

A satellite with two large solar panel arrays is shown in orbit above the Earth's cloud-covered surface. The satellite has a central body with various instruments and a gold-colored thermal blanket at the base. The background is the blackness of space with stars.

ALBEDO PROJECT

Prof. Federico Rossi

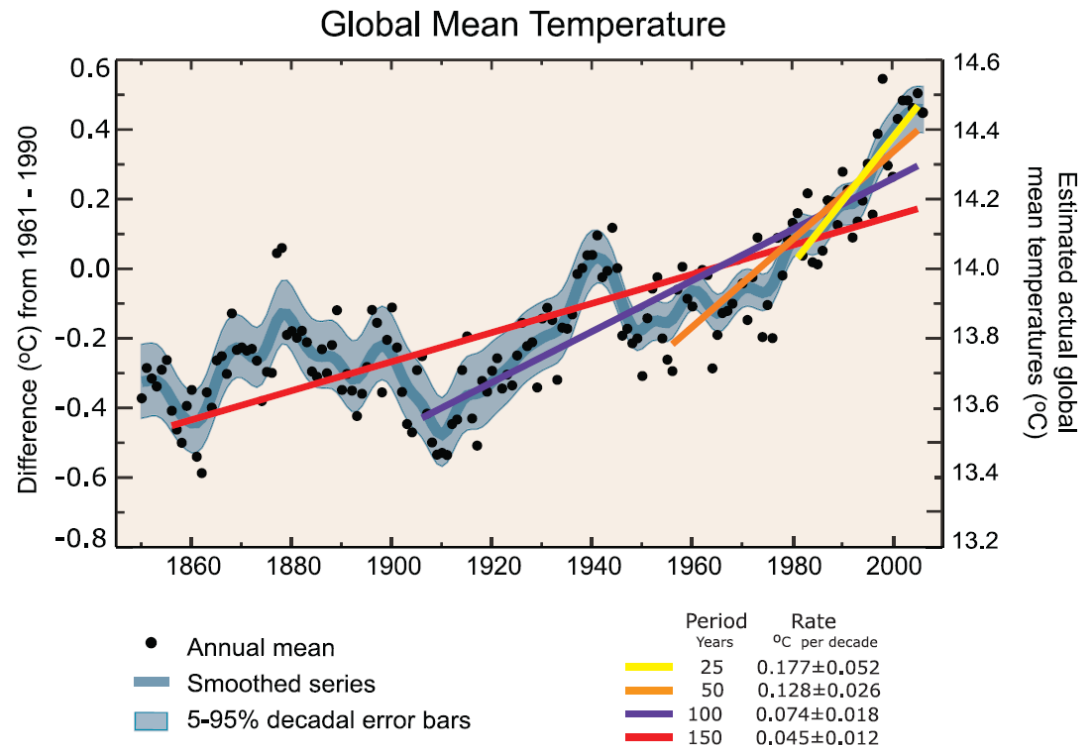
Interuniversity Research Center on Pollution from Physical Agents

University of Perugia - ITALY

GLOBAL WARMING

- Atmospheric concentration of CO₂ is currently nearly **40 %** above its preindustrial level (from **285** to **380 ppm**).
- By IPCC 4th Assessment Report GW is mainly due to human-induced effects.

**+ 0.64 Celsius
degrees on the
last fifty years**



GLOBAL WARMING

CONSEQUENCES

ECONOMIC

- Costs induced by extreme weather events can rise up to **25% of GDP** on affected countries.

GEOGRAPHIC

- sea-level rise predicted at 2100: **min 0.22 m, max 0.44 m.**
- **20 %** rain falling increase on South Asia by 2050, **10 %** less annual rainfall on sub-Saharan Africa.

