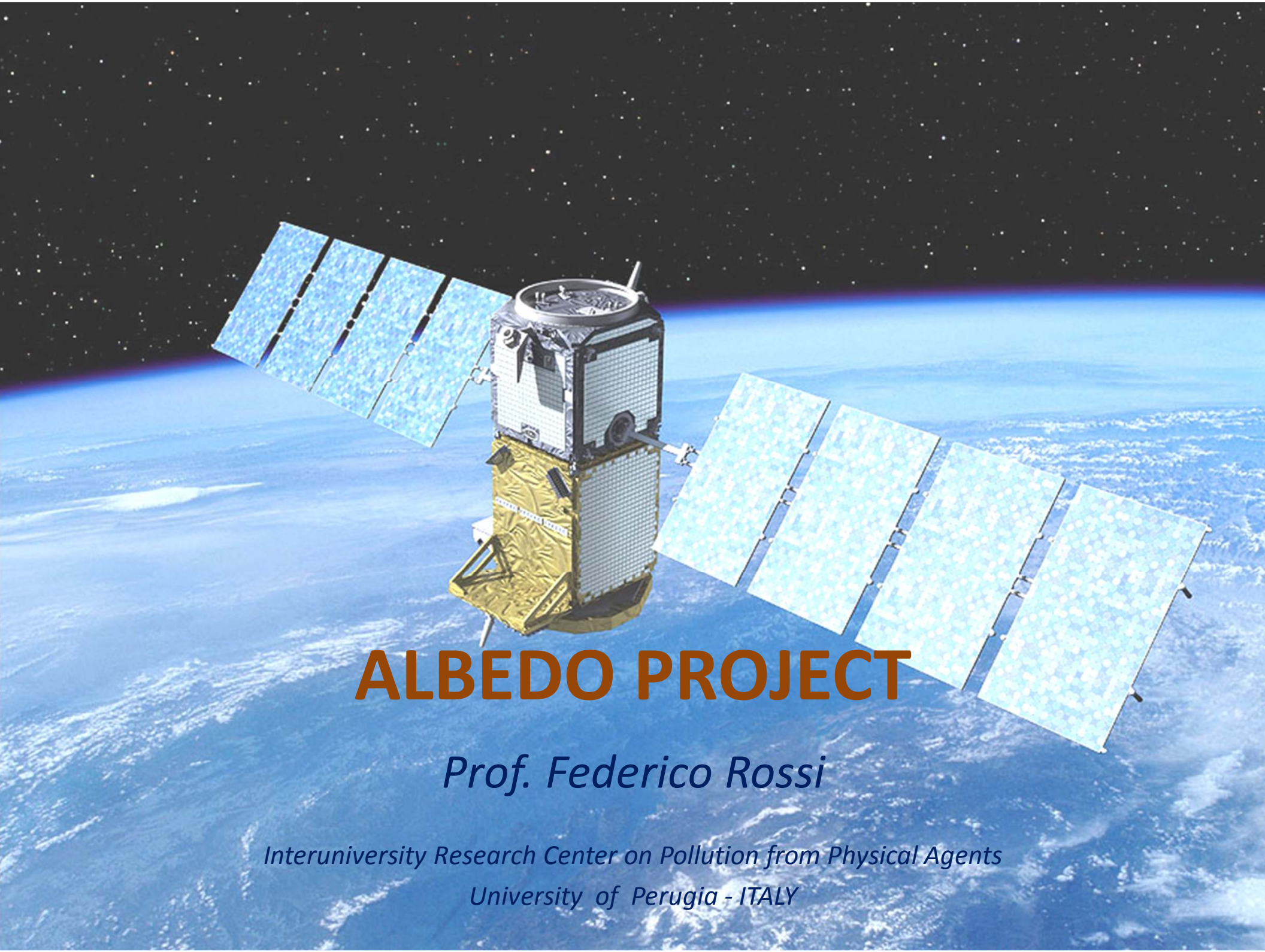


ALBEDO PROJECT

Prof. Federico Rossi

Interuniversity Research Center on Pollution from Physical Agents

