

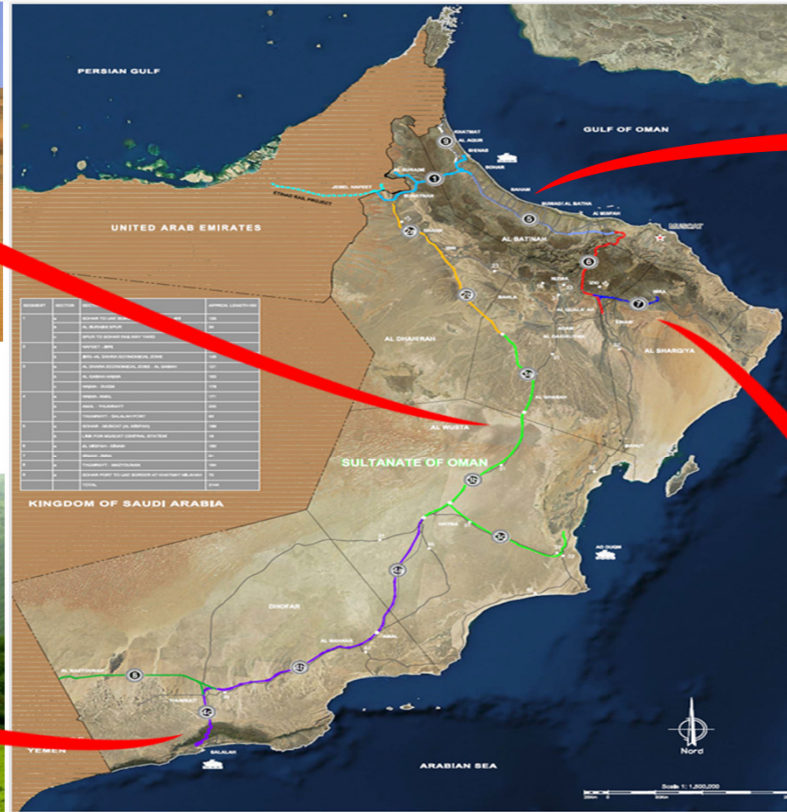
# L'applicazione dei criteri del protocollo LEED nelle Stazioni ferroviarie in Oman

23 Giugno 2017 – Tiziana Fazio

# Il progetto della nuova rete ferroviaria in Oman



diversi contesti...



...diverse soluzioni



# Gli obblighi contrattuali:



Obblighi contrattuali:

La progettazione della stazione deve rispettare gli standard di prestazioni per la sostenibilità in conformità o equivalente a LEED Gold

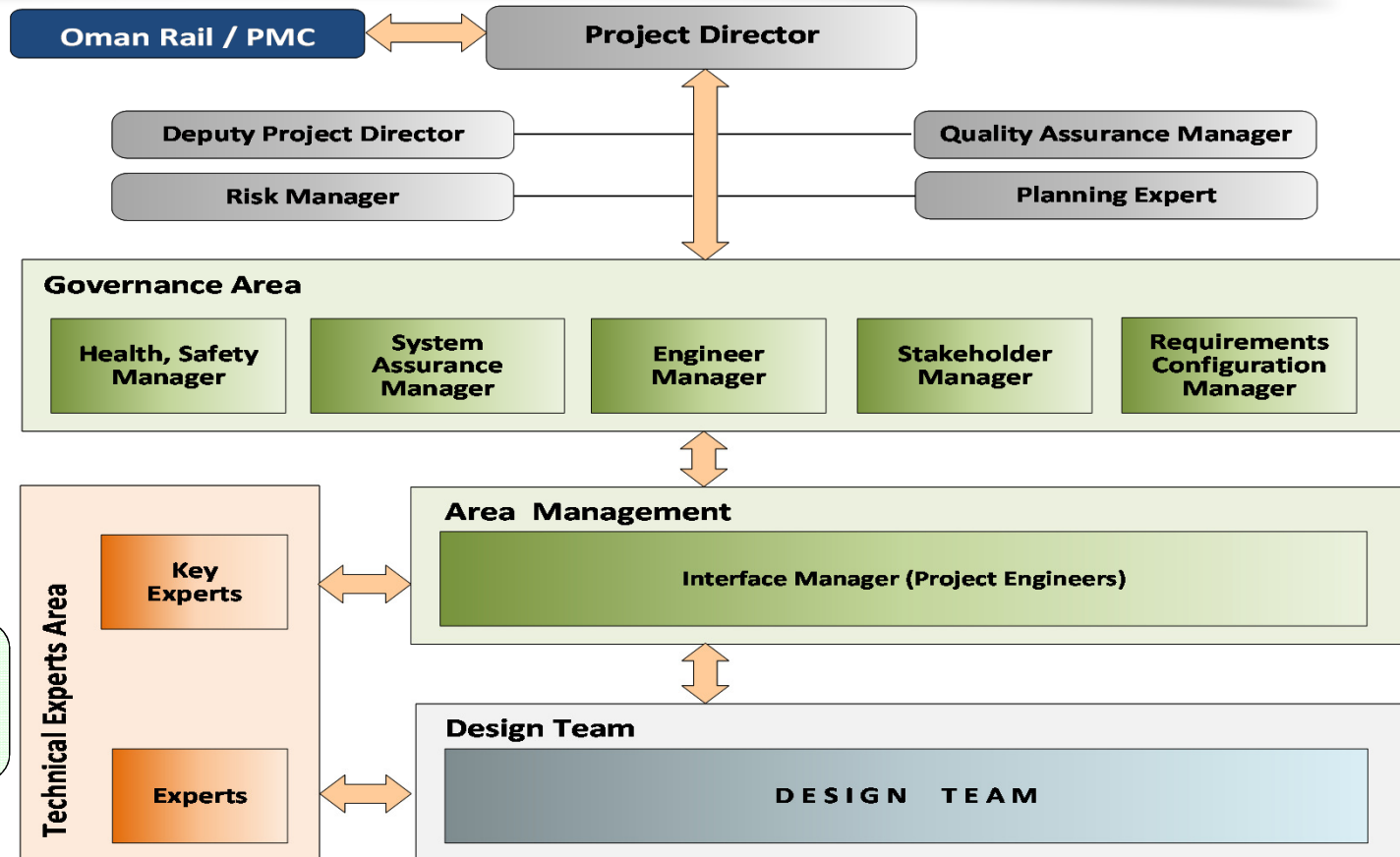


# L'Organizzazione del Progetto

## Focus on:

- Task Force
- Key Experts
- Procurement
- Tools
- Stakeholder

• Leed AP  
consulente and auditor





# La conoscenza del Paese: Al Batinah Region



*Nakal Fort*



*Farm (Barka)*



*Sohar Port*



*Wadi Al Ahyad*



*Falaj*



*Rustaq Mosque*



# La conoscenza del Paese: The Hajar Mountains



Jebel Shams 3.075 m slm - "La montagna del Sole"



Chourfat Al Nakhr - il "Grand Canyon" dell'Oman



Jebel Shams – Nevicata gennaio 2007



Jebel Akdar 2.980 m slm - "La montagna verde"



Tipico esempio di coltivazione a terrazza



Alberi di melograno



# La conoscenza del Paese: Il deserto... “*i deserti*”



... Ash Sharqiyah Sands



... Rub'Al Khali Sands - "Il quarto vuoto"



... lungo il segment 1



... lungo il segment 2



... Oryx Garden - lungo il segment 3



... lungo il segment 8

# La conoscenza del Paese: Il Dhofar

Regione del tutto particolare per il suo **microclima tropicale**:

- vegetazione lussureggiante durante il Khareef (giugno-settembre)
- rifugio di numerosissimi uccelli migratori
- Allevamenti di animali

Nota in tutto il mondo per la produzione di **franchincenso**.