SOCIAL

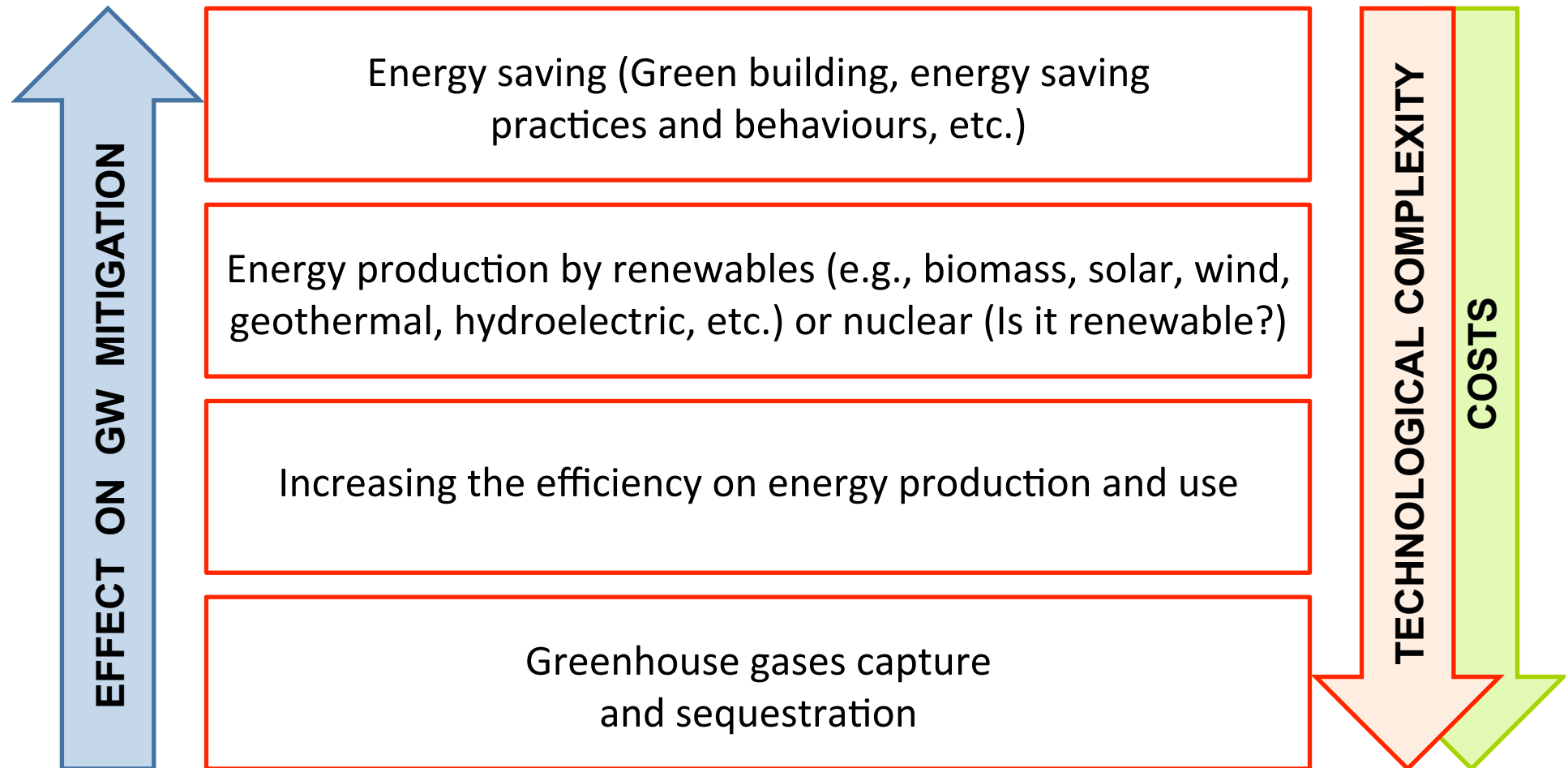
- **4.3 - 6.9 billion** of people living in severely stressed river basins.
- **200 million** of climate migrants by 2050.
- **50 %** fall of rain-fed agriculture in sub-Saharan Africa by 2020.
- **40 - 140 million** of people flooded per year by 2100.

HEALTH

- **400 million** additional population at risk for malaria.
- **3.5 billion** additional people at risk dengue.
- **300 %** heat-related death increase in 2100.
- Increase in malnutrition.

MITIGATION OF GLOBAL WARMING

TRADITIONAL METHODS



BEST RESULTS BY SIMPLER AND CHEAPER METHODS !!!

MITIGATION OF GLOBAL WARMING

GEOENGINEERING (EXOTIC PROPOSALS)

- Solar deflector (or multiple small deflectors) in a synchronous earth-sun orbit (*The Moon*, D. R. Criswell, 2002)
- Marine aerosols injections to enhance cloud albedo (J. Latham et al.)
- Aerosols into the stratosphere to enhance solar radiation reflection (K. Caldeira & L. Wood)
- Modification of oceanic processes to improve sequestration of CO₂ (V. Smetacek & S.W. Naqvi)

MITIGATION OF GLOBAL WARMING

GEOENGINEERING (EXOTIC PROPOSALS)

- UNPROVED EFFECTIVENESS
- HIGH COSTS
- IRREVERSIBILITY

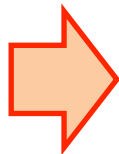
ALBEDO PROJECT

SOLAR RADIATION MANAGEMENT (SRM)

- **Earth albedo** plays an CRUCIAL role on Earth temperature.
- **Artificial enhancement of terrestrial albedo (SRM)** may contribute to offset CO₂ effect on earth average temperature.