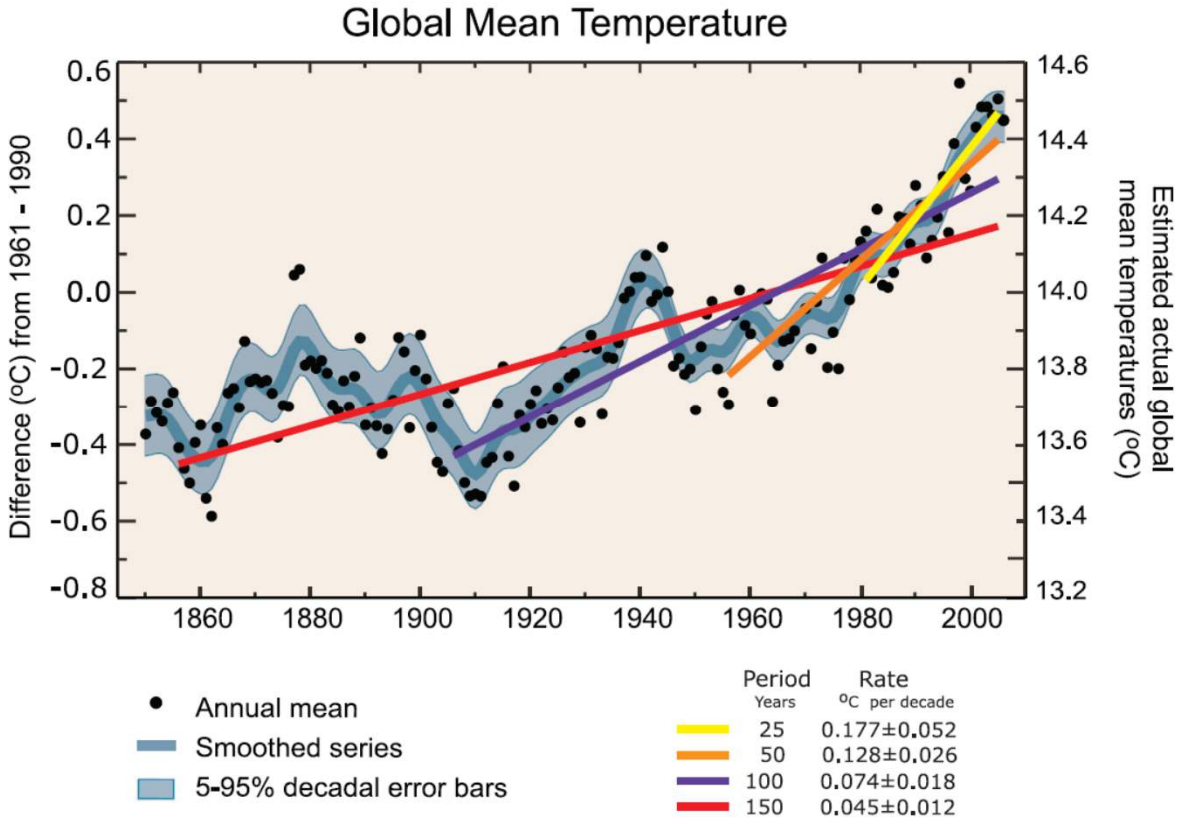
University of Perugia - ITALY

GLOBAL WARMING

- Atmospheric concentration of CO_2 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