*Albero di franchincenso*



*Dhofar - Tipica strada con tornanti*



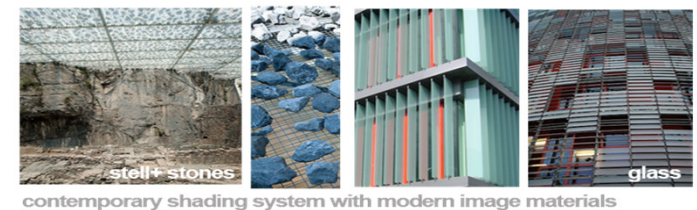
*Dhofar Mountains durante il khareef*



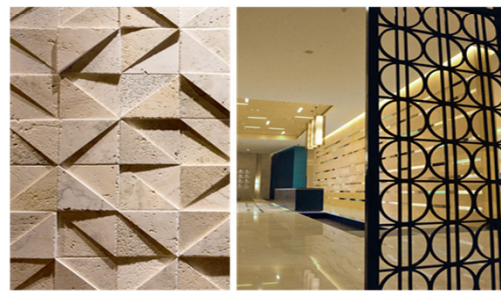
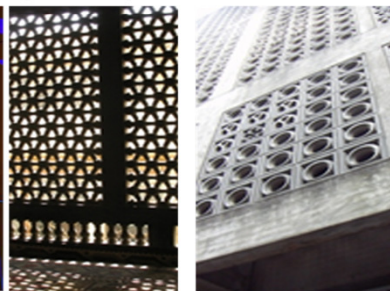
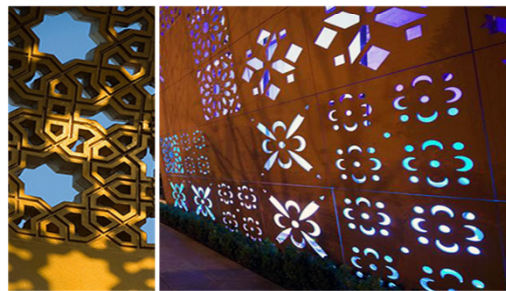
# Materiali e tecnologie

Lo scopo dello studio dei materiali è stato di creare sinergie con il contesto naturale, le condizioni climatiche spesso estreme, gli stili architettonici delle regioni desertiche e delle aree costiere fortemente urbanizzate.

## CEILINGS, SHADING SYSTEMS PATTERNS & MATERIALS



## FLOORS, WALL PATTERNS & MATERIALS

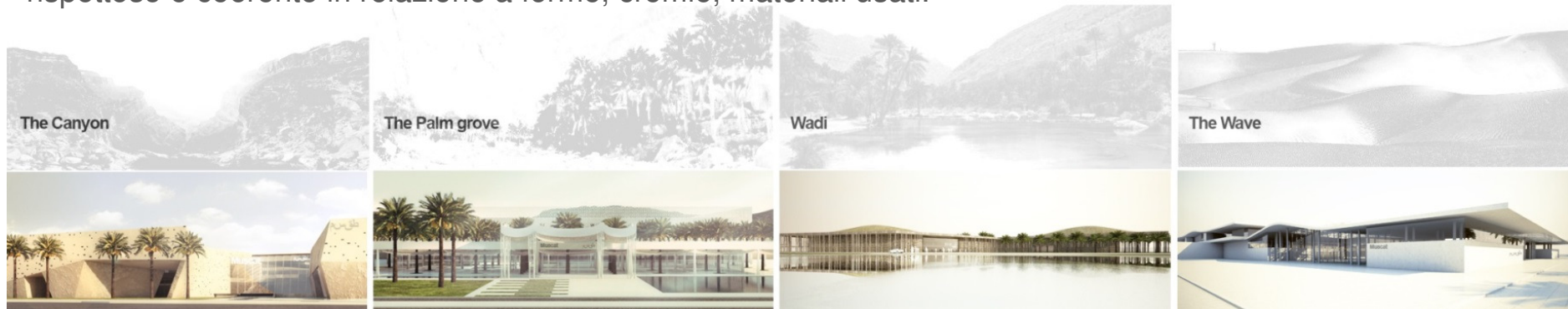




# Dallo studio del contesto agli studi preliminari



La progettazione è la capacità di cogliere gli aspetti principali del paesaggio, al fine di studiare un inserimento rispettoso e coerente in relazione a forme, cromie, materiali usati.



# Condivisione delle strategie con il Cliente - Workshop 19.06.2014 – LEED

LEED 2009 for New Construction and Major Renovations				Project Name Oman Rail Segment 1 Stations Preliminary Design			
Project Checklist				Date 22 April 2014			
13 5 8		<b>Sustainable Sites</b>	Possible Points: 26	10 3 2		<b>Indoor Environmental Quality</b>	Possible Points: 15
Y	P	M		Y	P	M	
1			Prereq 1 Construction Activity Pollution Prevention	1	1		Credit 4 Recycled Content 1 to 2
			Credit 1 Site Selection 1	1	1		Credit 5 Regional Materials 1 to 2
		5	Credit 2 Development Density and Community Connectivity 5			1	Credit 6 Rapidly Renewable Materials 1
		1	Credit 3 Brownfield Redevelopment 1			1	Credit 7 Certified Wood 1
6			Credit 4.1 Alternative Transportation—Public Transportation Access 6				
1			Credit 4.2 Alternative Transportation—Bicycle Storage and Changing Rooms 1				
	3		Credit 4.3 Alternative Transportation—Low-Emitting and Fuel-Efficient Vehicles 3				
		2	Credit 4.4 Alternative Transportation—Parking Capacity 2				
1			Credit 5.1 Site Development—Protect or Restore Habitat 1				
	1		Credit 5.2 Site Development—Maximize Open Space 1				
1			Credit 6.1 Stormwater Design—Quantity Control 1				
1			Credit 6.2 Stormwater Design—Quality Control 1				
1			Credit 7.1 Heat Island Effect—Non-roof 1				
1			Credit 7.2 Heat Island Effect—Roof 1				
1			Credit 8 Light Pollution Reduction 1				
10			<b>Water Efficiency</b>	Possible Points: 10			
Y	P	M					
4			Prereq 1 Water Use Reduction—20% Reduction				
2			Credit 1 Water Efficient Landscaping 2 to 4				
4			Credit 2 Innovative Wastewater Technologies 2 to 4				
4			Credit 3 Water Use Reduction 2 to 4				
23 10 2			<b>Energy and Atmosphere</b>	Possible Points: 35			
Y	P	M					
Y			Prereq 1 Fundamental Commissioning of Building Energy Systems				
Y			Prereq 2 Minimum Energy Performance				
Y			Prereq 3 Fundamental Refrigerant Management				
9 10			Credit 1 Optimize Energy Performance 1 to 19				
7			Credit 2 On-Site Renewable Energy 1 to 7				
2			Credit 3 Enhanced Commissioning 2				
2			Credit 4 Enhanced Refrigerant Management 2				
3			Credit 5 Measurement and Verification 3				
		2	Credit 6 Green Power 2				
4 3 7			<b>Materials and Resources</b>	Possible Points: 14			
Y	P	M					
		3	Prereq 1 Storage and Collection of Recyclables				
		1	Credit 1.1 Building Reuse—Maintain Existing Walls, Floors, and Roof 1 to 3				
		1	Credit 1.2 Building Reuse—Maintain 50% of Interior Non-Structural Elements 1				
		2	Credit 2 Construction Waste Management 1 to 2				
		2	Credit 3 Materials Reuse 1 to 2				
4			<b>Innovation and Design Process</b>	Possible Points: 6			
1			Credit 1.1 Innovation in Design: Specific Title MRC2 (95%) 1				
1			Credit 1.2 Innovation in Design: Specific Title MRC3 (30%) 1				
1			Credit 1.3 Innovation in Design: Specific Title SSC 7.1 (100%) 1				
			Credit 1.4 Innovation in Design: Specific Title 1				
			Credit 1.5 Innovation in Design: Specific Title 1				
1			Credit 2 LEED Accredited Professional 1				
			<b>Regional Priority Credits</b>	Possible Points: 4			
			Credit 1.1 Regional Priority: Specific Credit 1				
			Credit 1.2 Regional Priority: Specific Credit 1				
			Credit 1.3 Regional Priority: Specific Credit 1				
			Credit 1.4 Regional Priority: Specific Credit 1				
64 21 19			<b>Total</b>	Possible Points: 110			
Certified 40 to 49 points Silver 50 to 59 points Gold 60 to 79 points Platinum 80 to 110							

- analisi dei crediti
- pianificazione delle strategie
- condivisione con il Committente
- progettazione
- workshop intermedi di controllo delle misure adottate e di condivisione con il cliente
- redazione dei documenti progettuali, delle specifiche tecniche e dei documenti Contrattuali
- assessment finale di verifica

# La scelta delle alternative



Alternative 1 : The Canyon



Alternative 2: Wadi



Alternative 3 : The Wave



Alternative 4 : The Palm grove

## Parameter / Criteria

Sustainability *	High	Medium	Medium	Low
Constructability **	Low	High	Medium	Low
Use of Materials ***	Low	Medium	High	High
Interior comfort	High	Medium	Low	Low
Energy efficiency/shading	Low	High	High	High



\* With reference to LEED protocol.