ETIOLOGY

SURFACE
ALBEDO
INCREASE



GLOBAL AVERAGE
TEMPERATURE
DECREASE



CO₂
EMISSIONS
OFFSET

MODELLING OF GW MITIGATION BY ALBEDO ENHANCEMENT

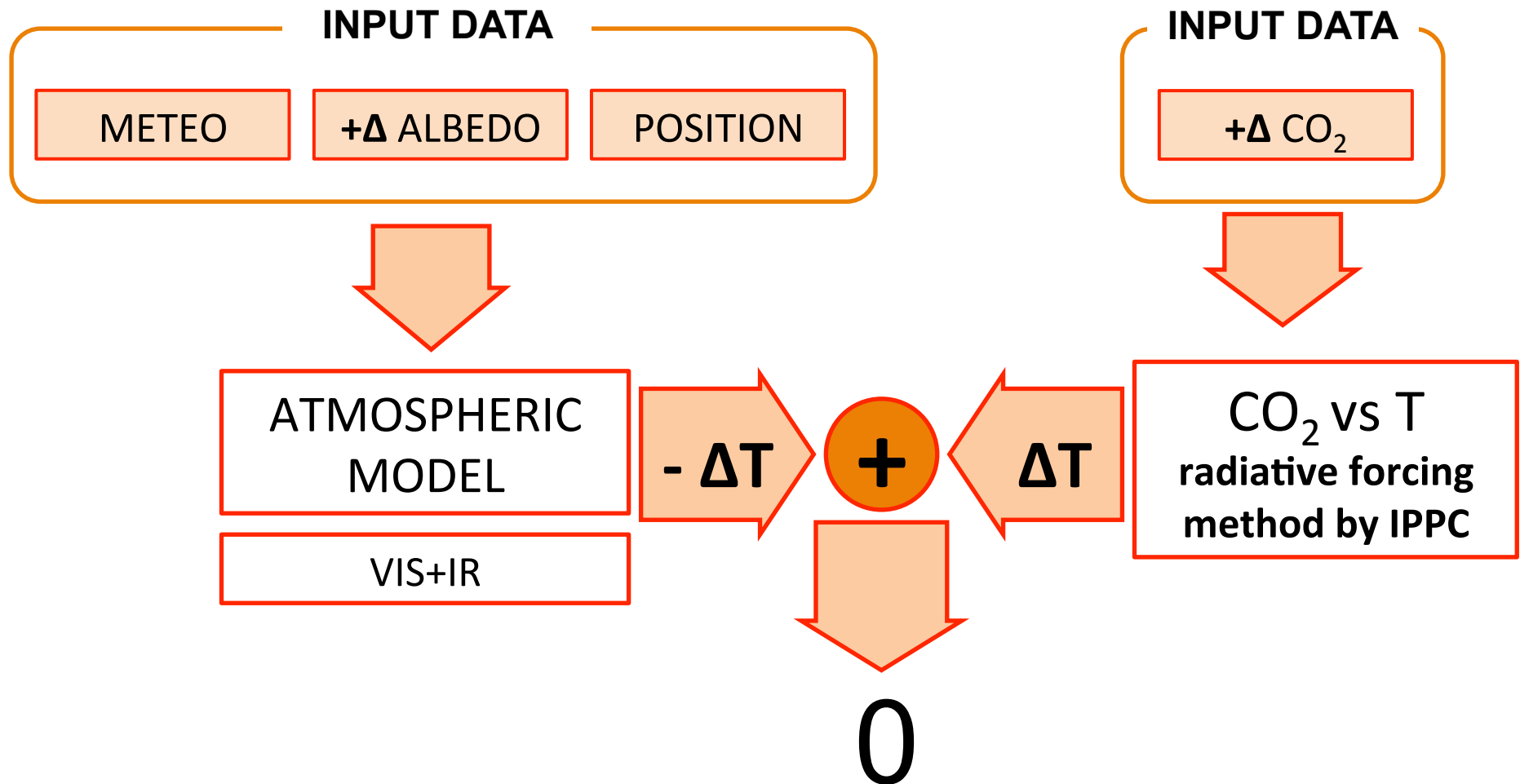
- Several models are still available to predict the effect of Earth albedo on earth temperature.
- A new method (CIRIAF PATENT) is the only one that takes into account the **high albedo surface peculiarities**: (latitude, tilt angle, azimuth angle, albedo).

