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Building Integration of Solar Thermal Systems – TU1205 – BISTS


Building Integration of Solar Thermal Systems (BISTS): Case Study reviews


Dr Mervyn Smyth




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A solar thermal system is considered to be building integrated, if for a building component this is a prerequisite for the integrity of the building's functionality.







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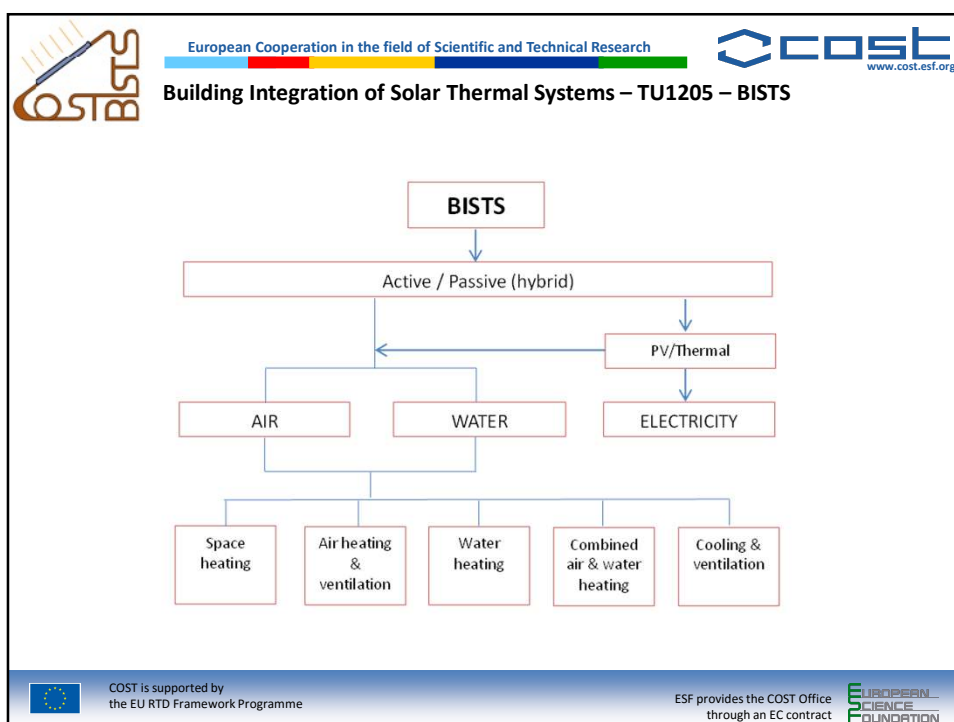

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Building Integration of Solar Thermal Systems – TU1205 – BISTS


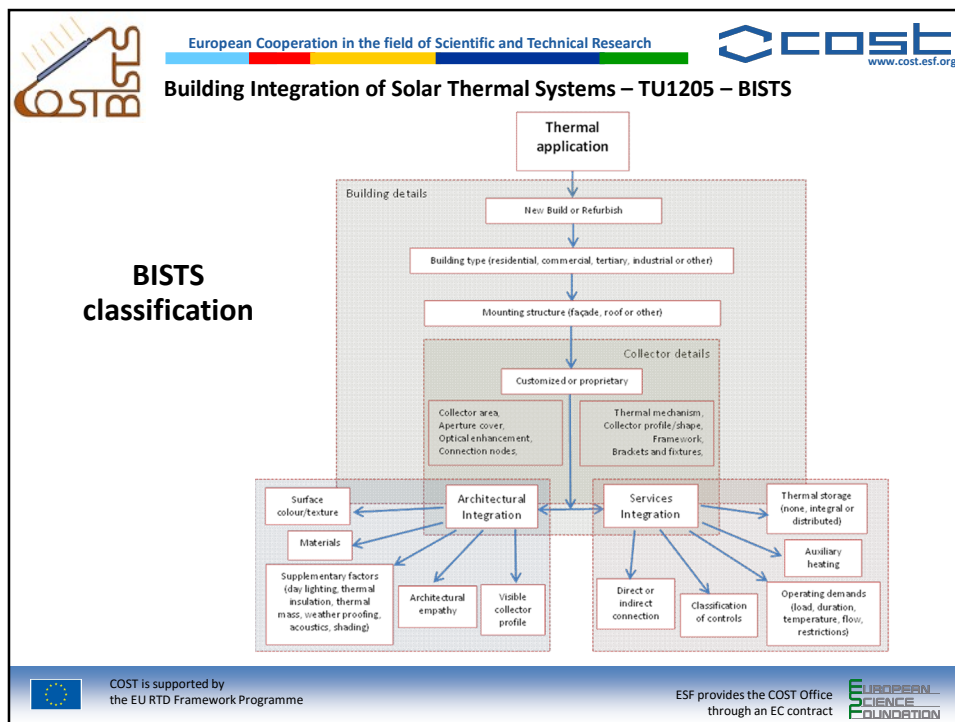
Over 94 case studies submitted to date
86 have been allocated reference numbers and reviewed
64 are of direct relevance
The remainder are model or support material

**Not a quantitative analysis but
rather indicative**

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COST Action TU1205
Building Integrated Solar Thermal Systems

BIST ref number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Application																											
air heating	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
water heating	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
comb-system	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
cooling/ventilation	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ventilation (mechanical, natural, hybrid)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ventilation mode (supply, exhaust, buffer)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
BIPV/T	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
linked (auxiliary system)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Type																											
active	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
passive	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
hybrid	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
concentration	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
other	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Services Integration																											
direct supply	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
data extraction	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1