\*\* Complexity of system structures and construction

\*\*\* The concept design considers to treat main station with most precious materials ( natural stone, glass, mosaic).

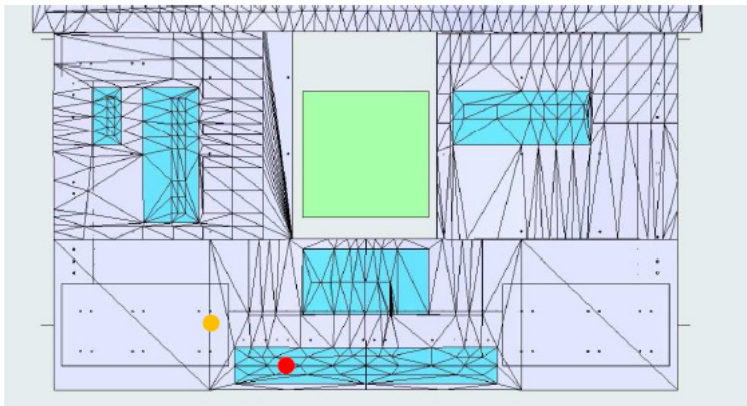
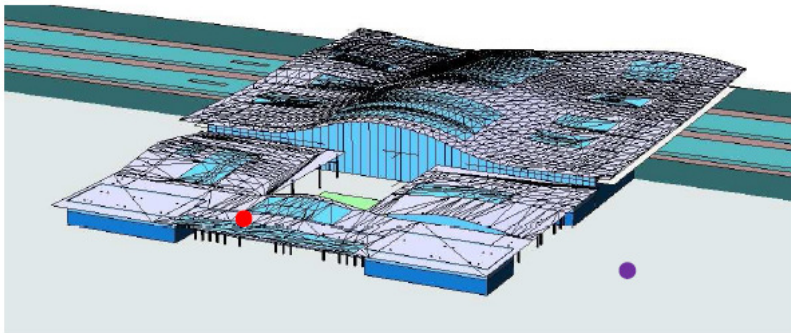
While commuter station may be less expensive materials

The analysis shows the substantial differences between the design alternatives.

The method , which is used, in the comparison analysis does not have the aim to evaluate each alternative in absolute terms, but in relative terms compared to the other ones.



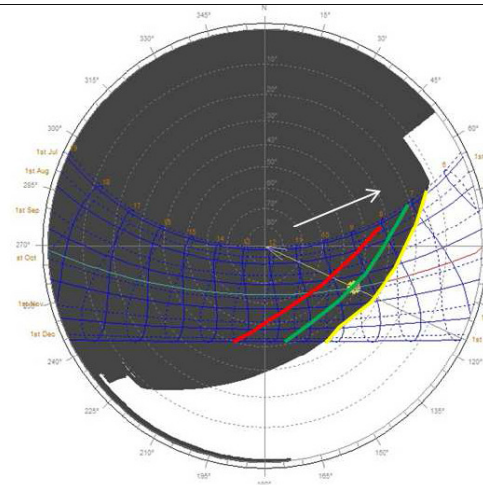
# Orientamento e Analisi solare delle facciate



Selected point for solar analysis (violet, red and orange)

**Stereographic Diagram**  
Location: 24.3°, 56.7°  
Obj: 20061 Orientation: 0.0°, 0.0°  
Sun Position: 115.1°, 41.4°  
WSA: -119.4°  
VSA: 119.1°

SUNSET



SUNRISE

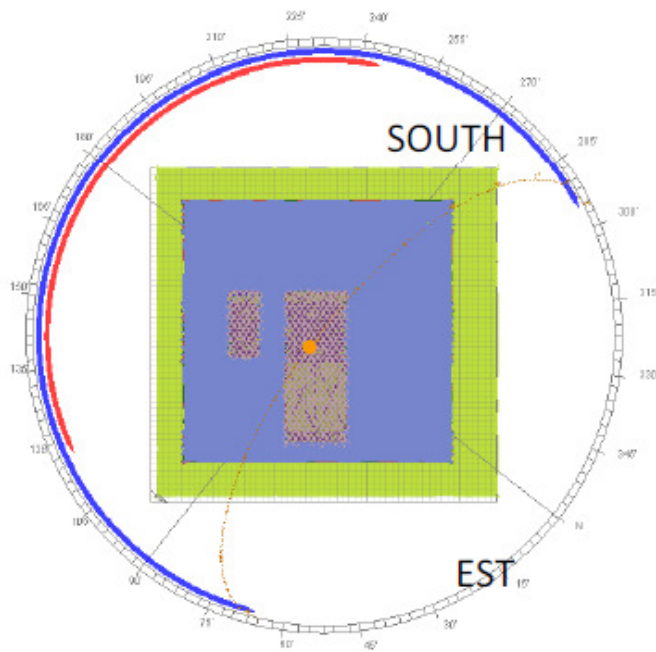
Time: 09:30  
Date: 19th Mar (78)  
Dotted lines: July-December.

Sunpath diagram for the orange point (left side)

On the sunpath diagram it is marked how the shadow border line moves, when the covering projection is increased. Starting step: cantilever projection 1,5 m (red line) – Middle step: cantilever projection 2,5 m (green line) – Final step: cantilever projection 3,5 m (yellow line).

# Analisi solare della copertura

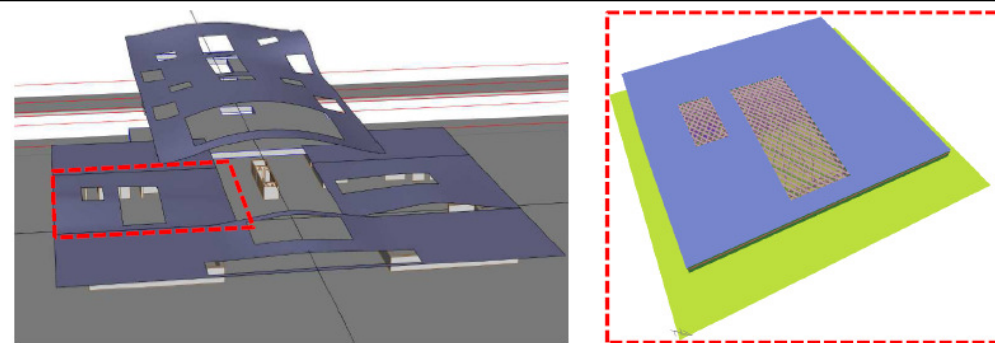
## 2.3.1 Sohar Station



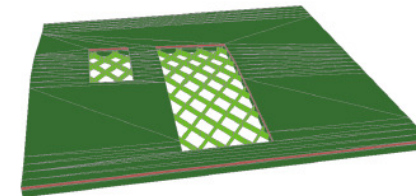
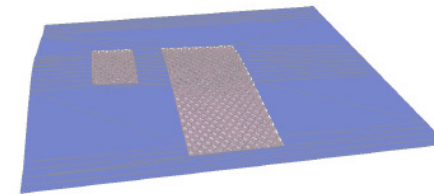
21th JUNE 12:00 a.m.