$$CO_2 \text{ OFFSET} = f(\alpha, \beta, \gamma, r_s, \tau, M)$$

The diagram illustrates the components of the function $f(\alpha, \beta, \gamma, r_s, \tau, M)$ in the equation $CO_2 \text{ OFFSET} = f(\alpha, \beta, \gamma, r_s, \tau, M)$. Red arrows point from each variable to its corresponding physical meaning:

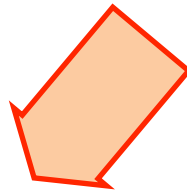
- α points to *Latitude*
- β points to *Tilt angle*
- γ points to *Azimuth angle*
- r_s points to *Surface solar albedo*
- τ points to *Time*
- M points to *Meteo conditions*

ALBEDO PROJECT

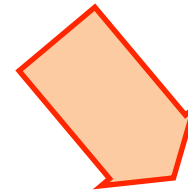


ALBEDO PROJECT

ALBEDO
ENHANCEMENT

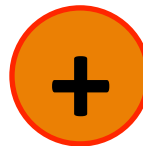


GLOBAL WARMING
MITIGATION



BUILDING PASSIVE
COOLING

CO₂
OFFSET



AVOIDED CO₂
EMISSIONS

TECHNOLOGIES FOR ALBEDO ENHANCEMENT

Cool Roofs

INHERENTLY COOL ROOFS



GREEN ROOFS



COATED COOL ROOFS

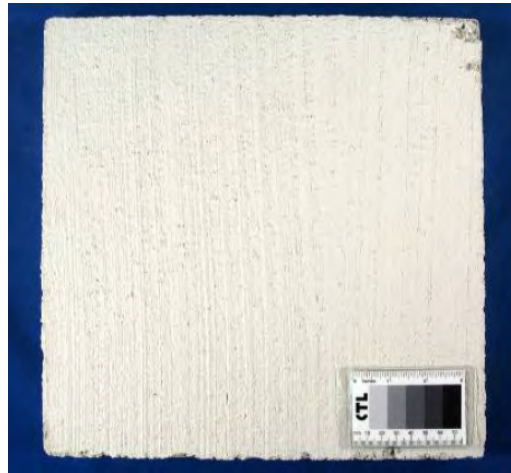


Certification requirements for
different cool roof programs

<i>Slope</i>	<i>Solar Reflectance</i>	<i>SRI</i>
	Energy Star	US GBC LEED
Low	0.65	78
Steep	0.25	29

TECHNOLOGIES FOR ALBEDO ENHANCEMENT

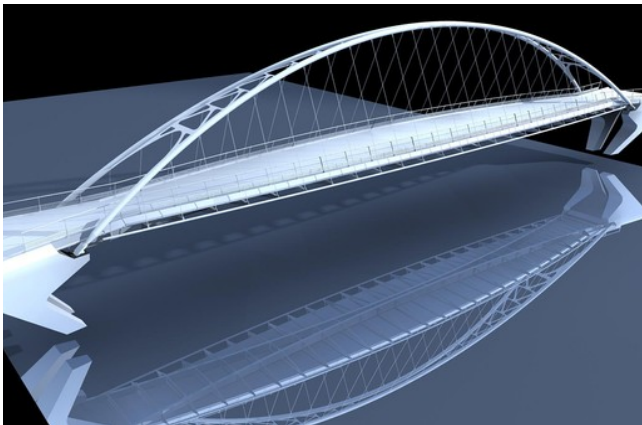
CONCRETES



<i>Material</i>	<i>Solar Reflectance</i>	<i>Emittance</i>	<i>SRI</i>
Black acrylic paint	0.05	0.90	0
New asphalt	0.05	0.90	0
Aged asphalt	0.10	0.90	6
White asphalt shingle	0.21	0.91	21
Aged concrete	0.20 to 0.30	0.90	19 to 32
New concrete (ordinary)	0.35 to 0.45	0.90	38 to 52
New white Portland cement concrete	0.70 to 0.80	0.90	86 to 100

TECHNOLOGIES FOR ALBEDO ENHANCEMENT

ARCHITECTONIC STRUCTURES



SALT PANS



ARBOREAL SPECIES



CO₂ OFFSET BY ALBEDO ENHANCEMENT

[M²/TON CO₂_{EQ}]

EXPOSURE MUST BE GUARANTEED FOR 30 YEARS

NIAMEY (Niger) Latitude $\alpha = 13^\circ$		Surface Solar Albedo r		
		0.4	0.6	0.9
Tilt angle β	0° Horizontal	16	10	5
	45°	22	13	7

ROME (Italy) Latitude $\alpha = 41^\circ$		Surface Solar Albedo r		
		0.4	0.6	0.9
Tilt angle β	0° Horizontal	24	15	8
	45°	20	11	6