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BISTS Combinations


				Installed on					
				Wall		Roof		Other	
				New	Refurbishment	New	Refurbishment	New	Refurbishment
Output	Air	Air heating	Active	5 off	3 off	5 off	4 off	2 off	2 off
			Passive	3 off	1 off	2 off	1 off		
		Combi systems	Active	1 off		6 off	2 off		
			Passive						
	Water	Water heating	Active	11 off	4 off	17 off	5 off	5 off	4 off
			Passive	1 off	1 off	2 off		2 off	1 off
		Cooling	Active	5 off	2 off	3 off	1 off		
			Passive	3 off	1 off	2 off	1 off	1 off	
	Electricity	PV/T	Active						
			Passive	2 off	1 off	1 off			


In addition, a further 15 systems have been described as being Hybrid in operation and 3 system utilised some form of solar concentration




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






















































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				Installed element					
				Façade		Roof		Other	
				New	Retrofit	New	Retrofit	New	Retrofit
OUTPUT	AIR	Air heating & ventilation	Active						
			Passive						
		Space heating	Active						
			Passive						
		Combined air and water heating	Active						
			Passive						
	WATER	Water heating	Active						
			Passive						
		Cooling & ventilation	Active						
			Passive						
	ELECTRICITY	PV/T	Active						
			Passive						




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BIST Description

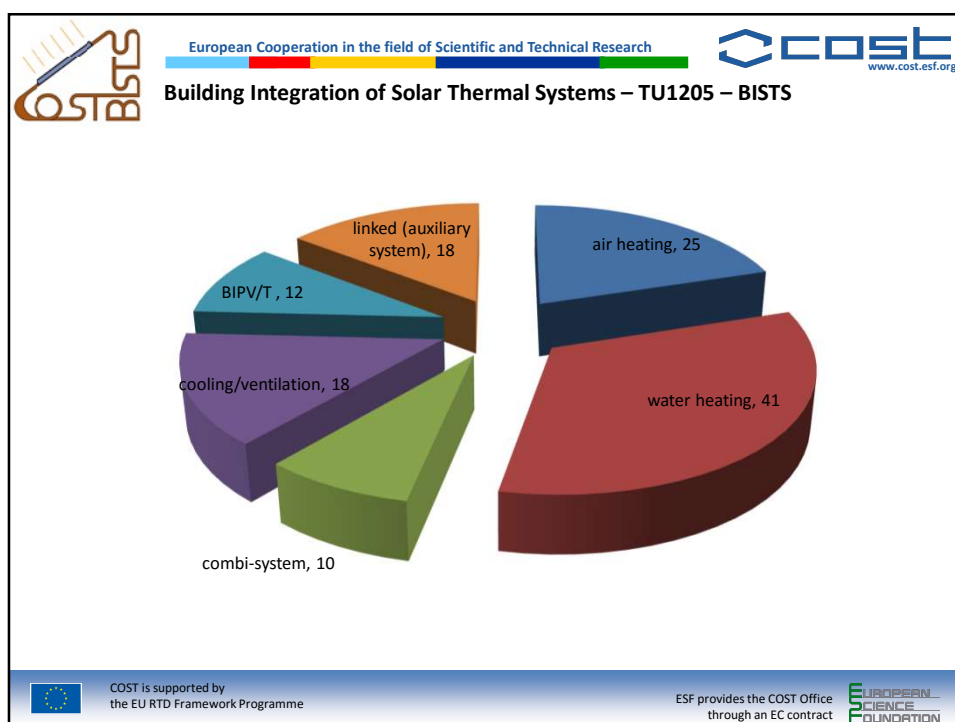
Application



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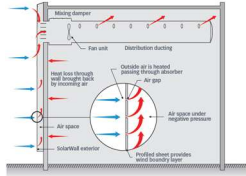
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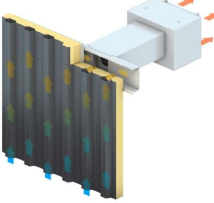

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Air heating


Transpired façade collector, Canada


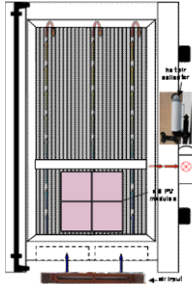
Façade crown collector, UK

PVT roof collector, Canada



Window shutter, France

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Water heating

Shading device, France



Ridge tiles, Holland




Integrated roof tiles, China




Solar balustrade, USA



Unglazed façade collector, Switzerland

Flat plate collector, Ireland



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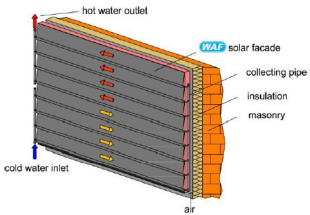
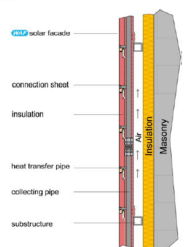

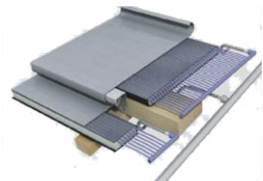

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Combi-system

WAF solar facade
collecting pipe
insulation
masonry
air

hot water outlet
cold water inlet

Wall combined air/water collector

Roof combined air/water collector

connection sheet
insulation
heat transfer pipe
collecting pipe
substructure

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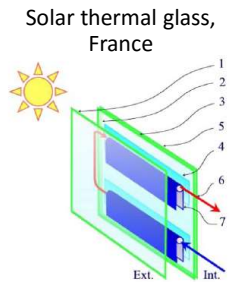

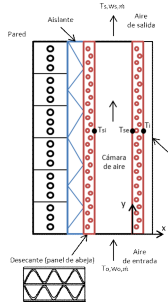

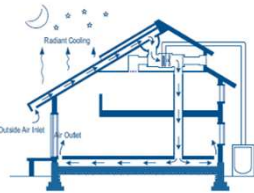

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Cooling/ventilation/shading

Solar thermal glass, France

Solar awning, USA

Desiccant Ventilated Façade

Radiant cooling, Japan

Solar facade blinds, USA

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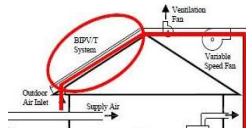
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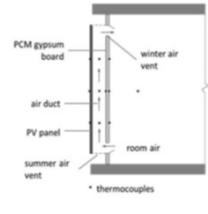
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Building Integrated PV/Thermal