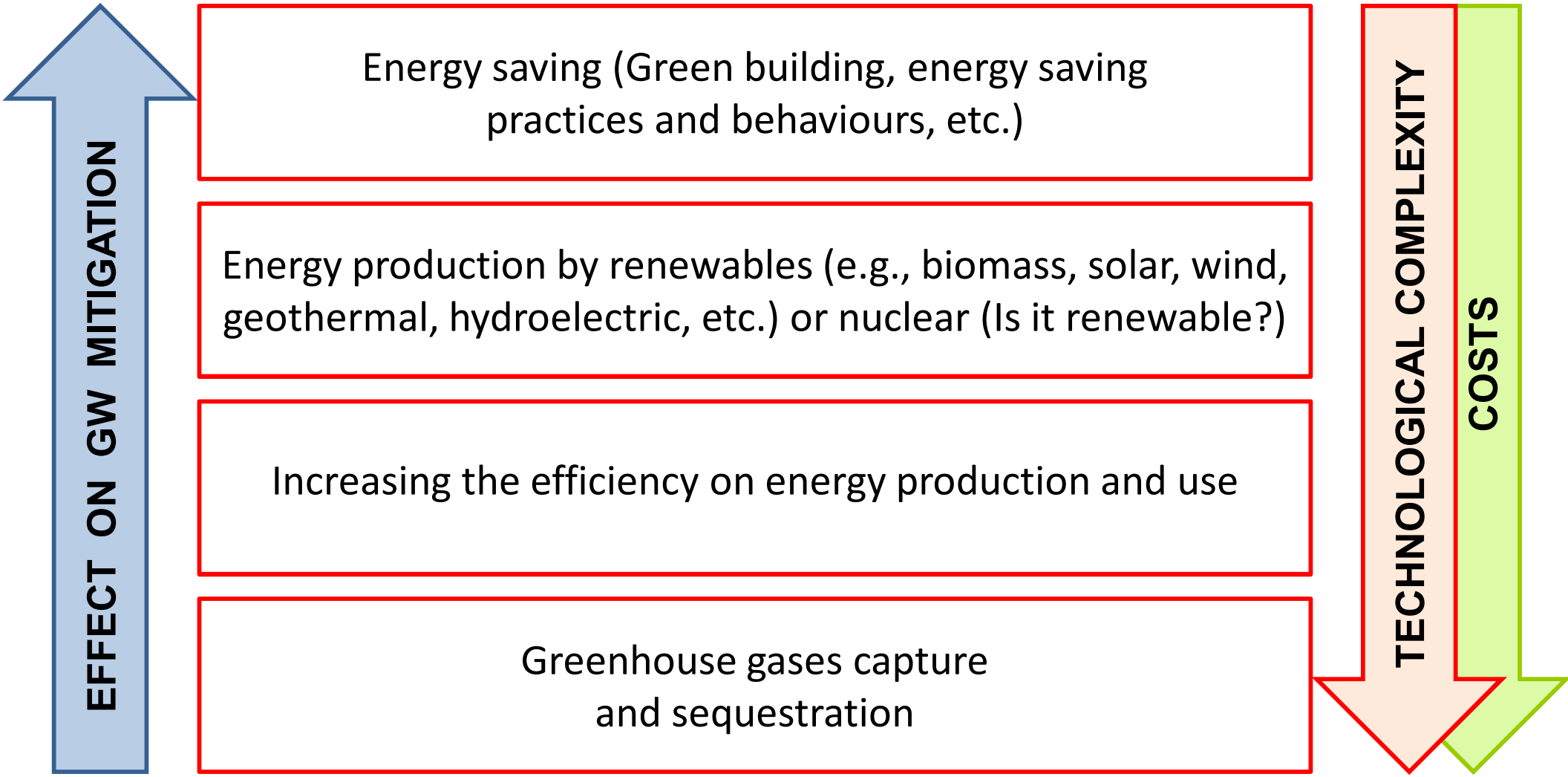
- **4.3 - 6.9 billion** of people living in severely stressed river basins.
- **200 million** of climate migrants by 2050.
- **50 %** fall of rain-fed agricolture in sub-Saharan Africa by 2020.
- **40 - 140 million** of people flooded per year by 2100.

HEALTH

- **400 milion** additional popolation 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 CO_2 (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 CO_2 effect on earth average temperature.