PARIS (France) Latitude $\alpha = 48^\circ$		Surface Solar Albedo r		
		0.4	0.6	0.9
Tilt angle β	0° Horizontal	30	18	10
	45°	21	12	7

LITERATURE COMPARISON

CO₂ OFFSET* [m² ⁽¹⁾/ton CO₂]

**Input data has been homogenized for comparison*

	CIRIAF	HARTE	AKBARI
Earth average ⁽²⁾ ⁽³⁾	23	26	10
NIAMEY - Niger ($\alpha = 13^\circ$, $\tau = 30$)	16	X	X
ROME - Italy ($\alpha = 41^\circ$, $\tau = 30$)	24	X	X
PARIS - France ($\alpha = 48^\circ$, $\tau = 30$)	30	X	X

⁽¹⁾ High reflecting surface size

⁽²⁾ Incident flux of solar radiation = 342 W/m²

⁽³⁾ Solar reflectance of surface $r = 0.40$

AVOIDED CO₂ COSTS

COMPARISON WITH RENEWABLES

Technology	c€/kg CO ₂
Ribbon silicon	59.0
Photovoltaic mono/multicrystalline silicon	60.5
Thermal solar (flat collector)	30.0
Wind generator	3.8
Hydroelectrical	2.6
High ALBEDO surface - lime paint ($r = 0.9$)	4.0
High ALBEDO surface - vinyl acrylic paint ($r = 0.9$)	5.0

BE ATTENTION !!!

- renewable technologies avoid CO₂
- albedo enhancement compensate CO₂

EMISSION TRADING SYSTEM

HOW ETS WORKS?

EU ETS is based on the *cap and trade* principle.

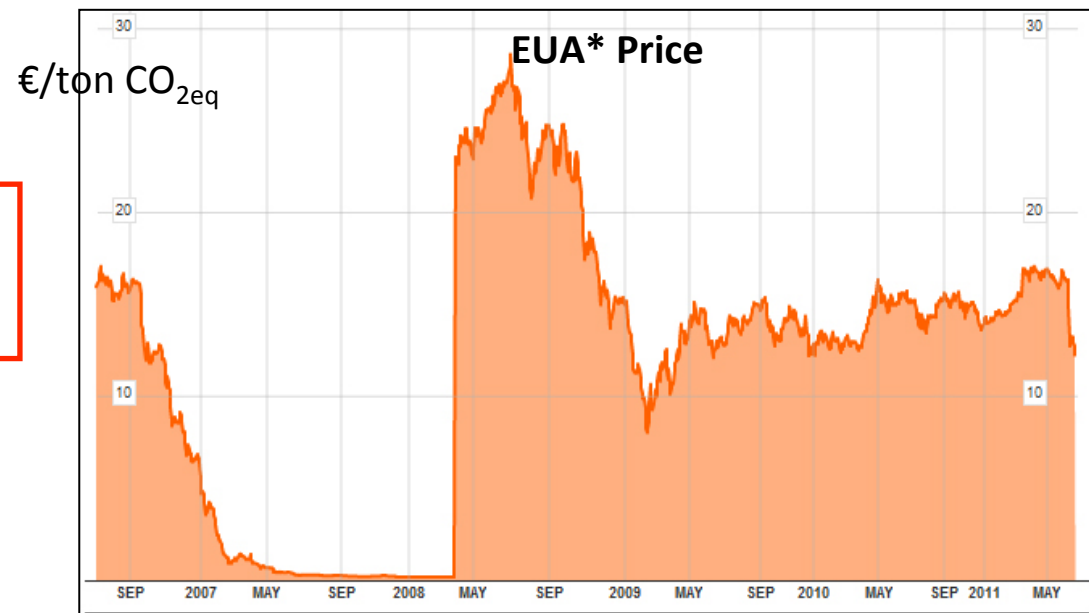
Cap on allowed CO₂ is set by EU for each country.

Within cap, *emission allowances* are released.

Allowances may be traded according to a market **VALUE**

By **ETS** 1 ton CO₂ value is actually **13 €**⁽¹⁾

⁽¹⁾ EEX - European Energy Exchange
(2011/07/05)



* European Union Allowance

ALBEDO PROJECT OPPORTUNITIES

1 ton of CO₂,eq is half absorbed by ecosystem and half contributes to increase atmospheric concentration.

To compensate 1 ton of CO₂,eq released into the atmosphere
4 m² $r = 0.9$ -ALBEDO surface are required in Rome.

**Which is the potential value of
1 m²@ $r = 0.9$ in Rome today?**

3 € for 30yrs exposure!!!!