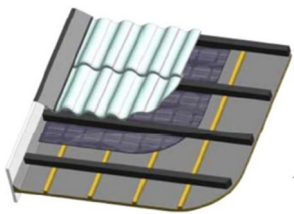
PV roof air heating, Canada

PV air heating, Portugal



PV water heating, Sweden



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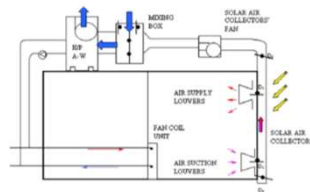
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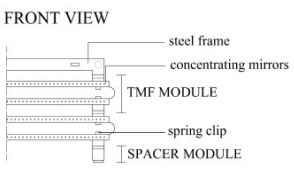
Linked systems



District heating, Sweden

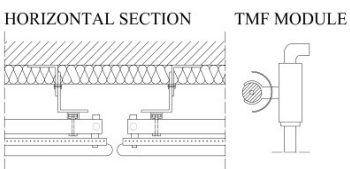


Air heat pump on the roof, Greece



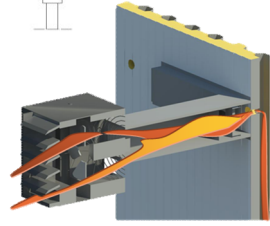
Front view

steel frame
concentrating mirrors
TMF MODULE
spring clip
SPACER MODULE



HORIZONTAL SECTION

TMF MODULE



Kingspan facade linked to auxiliary air heater, UK

Façade integrated solar thermal concentrated system linked to absorption chiller, Italy

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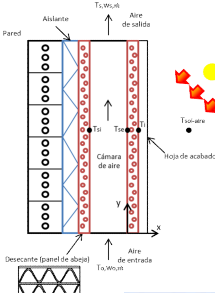
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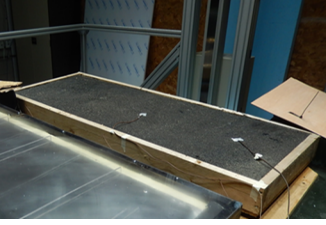
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Other



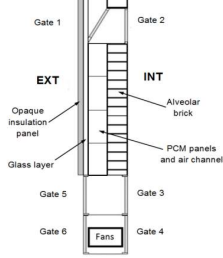
Desiccant Ventilated Façade



NCT asphalt collector, UK



Integrated photo-bioreactor, Germany



PCM envelopes, Spain

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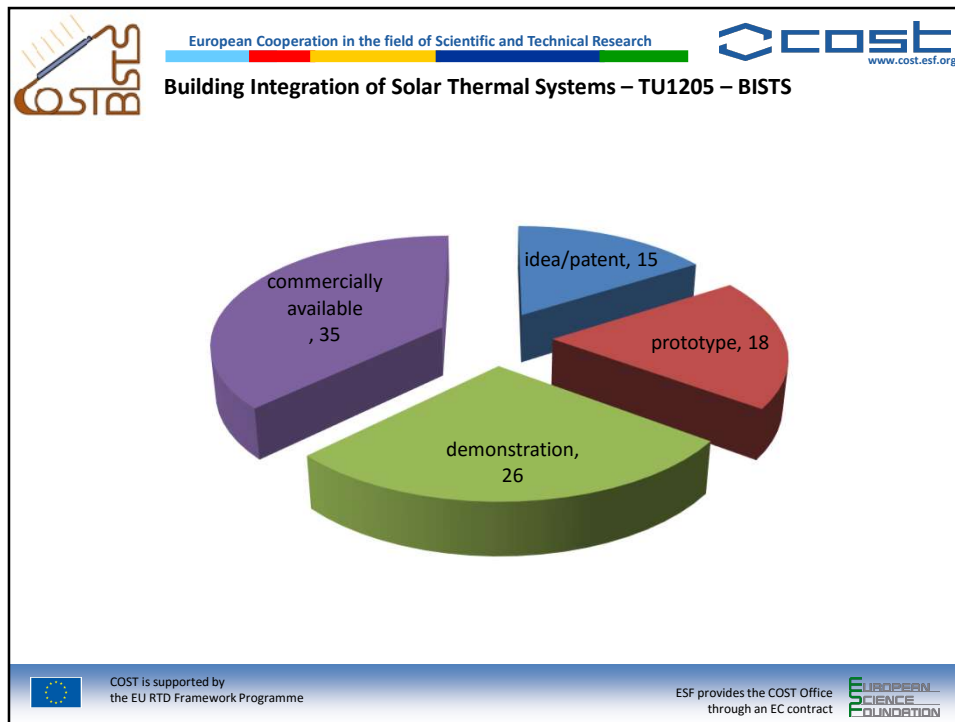
BIST Description