ETIOLOGY

SURFACE ALBEDO INCREASE → GLOBAL AVERAGE TEMPERATURE DECREASE → CO_2 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).

$$CO_{2\,OFFSET} = f(\alpha, \beta, \gamma, r_s, \tau, M)$$

Meteo conditions

Time

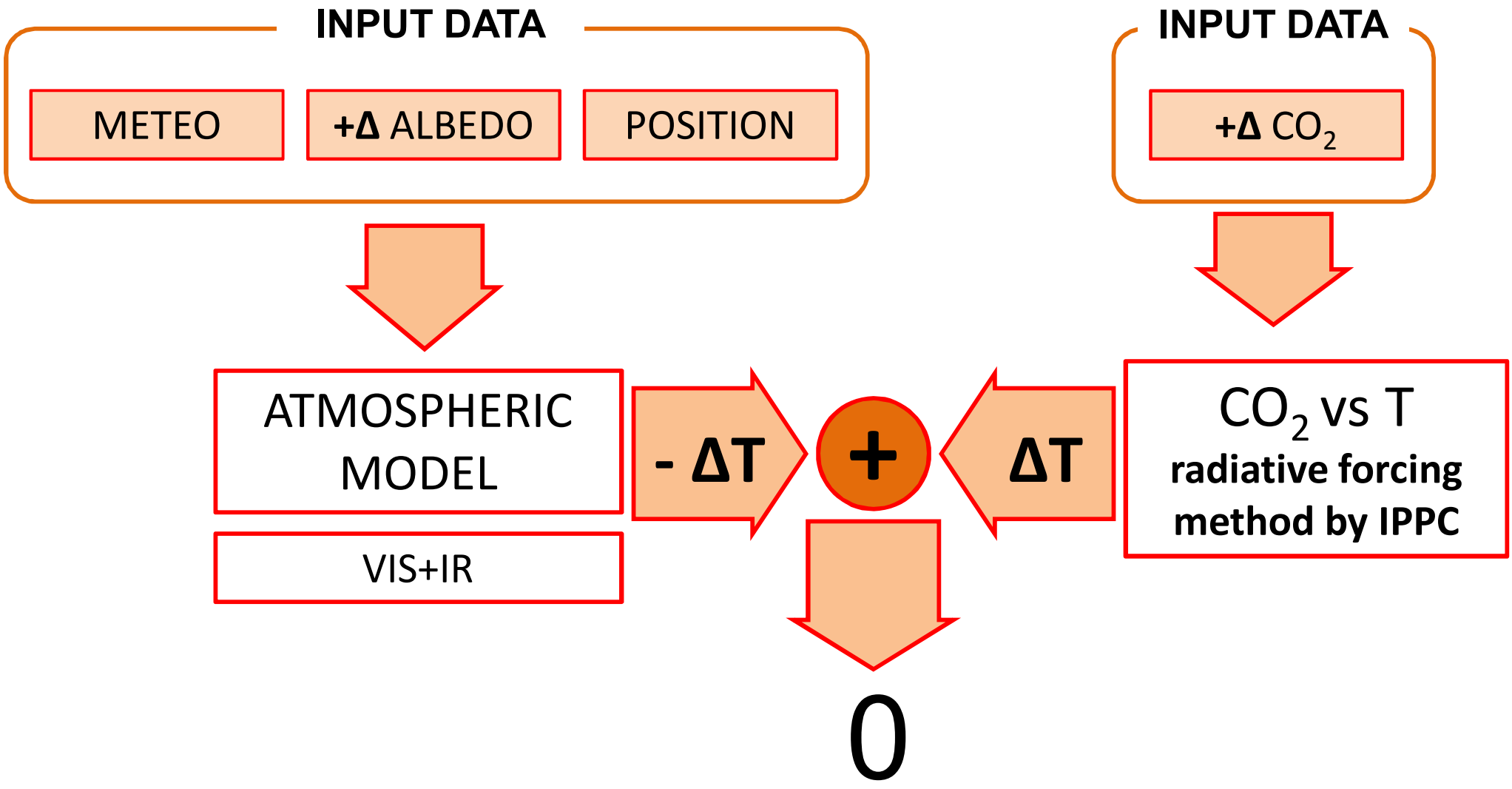
Surface solar albedo

Azimuth angle

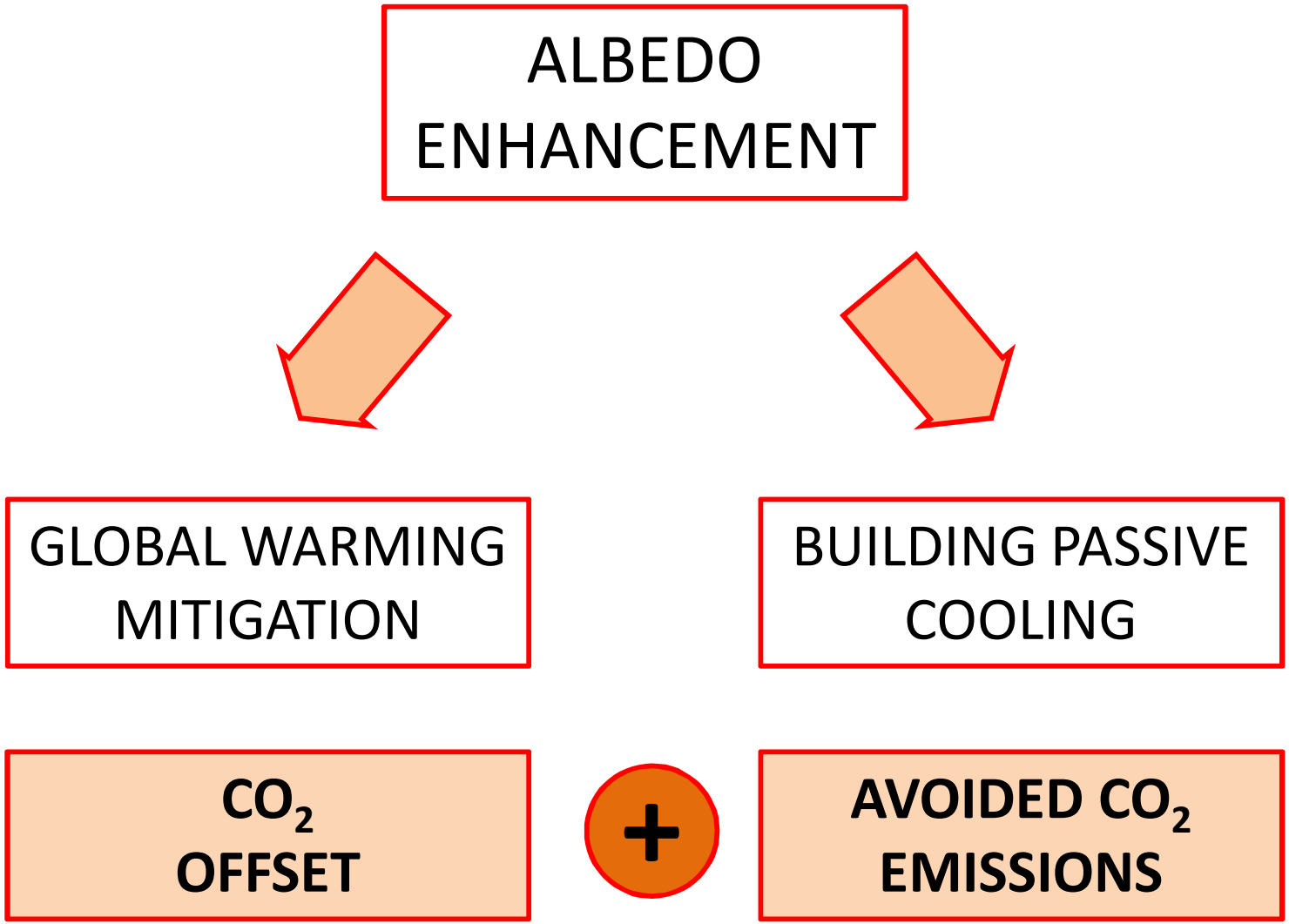
Tilt angle

Latitude

ALBEDO PROJECT



ALBEDO PROJECT



Technologies for Albedo Enhancement

Cool Roofs

Inherently Cool Roofs

Green Roofs

Coated Cool Roofs

Certification requirements for different cool roof programs

Slope	*Solar Reflectance*	*SRI*
	Energy Star	**US GBC LEED**
Low	0.65	78
Steep	0.25	29

