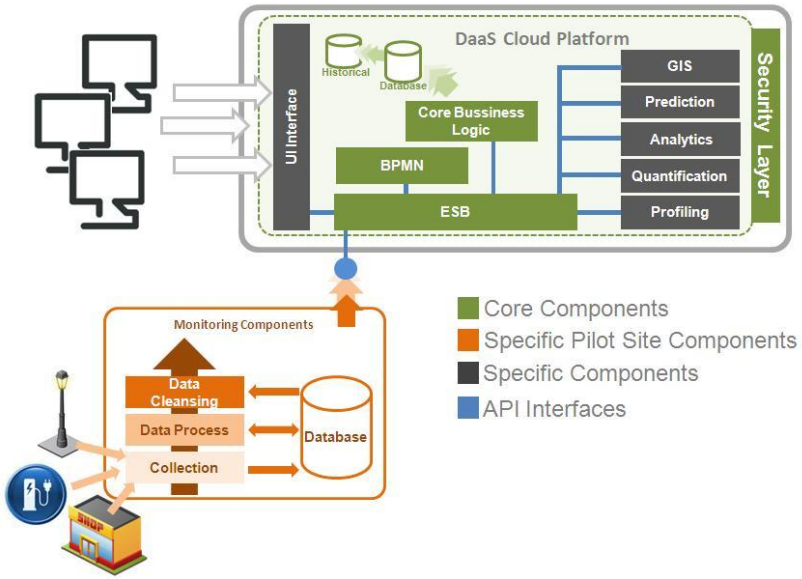
- Key Points
  - New refurbishments on a European scale
  - Several studies of cost-effective solutions for the holistic improvement of the energy performance
  - Deployment of a rigorous measurement and verification of energy performance and savings plan
  - A market and replication deployment plan
- Application – building type
  - Refurbishment
- Application – process
  - Disruptive & non-disruptive

URB-Grade

TRL = 8

Develops a Platform for Decision Support that will allow the city authorities and utilities to promote and choose the correct actions to upgrade a district.

- Key Points
  - Upgrades a district and make it more energy efficient, cost effective and increase the comfort through a Service Platform
  - DaaS platform: Display of overall measured values, Observation of specific KPIs, Forecasting of current performance in the future
  - collecting data from heterogeneous distributed sensors and other open data sources or survey-based data
- Application – building type
  - Refurbishment
- Application – process
  - Disruptive & non-disruptive



ZenN

TRL = 7-8

Aims to reduce energy use in existing buildings and neighbourhoods.

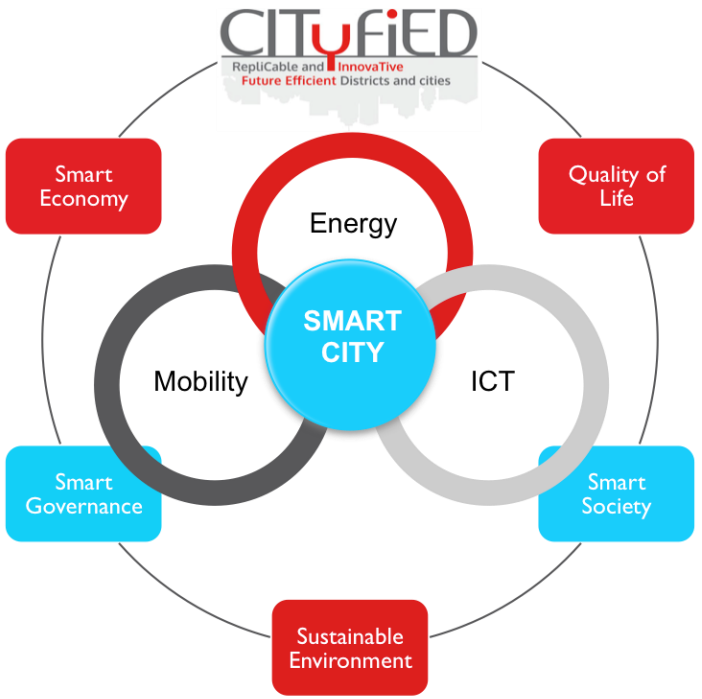
- Key Points
  - Identifies, optimizes and disseminates the most promising management and funding methods to facilitate large-scale implementation
  - Ambitious replication plans at several scales (local, regional etc.).
- Application – building type
  - Refurbishment
- Application – process
  - Disruptive & non-disruptive

CITyFiED

TRL = 8

Develops a replicable, systemic and integrated strategy to adapt European cities and urban ecosystems into the smart city of the future.

- Key Points
  - Innovative and cost effective methodologies for planning, deploying and replicating energy efficient district retrofitting actions
  - Better business models
- Application – building type
  - Refurbishment
- Application – process
  - Disruptive & non-disruptive

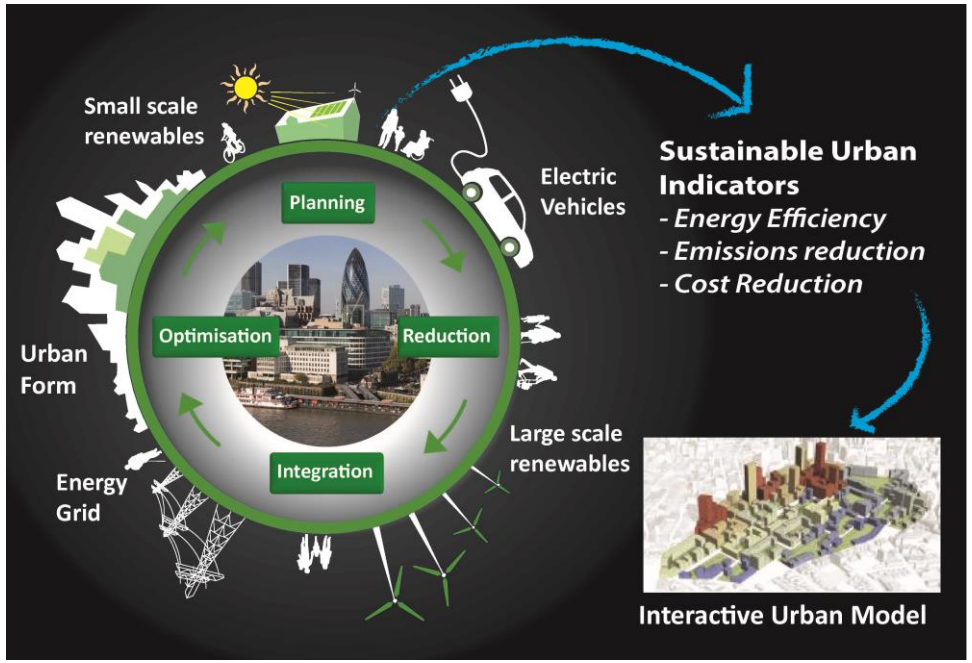


INDICATE

TRL = 8

Develops a tool to support urban planning and design decision making in an age of increasing demands and complexity.

- Key Points
  - Dynamic assessment of the interactions between buildings, energy distribution grids, renewable technologies
  - Dynamic simulation modelling, GIS & 3D urban modelling
- Application – building type
  - Refurbishment
  - New buildings
- Application – process
  - Disruptive & non-disruptive



Sinfonia

TRL = 8

Develops large-scale, integrated and scalable energy solutions in mid-sized European cities.

- Key Points
  - Transferability and scalability of the solutions
  - From demonstration to replication
- Application – building type
  - Refurbishment
- Application – process
  - Disruptive & non-disruptive