Stage of development

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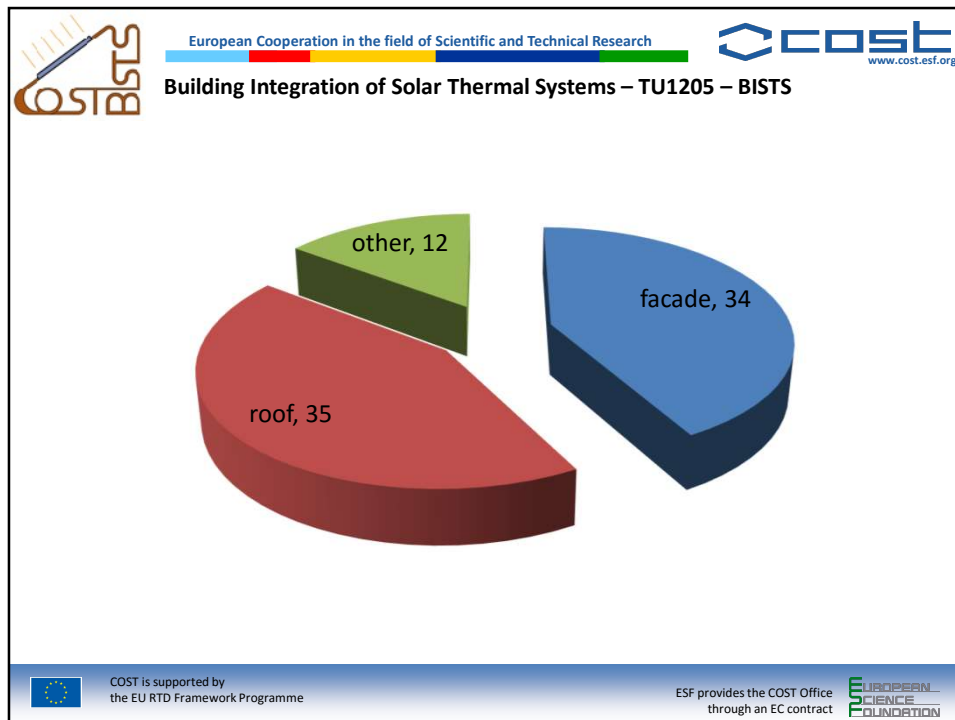
BIST Description

Collector building element

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Architectural wave, China

Other

All-ceramic solar collector, China


Intelliglass, Spain

Garden fence, USA


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Architectural integration

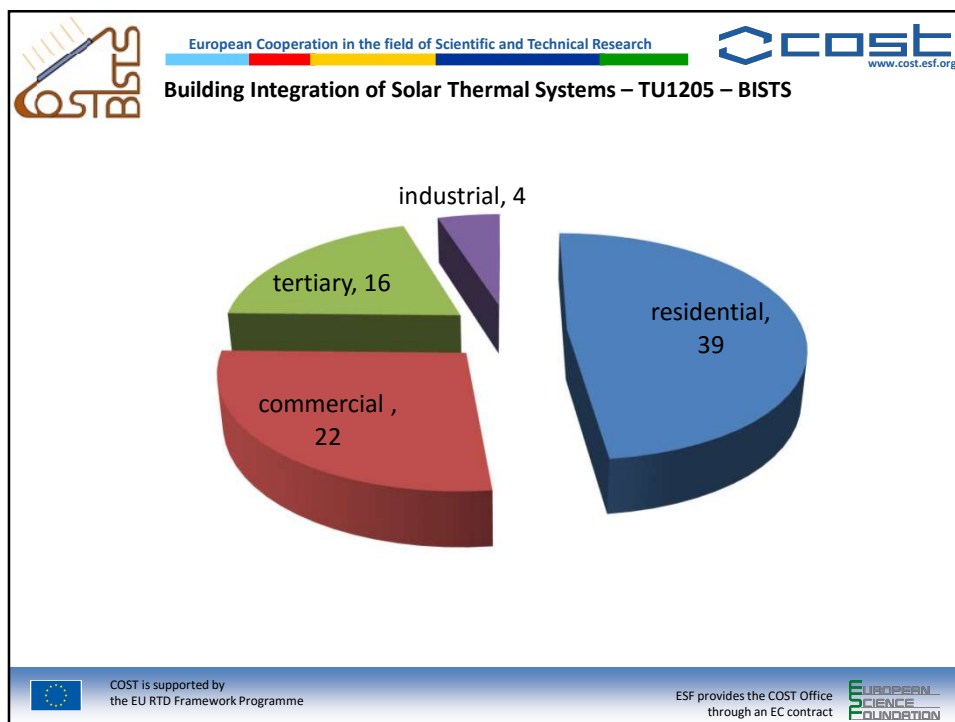
Building type




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Architectural integration


Building physics




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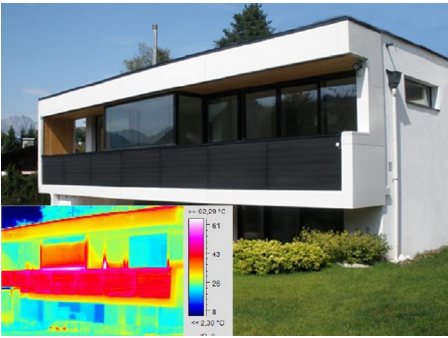




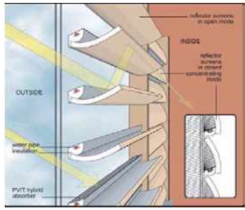
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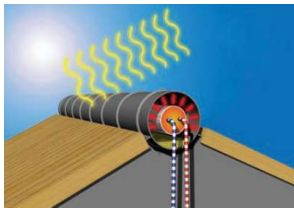
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Structure: Combined air/water balcony



Shading: PVT window blinds, Sweden




Integral storage: ICS ridge collector, Holland



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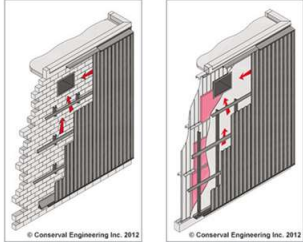


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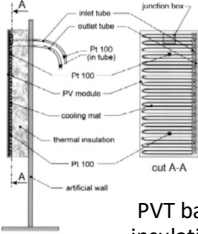
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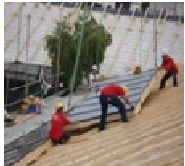
Insulation




© Conservall Engineering Inc. 2012



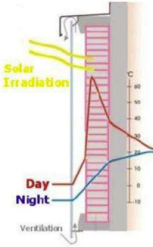
PVT back panel insulation, Brazil



Significant back panel insulation, Portugal



Solar-comb insulation, Austria



Transpired air collector with and without back insulation

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Architectural integration

Building Architectural Integration

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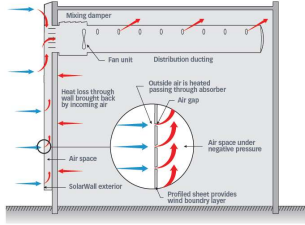
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Architectural empathy?