WEST

NORTH

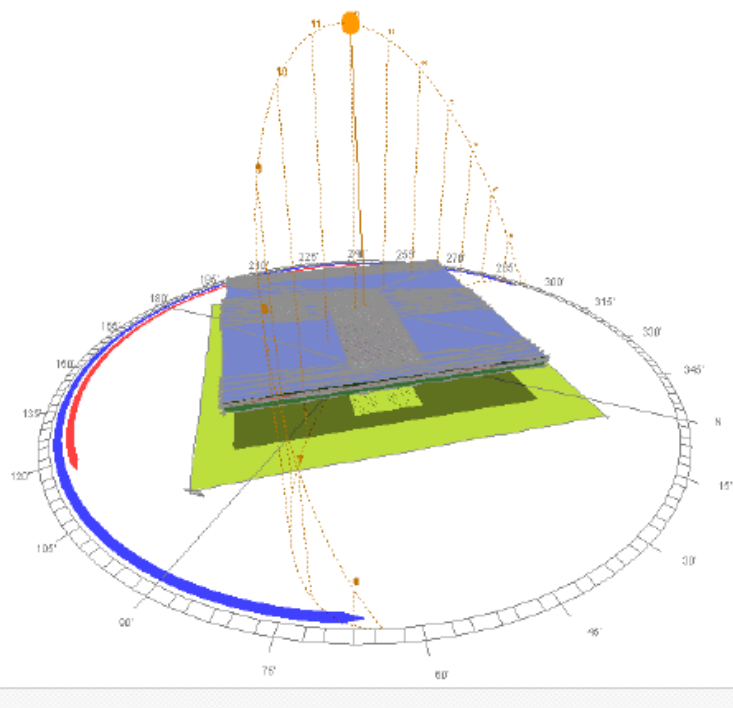


COVERING PACKAGE

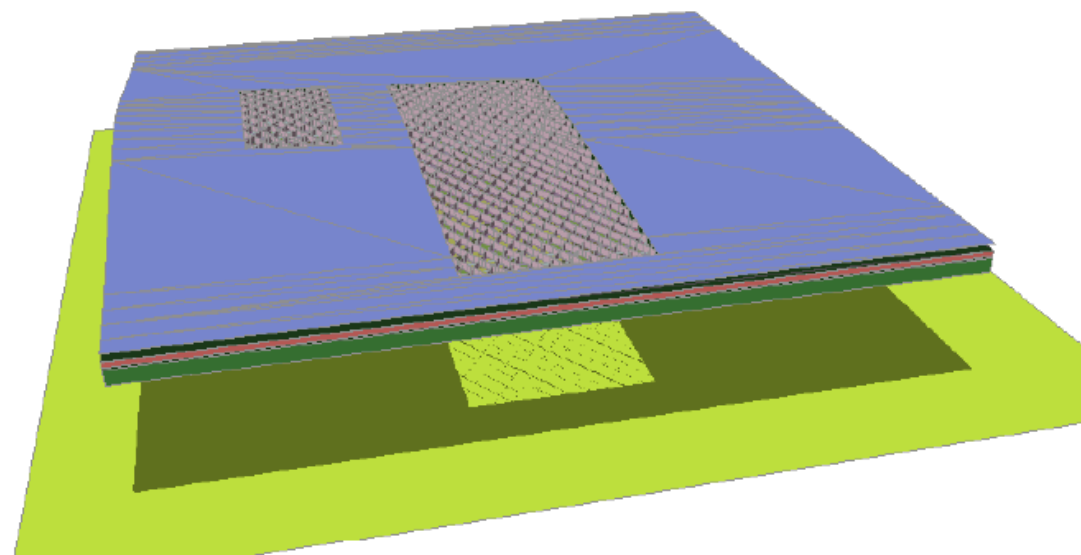




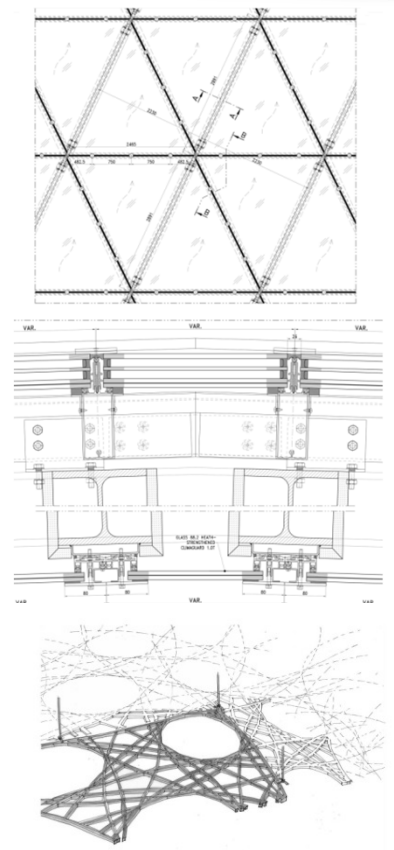
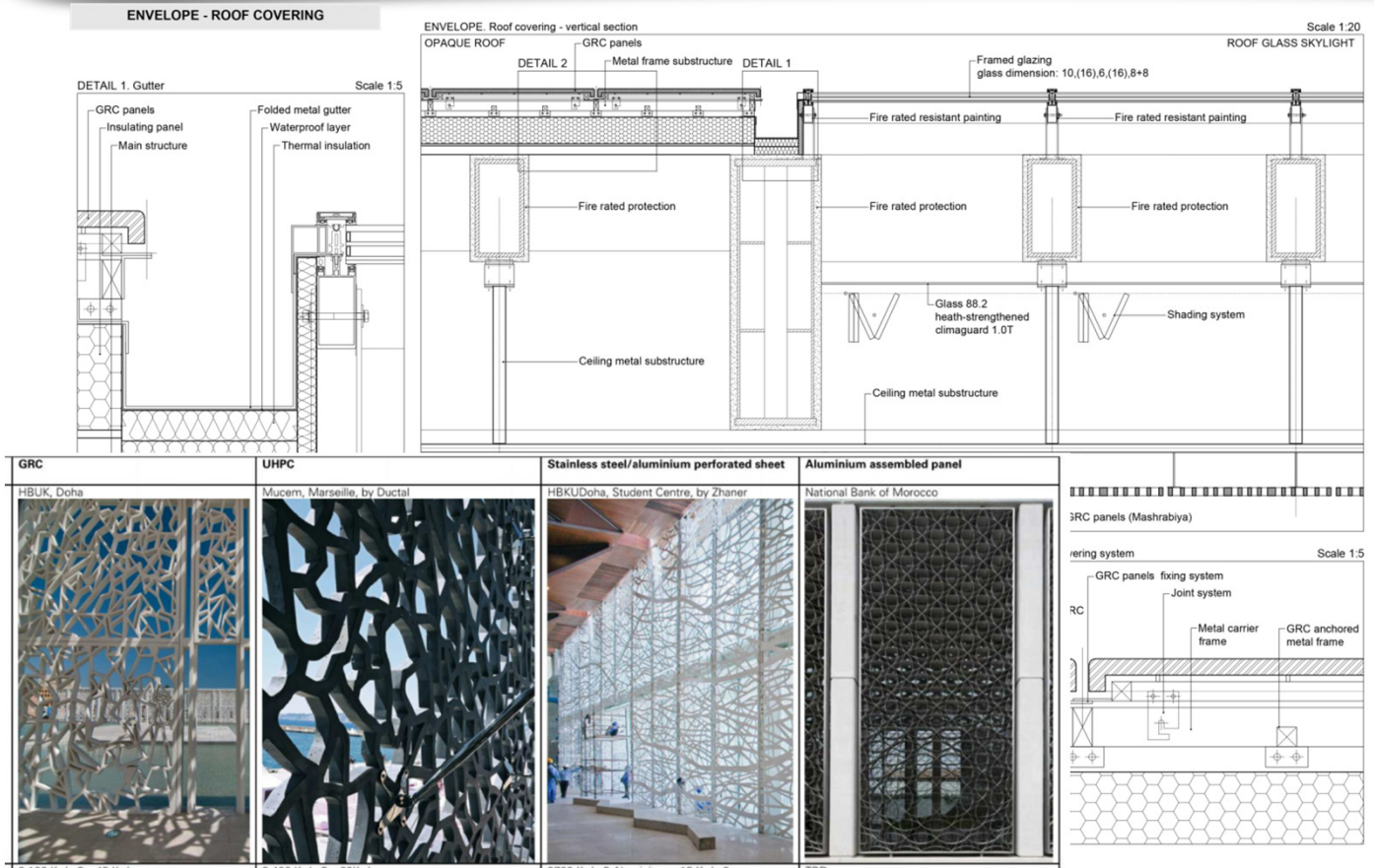
# Analisi solare della copertura