ALBEDO PROJECT OPPORTUNITIES

INCOMINGS FROM **1.000 M²** OF
HIGH ALBEDO SURFACES
($r = 0.9$, $\beta = 0^\circ$)

LOCALITY 1

NIAMEY
(NIGER)

5.200 €
174 €/yrs

LOCALITY 2

ROME
(ITALY)

3.250 €
109 €/yrs

LOCALITY 2

PARIS
(FRANCE)

2.600 €
87 €/yrs

HOW CAN WE GET IT ?????

AUTHORITY FOR ALBEDO

TASKS

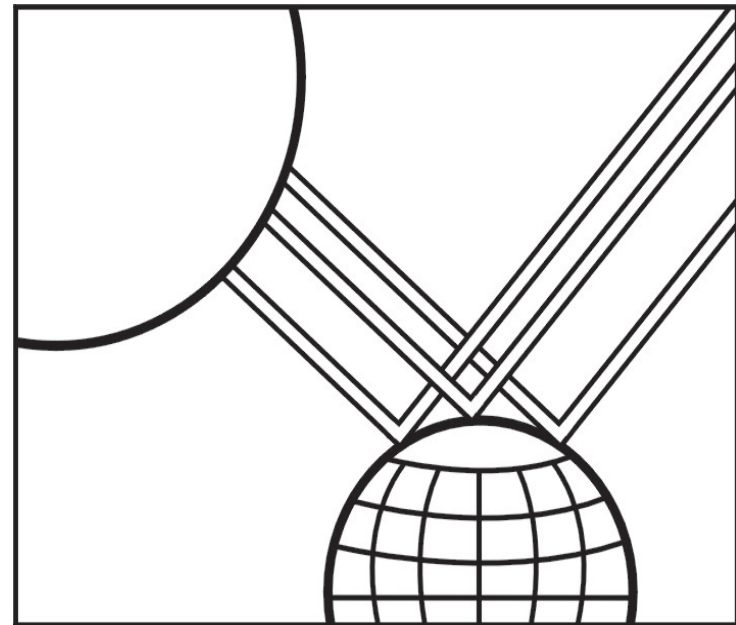
PROJECTS
APPROVAL

CREDITS
ISSUING

MARKET
REGULATION

PERIODIC ALBEDO
MONITORING
(*AlbedoSat*)

*A proposal for
certificate*



REFLECTING A BRIGHTER FUTURE

N° xxxx

95%

2011

CO₂ OFFSET

Ton/yr

.....