Obvious, but the north side is covered with the same stainless steel elements but not thermally active



Invisible transpired wall collector

Blended, mounted in the apex ridge of pitched roof

Out of sight

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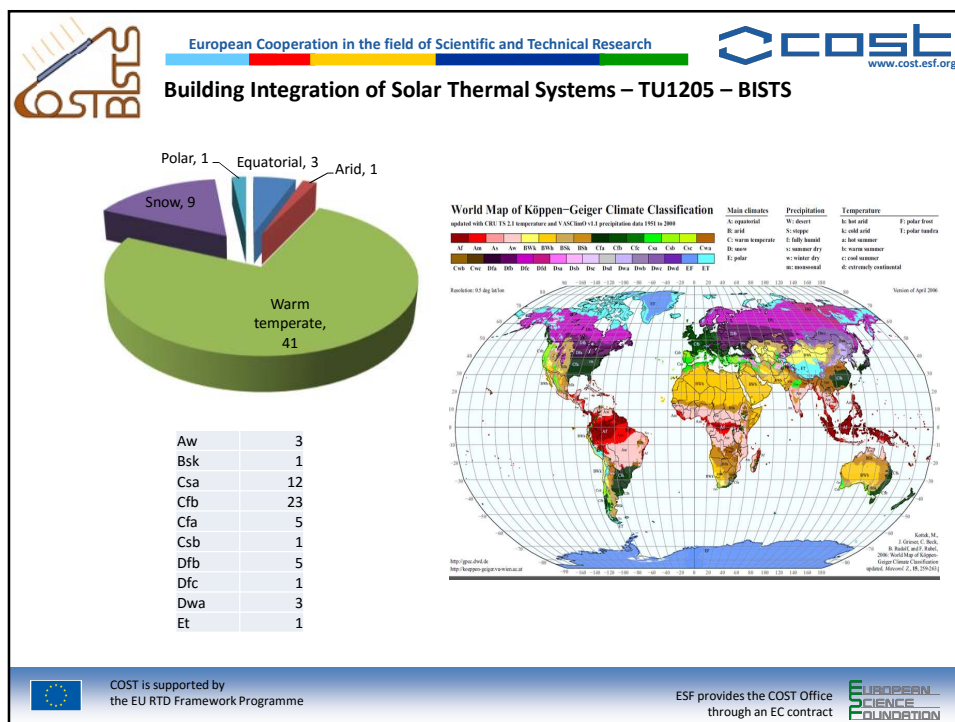
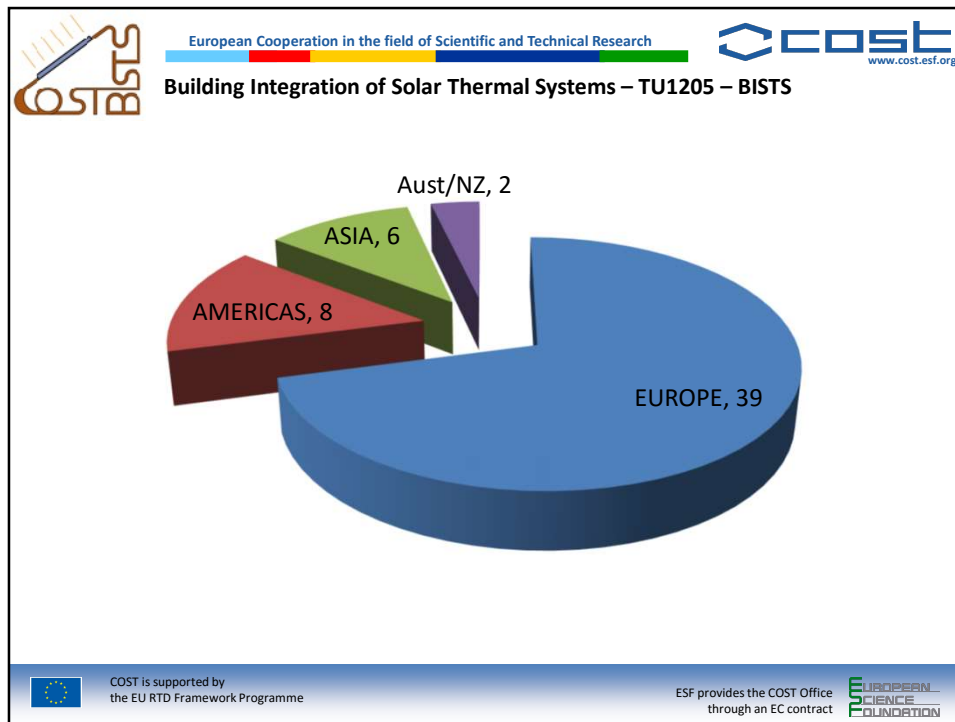
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Locations