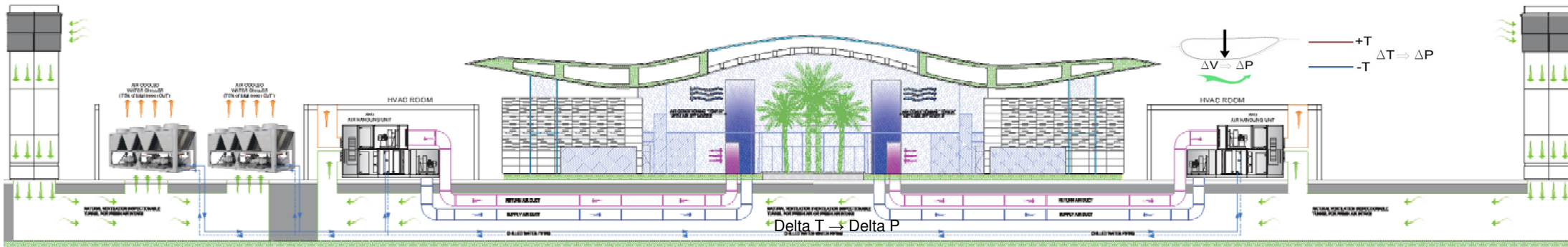
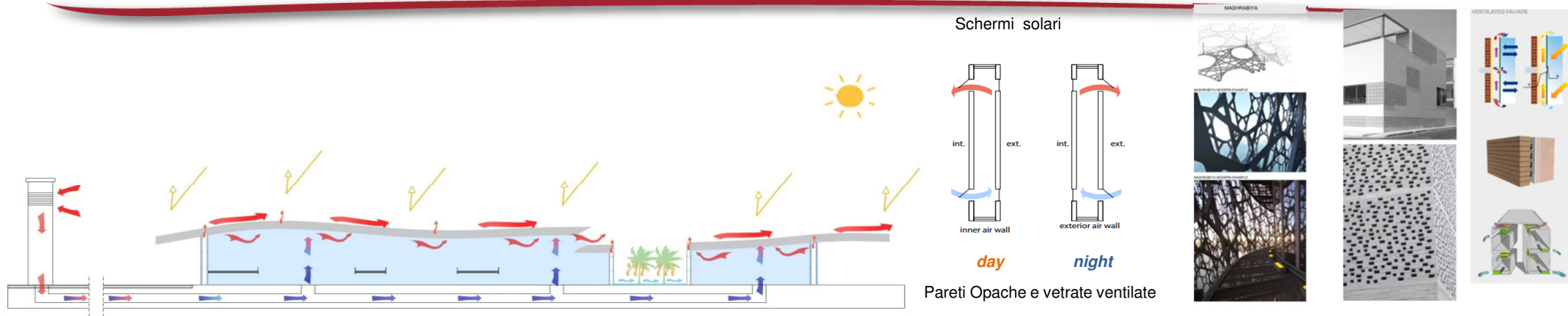
21th JUNE 12:00 a.m.



# La scelta dei materiali e delle tecnologie



# La scelta dei materiali e delle tecnologie



Geotermia e condizionamento: camini e cunicoli della ventilazione naturale

Forma aerodinamica

Green and water for natural cooling

Forte inerzia termica dell'involucro (tetto e facciate)



VENTILAZIONE NATURALE - LINEE GUIDA ASHRAE

LINEE GUIDA ASHRAE  
SU VENTILAZIONE NATURALE

IN CLIMI CALDO UMIDI

(CLASSIFICAZIONE KOPPEN: A e relativi sottogruppi)

MASSIMIZZARE LA VELOCITA' DELL'ARIA NELLE ZONE OCCUPATE

# Ottimizzare la prestazione energetica

## Credit 1: Optimize Energy Performance

12/19

### Reference Documents:

- "Design criteria- Passenger stations" §11.4.5
- "Technical specifications- infrastructure" §4.3.4; 13.2; 19.5.9; 19.5.11; 25.5
- "Stations and Facilities- technical report MEP"
- OM50.BD.R.17.SP.IF. 00 0 0.002 Technical specification MEP § 1.4; 1.6.2; 1.6.3; 2.1; 2.2; 3.1; 4

Comment: the credit will be achieved using option 1: whole building energy simulation.

In the technical specifications document, it is required a minimum savings percentage of 34% compared with the baseline building calculated according to ANSIASHRAE/IESNA Standard 90.1-

### SCHEME OF VENTILATION SYSTEM (PLAN)

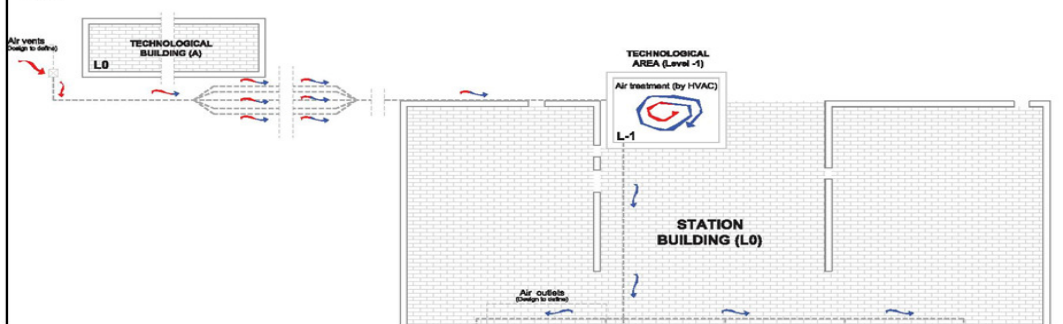


Fig.1 Scheme of Ventilation (Plan)

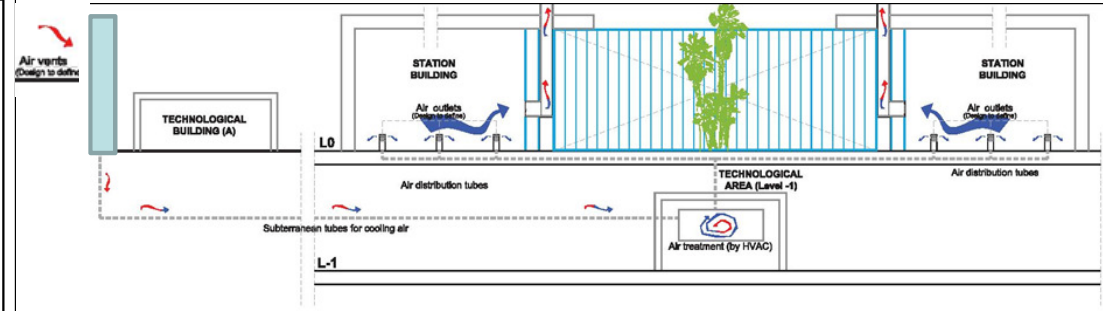
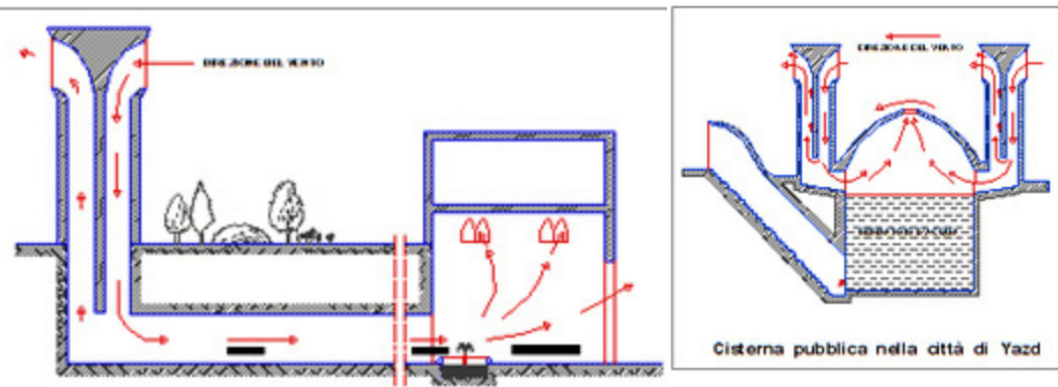