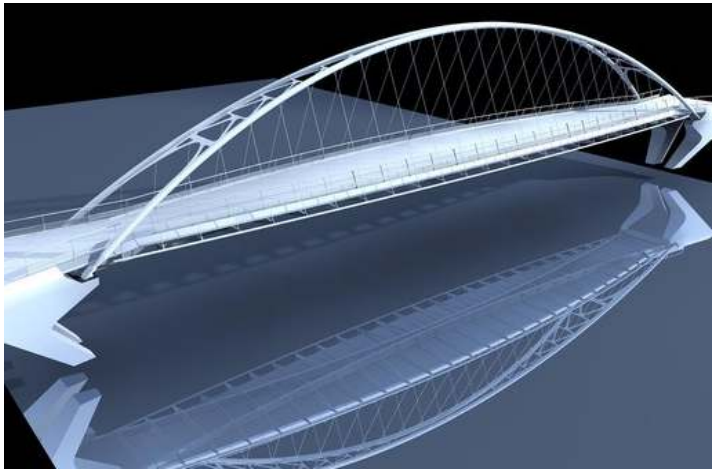
TECHNOLOGIES FOR ALBEDO ENHANCEMENT

CONCRETES

Material	*Solar Reflectance*	*Emittance*	*SRI*
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

CO_2 OFFSET BY ALBEDO ENHANCEMENT

[M^2/TON CO_{2EQ}]

EXPOSURE MUST BE GUARANTEED FOR 30 YEARS

NIAMEY *(Niger)* *Latitude α = 13°*		*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 α = 41°*		*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 α = 48°*		*Surface Solar Albedo* ***r***		
		0.4	*0.6*	*0.9*
Tilt angle β	*0° Horizontal*	**30**	**18**	**10**
	45°	**21**	**12**	**7**

LITERATURE COMPARISON

CO_2 OFFSET* [m^2 (1)/ton CO_2]

**Input data has been homogenized for comparison*

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

(1) High reflecting surface size

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

(3) Solar reflectance of surface r = 0.40

AVOIDED CO_2 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 CO_2

-albedo enhancement compensate CO_2

EMISSION TRADING SYSTEM

HOW **ETS** WORKS?

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

Cap on allowed CO_2 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 CO_2 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 m^2@*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, β = 0°)