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Wider considerations

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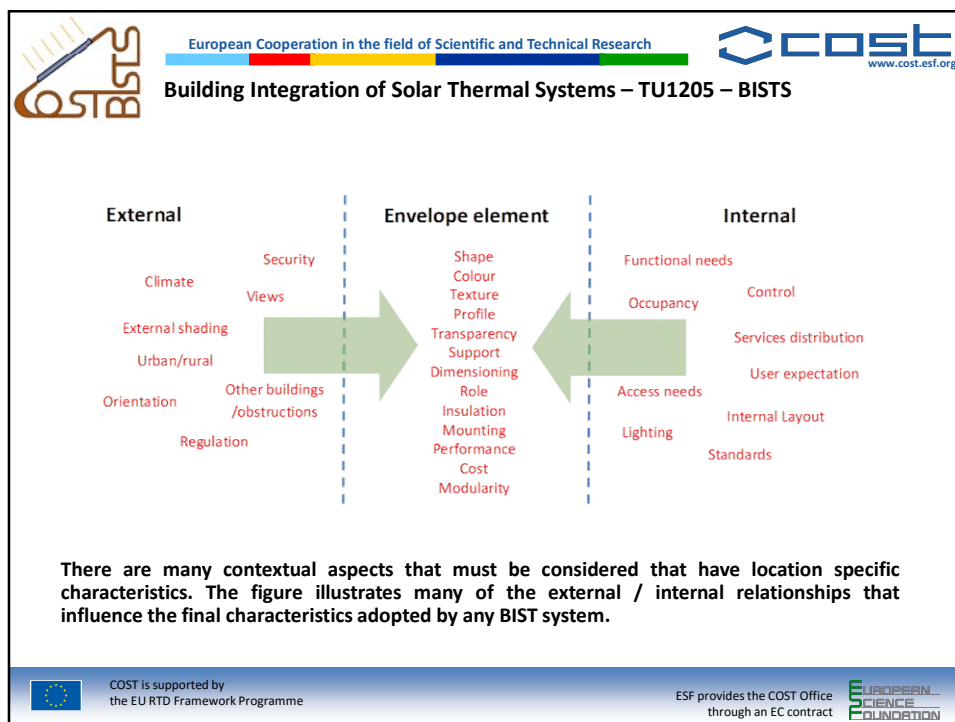
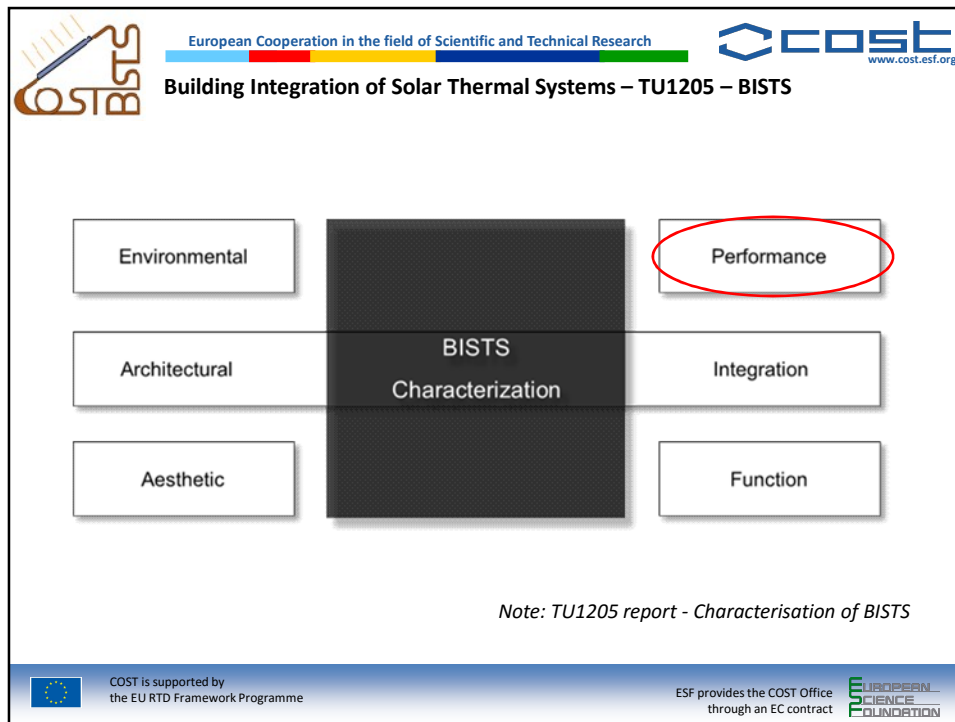
Areas of obvious technological development and deployment

Minimal work published in

- Economics.....some on capital costs and running costs, nothing on payback and maintenance
- Some on embodied energy, nothing on sustainable materials, environmental impact, fire safety
- Some on project motivation, nothing on social impact or legislation

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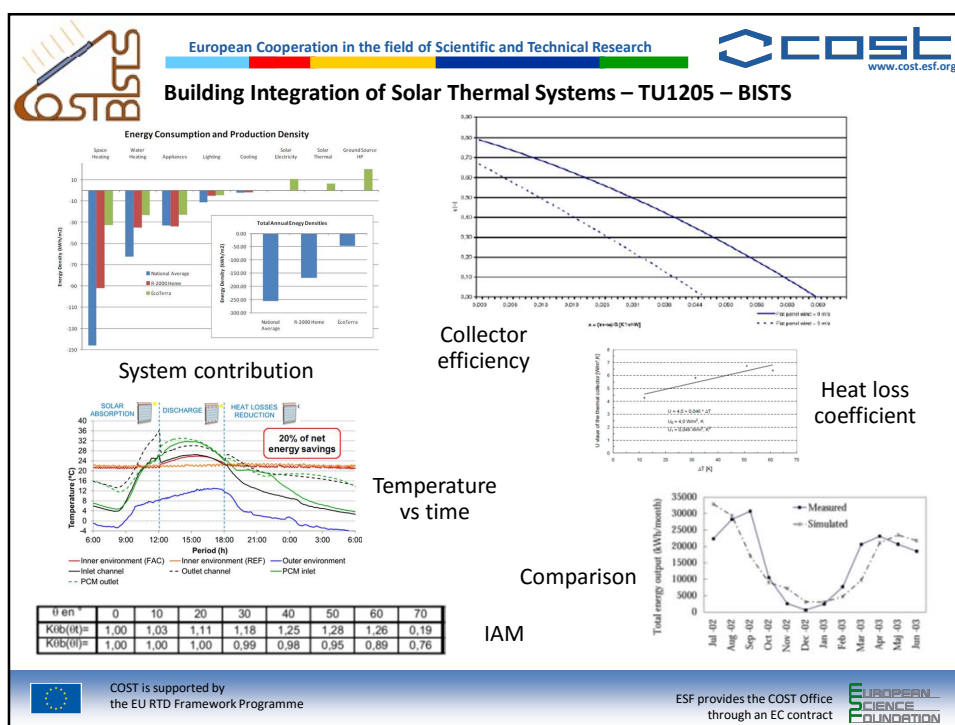
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Performance