Fig.2 Scheme of Ventilation (Section)



# Simulazione del consumo energetico totale ASHRAE

## LEED 2009 EA Credit 1 Summary Report

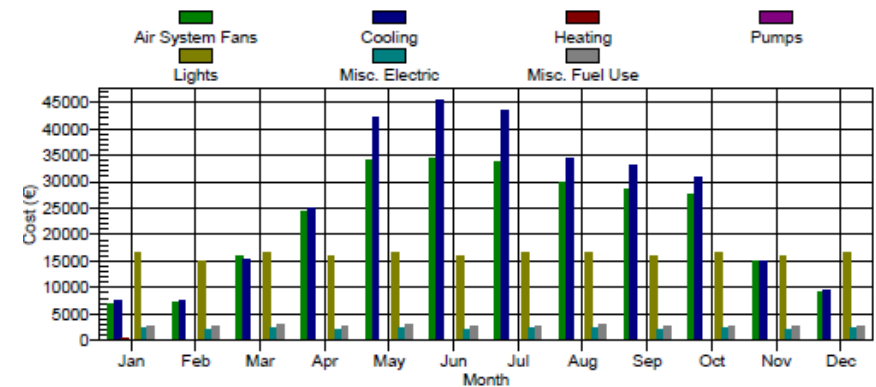
Oman 24 luglio 2014 LEED TEST  
FLUPROJECT

### Energy Cost and Consumption by Energy Type - Performance Rating Method Compliance

Energy Type	Proposed Design		Baseline Design	
	Energy Use	Cost (€)	Energy Use	Cost (€)
Electric	5.239.623 kWh	523.962	7.990.047 kWh	799.005
Natural Gas	11.138 Therm	33.414	11.138 Therm	33.414
<b>Subtotal (Model Outputs)</b>	<b>20.036.988 MJ</b>	<b>557.376</b>	<b>29.938.100 MJ</b>	<b>832.419</b>
	Energy Generated	Renewable Energy Cost Savings (€)		
Total On Site Renewable Energy				
	Energy Savings	Cost Savings (€)		
Exceptional Calculation Totals				
	Energy Use	Cost (€)		
<b>Net Proposed Design Total</b>	<b>20.036.988 MJ</b>	<b>557.376</b>		
	Percent Savings		Energy Use Intensity	
	Energy	Cost	Proposed Design (MJ/m <sup>2</sup> )	Baseline Design (MJ/m <sup>2</sup> )
<b>Summary Data</b>	33,1 %	33,0 %	1.197,10	1.788,63

## LEED 2009 EA Credit 1 Points Reference Table

New Construction % Cost Savings	Existing Building Renovations % Cost Savings	LEED 2009 Points Awarded
30%	26%	10 pts
<b>32%</b>	28%	<b>11 pts</b>
34%	30%	12 pts
36%	<b>32%</b>	<b>13 pts</b>

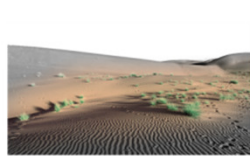
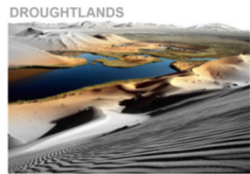




# Efficienza Idrica e Energia

## ARCHITECTURAL CONCEPT

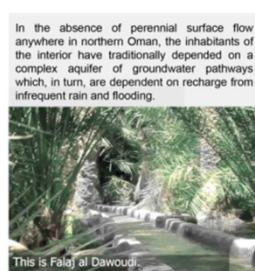
### Landscape analysis



### WETLANDS



### Oman traditional irrigation system



In the absence of perennial surface flow anywhere in northern Oman, the inhabitants of the interior have traditionally depended on a complex aquifer of groundwater pathways which, in turn, are dependent on recharge from infrequent rain and flooding.

This is Falaj al Dawoudi.

To access this source, they have employed falaj (pl. aflaj) irrigation technology whereby a system of sub-surface to surface channels conveys groundwater by means of gravity from a mother-well (umm) – for a distance of many kilometres – to the settlements and date plantations it serves. This is the phenomenon that not only shapes the oasis landscape but also forms a part of it and the type of settlement it creates is a discrete, demarcated unit, organised around a cultivated territory, in which the date-palm is the primary perennial crop.



Traditionally, a falaj is divided into three parts:

- A deep tunnel with access shafts for construction and cleaning.
- A partly covered section.
- Open-sky surface channels.

### Subsurface Drip Irrigation system

Subsurface drip irrigation (SDI) is the irrigation of crops through buried plastic tubes containing embedded emitters located at regular spacings. In agriculture is a method of irrigation where water is delivered to the plant root zone from below the soil surface and absorbed upwards. Water should be reused through a subsurface or buried drip irrigation system as a unique concept that speaks directly to the issues of acceptable wastewater disposal, water reuse and water conservation.

Sub surface drip irrigation involves the application of water to lawn via pipes, which are installed totally underground. The tube carries evenly spaced emitters or drippers, which deliver water directly to the root zone of the turf. Irrigation below ground offers several features that provide significant benefits over conventional above ground irrigation.

### EXTERNAL WORKS

RESOURCES & FINISHES

- TYPE A, GREEN FILLED
- TYPE B, GRAVEL FILLED
- GRASS BLOCKS paving
- CONCRETE PAVING BLOCKS
- Grass pavers
- Various densities