ALBEDOSAT PROJECT

SATELITE GENERAL SPECIFICATIONS

Orbit

Sun-Synchronous

Altitude

500 - 700 km

Orbit Inclination

97°

Orbits per day

15

Optical instruments

Panchromatic camera

Image spectrometer

Micro interferometer



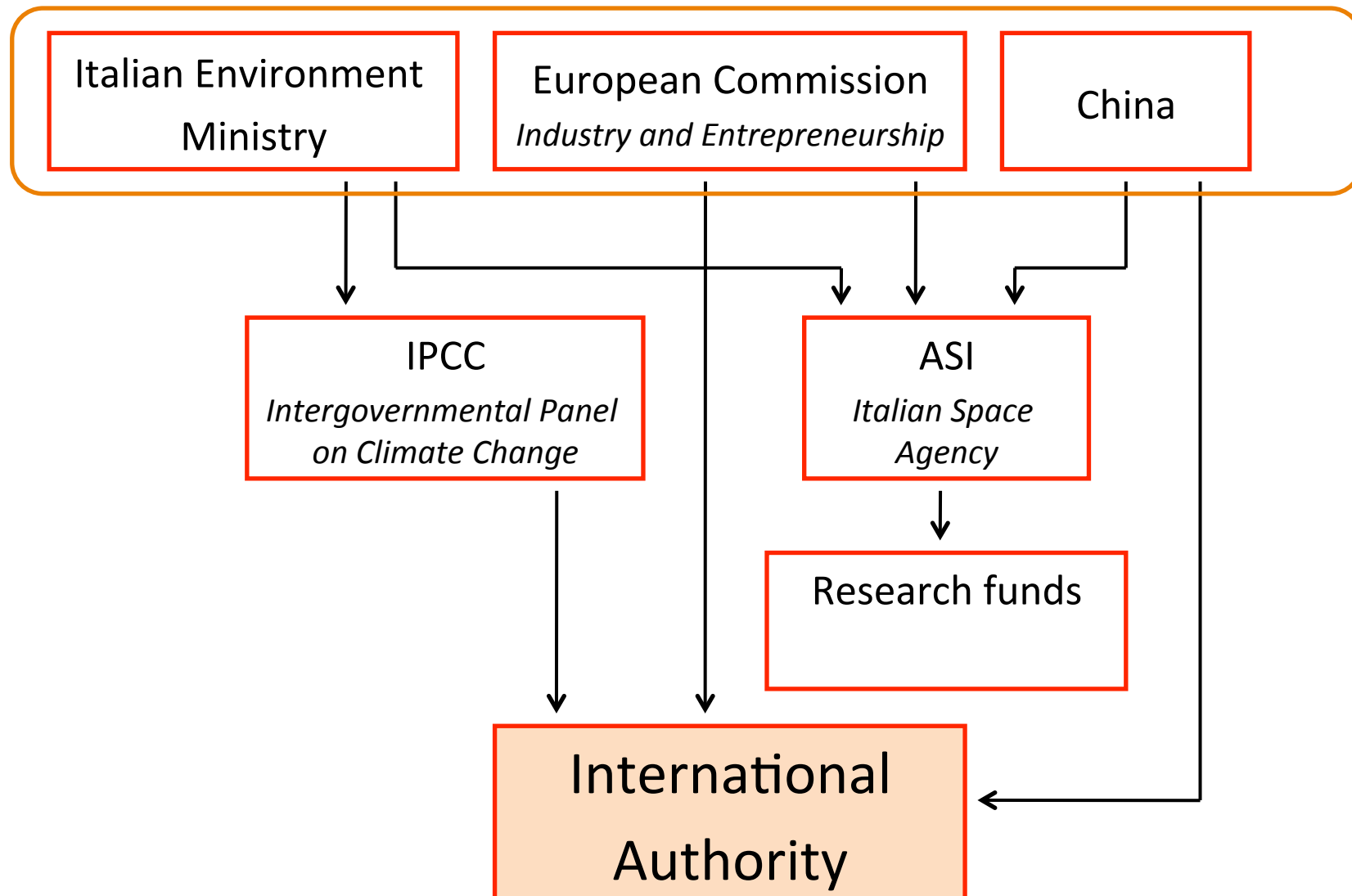
ALBEDOSAT PROJECT

POSSIBLE SATELLITE FEATURES

PANCHROMATIC CAMERA	IMAGE SPECTROMETER	MICRO INTERFEROMETER
<i>Spectral range</i> 400 - 900 nm	<i>Spectral range</i> 400 - 1000 nm	<i>Spectral range</i> 400 - 4500 nm
<i>GSD - Ground Sample Distance</i> 2 m	<i>Spatial resolution</i> 10 m	<i>Image size</i> 3 x 3 km
<i>Swath width</i> 10 km	<i>Image size</i> 10 x 10 km	
	<i>Field of View</i> 1.15°	

ALBEDOSAT PROJECT

FINANCIAL SCHEME 30 M€



W.E.C. CREDIT

23/11/2009European Climate Change Policy Beyond 2012 World Energy Council 2009

European Climate Change Policy Beyond 2012 World Energy Council 2009

112



European Climate Change Policy Beyond 2012

World Energy Council 2009

Promoting sustainable energy for the greatest benefit of all



Annex E: Alternative Technologies

Annex E 1: Albedo Control Systems (ACS)

The rapid and continuous increase in the concentration of GHGs and the weaknesses in policies and technical instruments to fight the increase made it necessary to find environmentally friendly, technically simple and cheap solutions to be applied in countries with limited economic resources to control the global average temperature increase.

An effective solution to reduce global warming and counteract the effect of emissions of GHGs in terms of global temperature could be the control of Earth's albedo (ACS) by implementing "white-

reflecting" surfaces with a high reflection coefficient. Reflecting surfaces reduce absorbed energy thus increasing the solar energy reflected in to space and so reducing the amount of energy contributing to the Earth's warming.

Quantification of reflecting surface effectiveness has been accomplished through an innovative and patented mathematical equation, based on an energy balance between sky, atmosphere and earth surface. The correlation between the temperature reduction and the GHG decrease in the atmosphere has been also calculated. The effectiveness of reflective surfaces is closely related to latitude and meteorological and morphological characteristics of the installation area. Each m² of high albedo (90%) surface compensates for an amount of CO₂-eq introduced in the atmosphere varying from 45 to 62 kg.