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Case Studies




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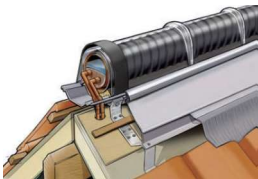
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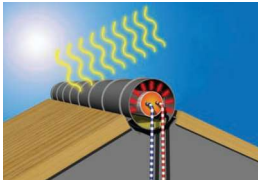


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The Eco-Nok

Roof ridge ICS solar water heating module.
Residential, new build and passive or active
Each module is 1.5m long 270mm in diameter
The effective collection area per module is 0.36 m²
Annual energy collection (3 modules) in Holland is 2.1GJ
Up to 50% annual savings on hot water energy consumption
The unit cost is Euro 420 with a family sized system costing up to Euro 3000 fully installed




CASE STUDY 1



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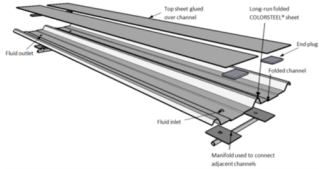
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Building Integration of Solar Thermal Systems – TU1205 – BISTS




Building Integrated Solar Heating and Radiant Cooling Collector

Developed to be directly integrated into a troughed sheet metal roof

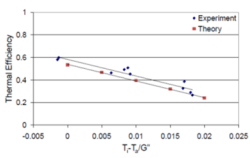
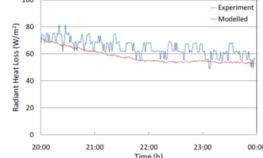
Unglazed solar water heater during the day

Unglazed radiant cooling panel at night

Separate heat and coolth storage



CASE STUDY 2a

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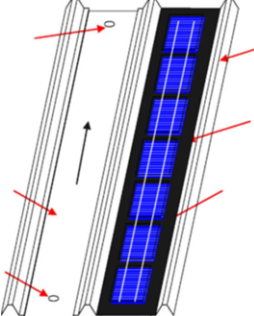
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The BIPVT roof collector

Simple fabrication process with holes drilled into the trough and connection nipples to connect to a manifold

Water or air heating

Laminated PV cells on top of the absorber sheet

Low-iron-glass aperture cover

CASE STUDY 2b

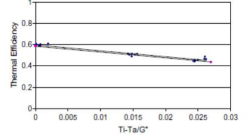
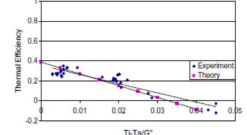



Fig. 5. Experimental and theoretical thermal efficiency of a glazed BIPVT collector.

Fig. 6. Experimental and theoretical thermal efficiency of an unglazed BIPVT collector.

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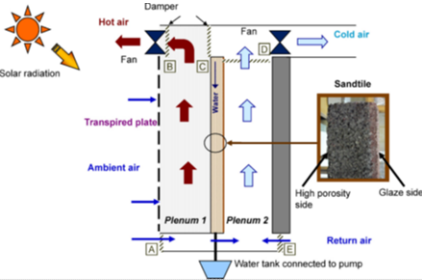
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The building integrated (solar thermal) cooling facade



Fan-assisted system that consists of two vertical plenums.

The first plenum was made of black aluminium (absorber) transpired plate and a sandtile wall (evaporative pad)

The second plenum is formed by the sandtile wall (with water-resistant layer) and the building wall

Energy consumption to generate 1 kW of cooling that cooled the air to 293K is only 52 W

CASE STUDY 3

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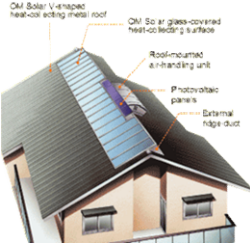
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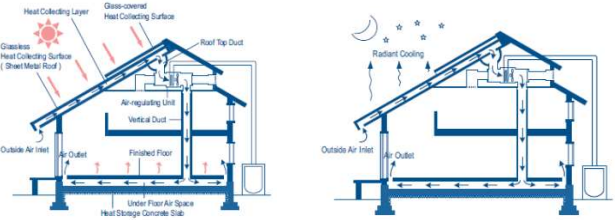
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The OM solar integrated dwelling



In heating mode, fresh outdoor air enters under the roof and flows upward in contact with the metal roof sheet, passing through an upper glazed section (to improve collection) whereupon the heated air enters roof ridge duct to the AHU

In cooling mode, outdoor air is drawn through the roof channels at night-time, sub-cooled using radiant cooling, and directed into the space to be cooled via the underfloor channels




CASE STUDY 4


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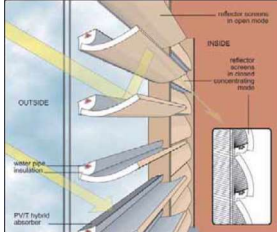

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The Solar Window


PVT Solar Window with day lighting control and additional envelope insulation

The reflectors have an optical concentration factor of 2.45

U value can be reduced from 2.8 to 1.2 W/m²K with the reflectors closed


The annual transmittance through the window is estimated to 609 kWh/m², of which 10% is PV delivery, 20% as active solar heat and 30% as net passive space heating