FOUNTAIN AND WATER BASINS

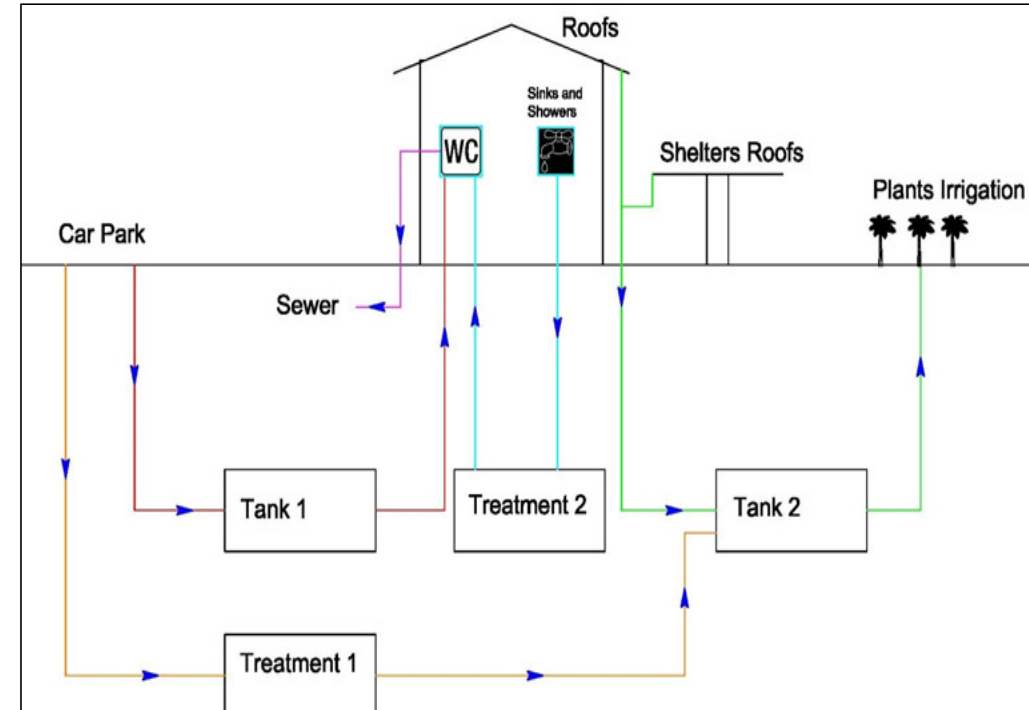
PHOTOVOLTAIC PANELS

PHOTOVOLTAIC PANELS Details

rainwater harvesting  
rainwater reused for fountain supply

# Gestione del ciclo dell'acqua

Credit 1: Water Efficient Landscaping	4/4
Reference Documents:	
<ul style="list-style-type: none"><li>• "Design criteria- Passenger stations" §7.3; 7.21; 11.1.12; 11.1.21; 11.4.2.2.1; 11.4.2.2.2; 16.1.1</li><li>• "Technical specifications- Infrastructure – Stations Architecture " § 3.1.9; 26.2</li><li>• OM50B9R44SHSN0004001_Landscape sheets 16, 17 and 18</li><li>• "Hydraulic Report"</li><li>• "Stations and Facilities- technical report MEP"</li><li>• OM50.BD.R.17.SP.IF. 00 0 0.002 Technical specification MEP § 1.4; 1.6.1; 1.6.2;</li><li>• OM50.BB.R.17.DX.IT.00.00.005 "Plumbing System – Sewage treatment system"</li><li>• OM50.BB.R.17.DX.IT.00.00.006 "Plumbing System – Grey Water Treatment System"</li></ul>	
Comment: It is intended to pursue the credit through option 2, path 1.	
In above listed documents it has been required to collect rainwater by roofs and shelters and to reuse it for irrigation as well as non-potable water supplied by public agency. It has been also required to use native plants and the best efficient irrigating technologies, too.	
In "Design criteria- Passenger stations", this credit is indicated in the list of credits that the Contractor is required to obtain.	



# Idrologia e idraulica: Il bilancio idrico

		Roofs	Shelters	Yards	Tot
Average Annual Rain Depth	mm	84,00	84,00	84,00	
Impervious Runoff Surface	m <sup>2</sup>	3.300,00	10.000,00	27.000,00	40.300,00
Runoff Coefficient	–	0,90	0,90	0,78	
Drought Period	days	358,00	358,00	358,00	
Filter Efficiency	–	0,90	0,90	1,00	
Storable Volume	l	<b>224.532,00</b>	<b>680.400,00</b>	<b>1.757.700,00</b>	
	m <sup>3</sup>	224,53	680,40	1.757,70	1.982,23

Irrigation Surface (25% of yards surface)	m <sup>2</sup>	6.750,00
Vegetation Annual Water Requirement	l/m <sup>2</sup>	100,00
<b>Total Irrigation Requirement</b>	l	<b>675.000,00</b>
Daily Users	n.	500,00
Equivalent Daily Users	n.	150,00
Flush Daily Discharge per user	l	6,00
Annual Flush Discharge	l	<b>324.000,00</b>
<b>Annual Total Water Requirement</b>	l	<b>999.000,00</b>

Applying the equation (3) the following storage volumes can be estimated:

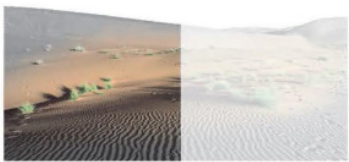
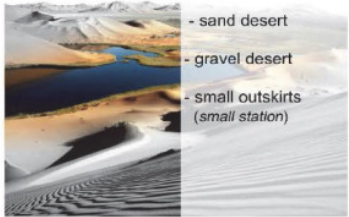
		Roofs (toilet flushes)	Shelters (irrigation)	Yards	Tot
<b>Storage Volume</b>	l	269.006,10	662.054,79	759.615,19	<b>1.690.676,09</b>
	m <sup>3</sup>	269,01	662,05	759,62	1.690,68

%	Reduction Points
30%	2
35%	3
<b>40%</b>	<b>4</b>

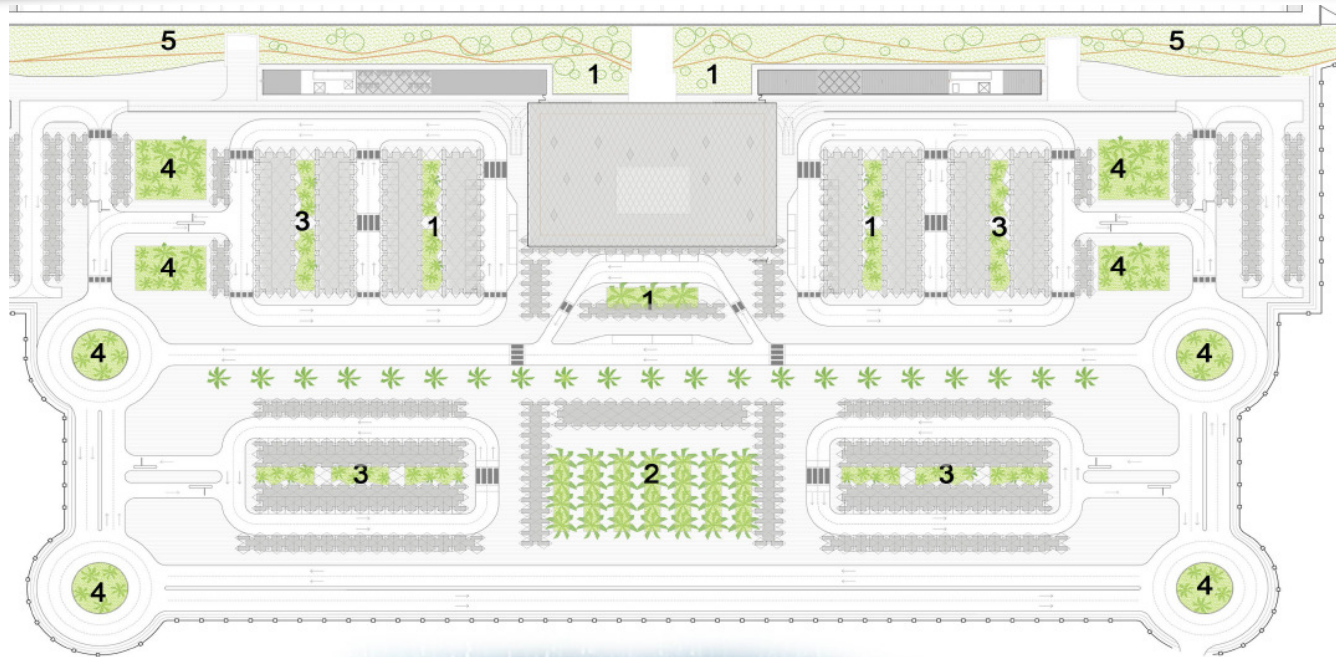


# Landscape analysis and green design

## DROUGHTLANDS



## WETLANDS



n° 1

materials	% of covered areas for droughtland	% of covered areas for wetland
- pond	/	5%
- mulch	20%	5%
- gravel / rip-rap	30%	10%
- lawn	30%	30%
- flower beds	20%	50%
- arboreal types:	palm	
- bushes types:	/	

n° 2














materials	% of covered areas for droughtland	% of covered areas for wetland
- pond	/	/
- mulch	30%	30%
- gravel / rip-rap	20%	10%
- lawn	50%	50%
- flower beds	/	10%
- arboreal types:	palm and ficus	
- bushes types:	/	

n° 5

materials	% of covered areas for droughtland	% of covered areas for wetland
- pond	/	/
- mulch	10%	10%
- gravel / rip-rap	80%	40%
- lawn	10%	40%
- flower beds	/	10%
- arboreal types:	/	
- bushes types:	pteropyrum s., salvadora p., maerua c.	