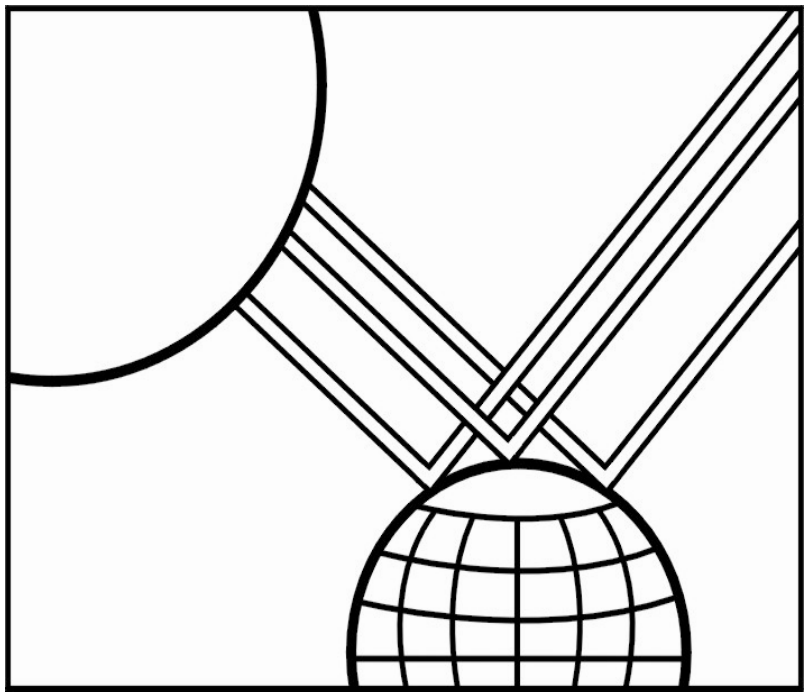
LOCALITY 1	LOCALITY 2	LOCALITY 2
NIAMEY (NIGER)	ROME (ITALY)	PARIS (FRANCE)
5.200 €	**3.250 €**	**2.600 €**
174 €/yrs	**109 €/yrs**	**87 €/yrs**

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**
CO_2 OFFSET		
Ton/yrs	**…….**	