Production costs for the Solar Window excluding the glazing are estimated to approximately €250/m²




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CASE STUDY 5



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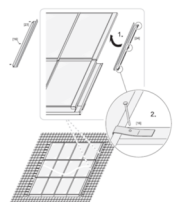
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Case Studies – observations...so far


- **Wide range of interesting concepts/systems** (although some repetition of the same system on different buildings)
- **Limited information**
- **BIST description** (generally good, less regarding the building detailing)
- **Sizing procedure** (minimal)
- **Building physics** (secondary consideration)
- **Physical connection** (some detailing, but minimal)
- **Costs - economic, environmental, social** (limited)
- **Performance** (wide variation)
- **Aesthetics** (missing)
- **Distribution** (exclusively developed world)





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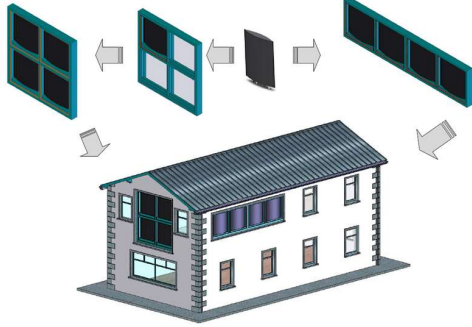
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COST TU1205 Working Case Studies....

- Project 1 - Solar Thermal Façade System
- Project 2 - Hybrid PV/T/solar Thermal façade module
- Project 3 - Solar Plenum
- Project 4 - Concentrating PV/T Glazing
- Project 5 - trapeze solar-thermal collector



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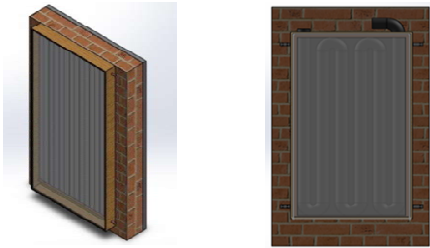
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Project 1 - Solar Thermal Façade System

The Solar Thermal Façade System is a flat-plate collector, which consists of the usual parts found in stand-alone systems without the casing and the whole construction is set up in front of the brick of the normal brick-wall. The system can use water or air as heat transfer medium



Department of Mechanical Engineering and Materials Science and Engineering, Cyprus University of Technology, Cyprus

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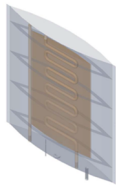
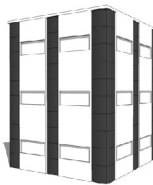
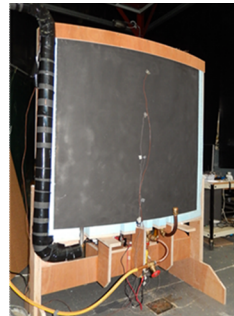
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Project 2 - Hybrid PV/T/solar Thermal façade module

The innovative modular HyPV/T façade concept integrates a novel cascade thermal diode configuration in an Integrated Collector/Storage (ICS) solar water heater with PV cells into a single multi-functional facade element

Centre of Sustainable Technologies at the School of the Built Environment, Ulster University, Northern Ireland

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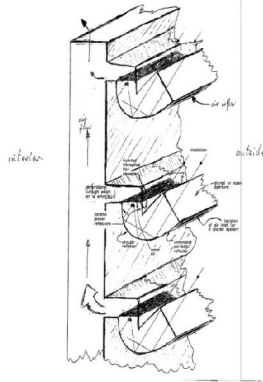
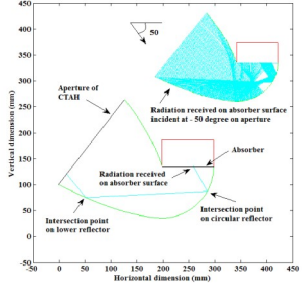
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Project 3 - Solar Plenum

The “solar plenum” is an air heating solar collector which integrates an asymmetric compound parabolic concentrator with a tertiary reflector sector that reflects solar radiation into a downward facing absorber surface.

Dublin Institute of Technology, Dublin, Ireland

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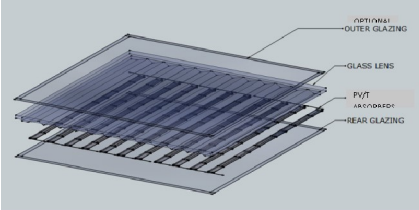
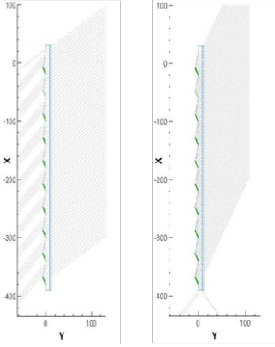
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Project 4 - Concentrating PV/T Glazing

The Concentrating PV/Thermal Glazing (CoPVTG) façade technology combines glazing based solar concentrating elements coupled with PV/Thermal absorbers. It can provide solar generated electricity and heated air through the PV/T absorbers while insulating the building thermally.

Centre of Sustainable Technologies at the School of the Built Environment, Ulster University, Northern Ireland

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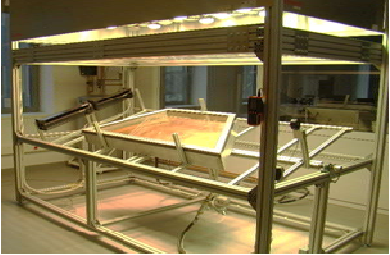
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Project 5 - Trapeze solar-thermal collector

The Trapeze FPSTC is a lego-type solar-thermal arrays with increased architectural and urban acceptance







Center Renewable Energy Systems and Recycling (RESREC), part of the R&D Institute of the Transilvania University of Brasov, Romania

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