# Gestione delle acque - Landscape

Credit 6.1: Storm-water Design- Quantity Control	1/1
Reference Documents:	
<ul style="list-style-type: none"> <li>• "Hydraulic Report"</li> <li>• OM50.BA.R.17.RH.SN.00.0.001 MEP Report</li> <li>• OM50.BD.R.17.SP.IF.00.0.002 Technical specification MEP §1.4; 1.6.1; 2.4; 4.3.2.1</li> <li>• "Design criteria - Passenger stations" §11.1.12; 11.3.7.3; 11.3.7.5</li> <li>• "Design criteria- Passenger stations" §6.2; 7.3; 7.21</li> <li>• OM50.BA.R.44.SH.SN.00.00.001 Typical drawings sheet 7</li> <li>• OM50B9R44SHSN0004001_Landscape sheets 16-17</li> </ul>	
Comment: the Contractor is required to implement the storm-water management plan.	
However, in Design Criteria §6.2 and in OM50.BA.R.44.SH.SN.00.00.001 Typical drawings sheet 7 it is required to use permeable surfaces for the parking lots.	
In OM50B9R44SHSN0004001_Landscape sheets 16-17 is required to collect storm-water in water collection basins.	

ARCHITECTURAL CONCEPT													
IMAGE	SPECIES	COMMON NAME	FLOWER COLOUR	MATURE SIZE Spread X Height	PLANT TOLERANT	NOTE	IMAGE	SPECIES	COMMON NAME	FLOWER COLOUR	MATURE SIZE Spread X Height	PLANT TOLERANT	NOTE
<b>TREE</b>							<b>SHRUB</b>						
	Prosopis cineraria	Ghaf	Pale yellow	6 X 10 m	Drought	Available in commercial and Government nurseries (important in desert areas as fodder for camels, the wood is used for fuel and construction).		Pteropyrum scoparium	Sidaf	Red	1 X 1,5 m	Drought	Habitat in wadis and gravel areas in northern Oman.
	Ziziphus spina-christi	Christ's thorn, sidr, (fruit)	Cream	6 X 10 m	Drought	Available in commercial and Government nurseries. Widely distributed in wadis and gravel plains, common as a street tree in Muscat/strucation.		Salvadora persica	/	Green/White	6 X 2 m	Some salinity	Not recorded during survey but occurs along the coast (sandy area), gravel and wadis at low elevations
	Acacia tortilis	Samur	Green	5 X 6 m	Drought	Available in commercial and Government nurseries (an important forage tree).	<b>SUCCULENT</b>						
	Ficus cordata	/	White/Green	5 X 8 m 6 X 15 m	/	/		Anabasis setifera	/	Brownish green	0.75 X 1.5 m	Drought	Common in sand and gravel areas in northern and central Oman
	Maerua crassifolia	Sarh	White	5 X 7 m	Drought	Usually found on plains but not recorded during the surveys. Habitat in mountain slopes and gravel plains throughout Oman.		Caralluma quadrangola	/	Yellow	0.3 X 0.5 m	Drought	Habitat in dry rocky slopes and high plateau of Dhofar
	Phoenix dactylifera	Date Palm	Green	9 X 18 m	Drought	/		Cissus quadrangularis	/	Cream	9 X 18 m	Drought	Common in rocky outcrops slopes and high plateau of Dhofar
	Dwarf palm Nannorrhops ritchiana	Palm	Green	3 X 6 m	Drought	/		Kleinia saginata	/	Red	0.4 X 0.4 m	Drought	Various medical uses are reported



# Leed Assessment

## 4. Management of the assessment

The report refers to the assessment activities conducted by the team of TÜV Italia the day 22 December 2014 at the head office of Italferr S.p.a..

Activities of preparation and further analysis were also carried out in back-office in the month of November and December, in preparation of the meeting.

### Assessment team

Tuv Italia Name – Surname	Role / Position
Sabrina Bruschi	Lead Auditor
Sara Buda	Auditor LEED AP BD+C

### Staff interviewed:

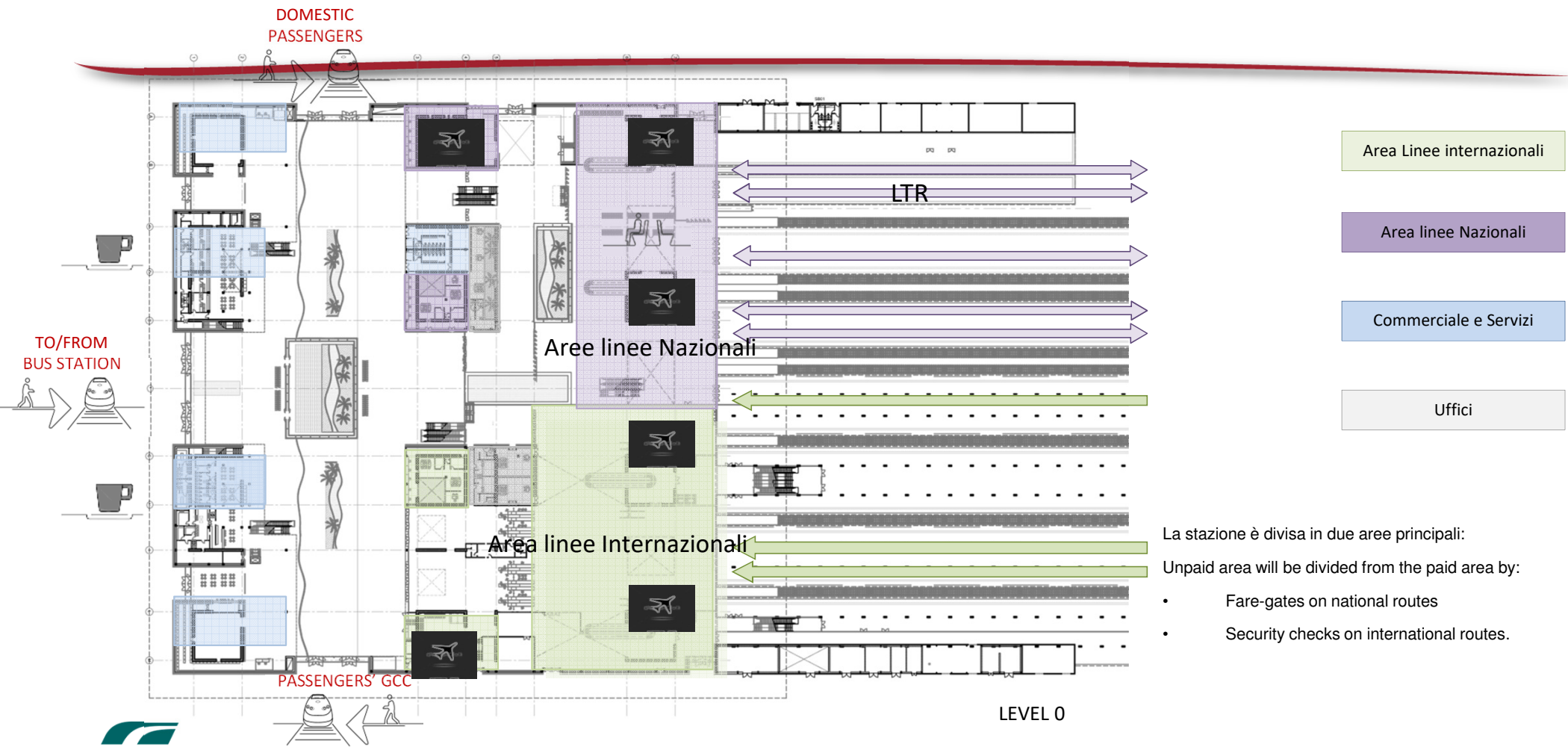
ITALFERR: Name – Surname	Role / Position
Tiziana Fazio	K-expert – Architecture
Federica Barelli	K-expert Mep
Alessandro Giuseppone	Electrical – power supply (Mep)
Matteo Ventura	Idraulic
Alfredo Corvaja	Environmental

## 6. Results

The results of the assessment are related to the categories of credits listed in the checklist of the LEED protocol:

LEED 2009 New Construction and Major Renovations  
Possible points: 110  
Points pursued: 78

Sustainable Sites (SS)  
Possible points: 26  
Points pursued: 18



- Area Linee internazionali
- Area linee Nazionali
- Commerciale e Servizi
- Uffici

La stazione è divisa in due aree principali:  
 Unpaid area will be divided from the paid area by:

- Fare-gates on national routes
- Security checks on international routes.