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

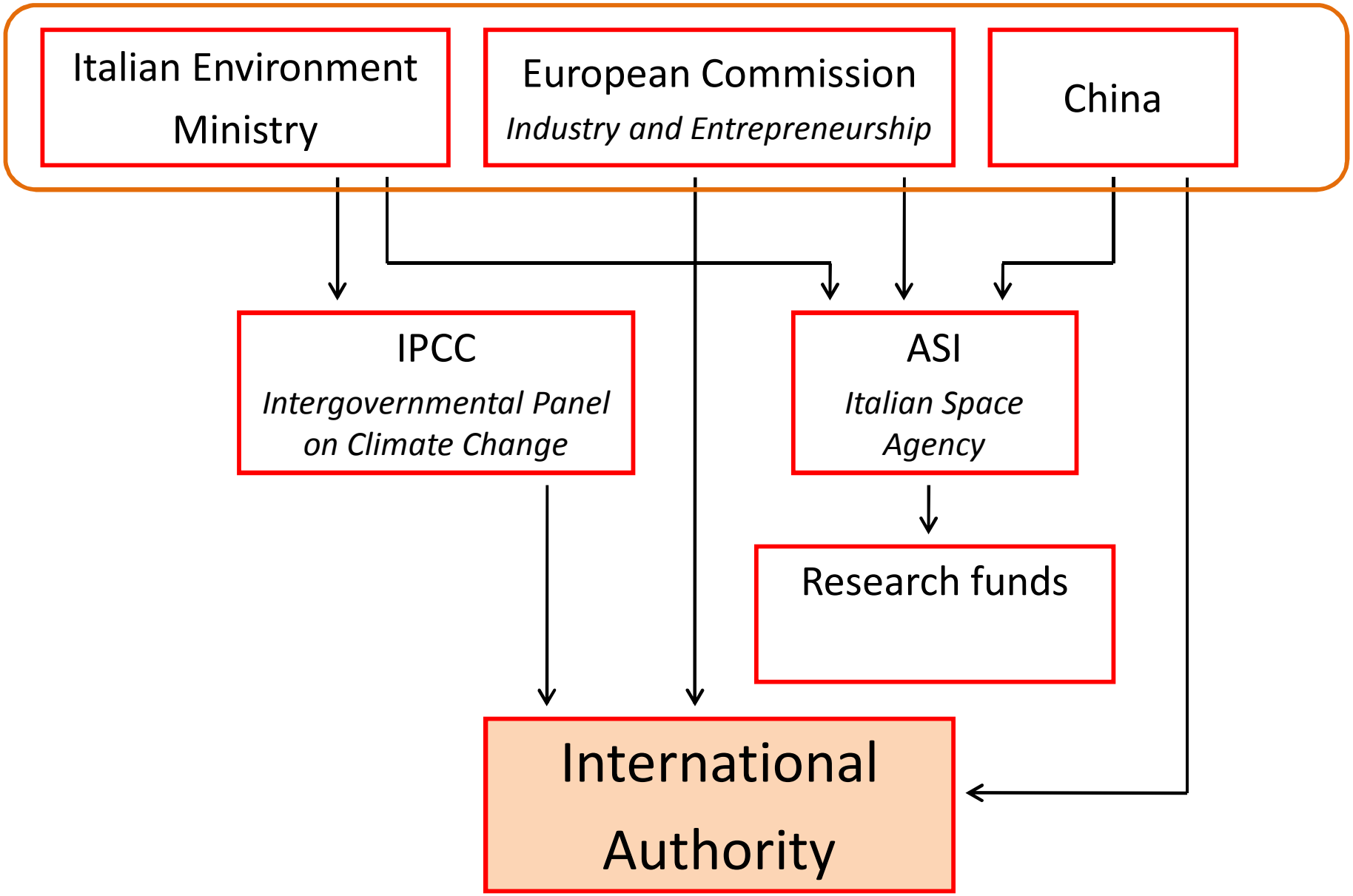
ALBEDOSAT PROJECT

POSSIBLE SATELLITE FEATURES

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

ALBEDOSAT PROJECT

FINANCIAL SCHEME 30 M€



W.E.C. CREDIT

WORLD ENERGY COUNCIL
CONSEIL MONDIAL DE L'ÉNERGIE

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 m^2 of high albedo (90%) surface compensates for an amount of CO_2-eq introduced in the atmosphere varying from 45 to 62 kg.

Table E-1
Comparison of avoided CO_2-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 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 CO_2-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.

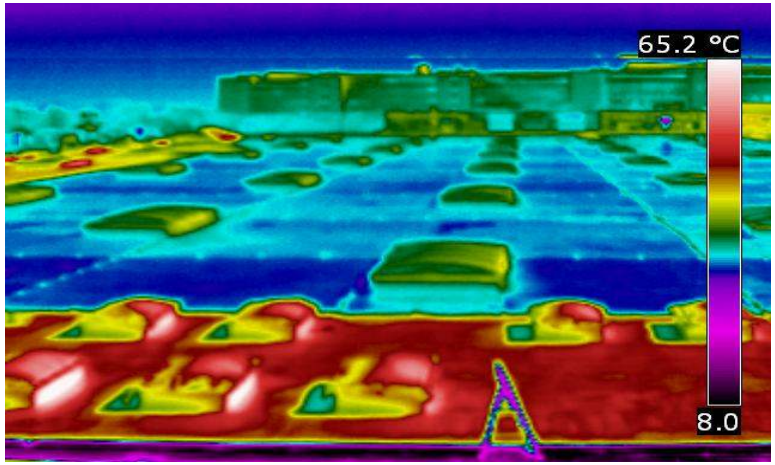
Interesting economic opportunities could arise for underdeveloped and developing countries in such areas. If the global warming reduction effectiveness of reflecting surfaces was internationally acknowledged, these countries could make a greater contribution to the worldwide efforts towards a better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

CARREFOUR ASSAGO PROJECTS

CARREFOUR ASSAGO THERMAL DEPICTION



CONSUMPTION DATA

Sales area: 16.000 sqm. - sales area internal height: 7 mt.
Diesel consumption (average years 2004-2010): 150,000 liters / year
Natural gas consumption in 2011 (with new condensing boilers with natural gas):
95,000 mc
Total average annual electricity consumption: 7,000 MWh

Consumption (weekly) measured on multimeters CDZ (week average for the period July-August):

- WITHOUT COOL ROOF

2007: 44.573 kWh - 2008: 46.783 kWh - 2009: 46.627 kWh - 2010: 45.259 kWh
average : **45.810 kWh**

- WITH COOL ROOF

2011: **33.500 kWh (-27%)**