Table E-1
Comparison of avoided CO₂-eq emission costs between different renewable sources and the white reflecting technology

Technology	Avoided CO ₂ -eq costs
	c€/KgCO ₂ -eq
Photovoltaic amorphous silicon	74.8
Photovoltaic multicrystalline silicon	83.0
Photovoltaic monocrystalline silicon	98.8
Thermal solar (flat collector)	14.5
Wind generator	3.9
Hydroelectrical	4.3
Albedo control	4.4

The reflective surfaces can be created both on land and sea; both artificial and natural surfaces can be used (roofs of houses, sport facilities and industrial plants, roads, pedestrian areas, city squares, car parking lots, gardens, parks, etc). Alternatively, trees, shrubs or flowers with appropriate colour characteristics (high average reflection coefficients) can also be utilised. On land, reflective surfaces can be obtained by laying paints, films, plates or any type of coating with a high reflection coefficient. Other cheaper materials, such as calcium carbonate powder, grain patterns for flower beds or gardens or lime hydrate could be used in many areas. Reflective surfaces could be also implemented by restoring disused salt evaporation ponds. A procedure to control surface albedo based on high definition satellite differential spectrophotometry has been developed and standardised.

In Table E-1, a comparison among ACS and renewable energy sources is shown, based on the cost required to avoid the same amount of introduced CO₂-eq. As far as renewable energy power plants are concerned, the cost of GHG emissions reduction has been evaluated as the ratio of the difference in production cost of ACS as compared with the most successful traditional technology in reducing emissions by the same amount, for the generation of an electrical or thermal energy unit. The reference price for white reflecting surfaces is the cost of paint/film, marked up to include the labour cost necessary to produce and efficiently operate the surfaces (Patent).

Territories in the equatorial belt (intertropical zones), dry and low cloud areas, seas and oceans

are favoured locations to implement the proposed solution due to high insulation and low cloud coverage.

Interesting economic opportunities could arise for underdeveloped and developing countries in such areas. If the global warming reduction effectiveness of reflecting surfaces was internationally acknowledged, these countries could make a greater contribution to the worldwide efforts towards a better climate.

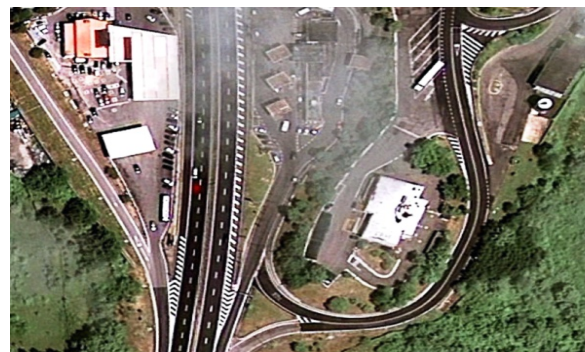
Annex E 2: Pipe\$net system

"Pipe\$net" is an innovative freight transport system for loads up to 50 Kg (volume 200-400 litres), constituted by a network of vacuum-sealed pipes divided into sections, where goods-carrying capsules are moved by electric linear motors (LSM) in very low-friction conditions and at variable speeds. In comparison to other systems, Pipe\$net focuses on small volume freight, avoiding many of the critical issues innovative systems meet in their development. With Pipe\$net, small volume freight is conveyed at high speeds in order to maintain a transport capability higher than traditional systems. Pipe\$net's main features are: high transport capability (through high speed and high linefill rate); traffic relief potential; low energy consumption (LSM recovers part of the acceleration energy); low environmental impact both from air and noise emissions; fast delivery of goods; seamless and affordable connections by flexible integration into existing transport facilities; intermodal/comodal integration with traditional transport systems to increase the quantity and quality of the solutions for the optimisation of

RUNNING PROJECTS

Total Petrochemicals S.p.A.

High albedo gas station roofs



Fornaci Briziarelli Marsciano S.p.A.
& Colorobbia S.p.A.

High albedo materials for roofs coating

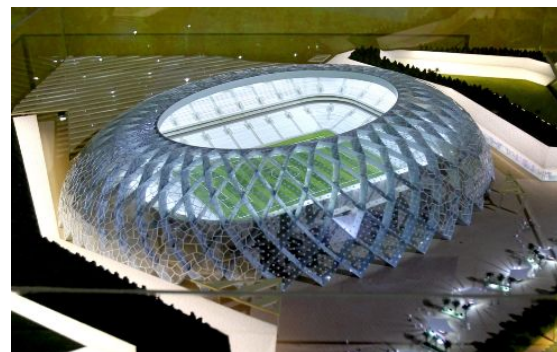
Cantine Fasola (Montevibiano)

Zero Emissions Farm



RUNNING PROJECTS

***Qatar 2022 FIFA World
Cup Stadiums***



Watergy (Water and Energy Technical
Innovations) S.r.l.

High albedo materials for buildings coating

Carrefour S.p.A.

High albedo materials for mall roofs

