Plenitude’s site is one of Morocco’s many phosphate surface mines needing remediation. The particular mining area is in the middle of three ancient towns and functions to absorb future growth while being a model for mine restoration and regeneration. The mined brownfield acts as our ‘limits to growth’ boundary with only heliostat mirror support columns; wind turbine windbreaks around the periphery assist farmers. Shade is partially provided by flipping over the mirror surfaces upon which two processes occur: 1) retaining daytime temperatures beneath the mirrors during the night; and 2) the reverse side enabling colored light to penetrate the ground and increase growth. Both conditions occur when the sun is sub-optimal for heliostat performance. The remaining agriculture occurs on the city’s rooftops and under the city’s large thermal chimney greenhouse. The thermal chimney is a regional hub for public transportation (see Energy Petal). The quadrant communities of the city’s north, south, east, west use the country’s ecozones as their vegetative themes, visibly listing native plant species. Plenitude thrives on a fundamental respect and support of indigenous habitats and a commitment to regenerate to whatever extent a bio-mimicking of these habitats. Finally, Plenitude is tessellated using voronoi algorithms to optimize distances for pedestrian and other transportation modes such as our RRpods throughout the city.

**Native Species of Morocco Bioregions**

1. **Opuntia Ficus-Indica**
2. **Panicum Turgidum**
3. **Argania Spinosa**
4. **Quercus Suber**
5. **Pinus Pinea**
6. **Phoenix Dactylifera**
7. **Arbutus Unedo**
8. **Osteospermums**
9. **Maerua Crassifolia**

**Transportation Plan for the Project**

**Food Harvest**

<table>
<thead>
<tr>
<th>Harvest MT/FR</th>
<th>1,800</th>
<th>1,200</th>
<th>1,000</th>
<th>800</th>
<th>600</th>
<th>400</th>
<th>200</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Supplementary Area</strong></td>
<td>Grain (wheat)</td>
<td>Grain (wheat)</td>
<td>Fish &amp; Aquatic Plants</td>
<td>Fish &amp; Aquatic Plants</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total Food Energy**

<table>
<thead>
<tr>
<th>Kcal/person-day</th>
<th>1,200</th>
<th>1,000</th>
<th>900</th>
<th>700</th>
<th>500</th>
<th>300</th>
<th>100</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Supplementary Area</strong></td>
<td>Grain (wheat)</td>
<td>Grain (wheat)</td>
<td>Fish &amp; Aquatic Plants</td>
<td>Fish &amp; Aquatic Plants</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Surface Mining**

**Residential Densities**

- Residential: 39%
- Retail & Commercial: 34%
- Civic - school: 3%
- Civil: 1%
- Industrial: 2%
- Religious: 1%
- Office: 20%
- Low-Density Residential: 30%
- Apartment & Commercial: 20%
- City school: 3%
- Industrial: 2%
- Civic: 1%
**SOURCE**
1. Dye-sensitized greenhouse vegetables
2. Greenhouse aquaculture
3. Greenhouse orchards
4. Brine water salicornia (cattle feed)
5. Brine water shrimp
6. Brine fish species
7. Roof top container garden
8. Integration kitchen gardens
9. Courtyard herb vegetables
10. Home chicken, pigeons, and fish farms
11. Pulse fed animal husbandry
12. Adaptive traditional animal husbandry
13. Enhanced traditional gardening methods

**PROCESS**
1. Vegetable preparation for markets
2. Food preparation for markets
3. Meat butcher
4. Medicinal plant preparation
5. Home meat/fish preparation
6. Poultry preparation - pigeon/chicken
7. Animal slaughtering
8. Large-scale solar dryers
9. Adaptive reuse of traditional cooking methods

**USE**
1. Personal nutrition: fiber, protein, carbohydrates, vitamins & minerals
2. Restaurants
3. Store front sales
4. Street vendors
5. Open air market vendors
6. Bulk sales outside communities
7. Traditional market sales
8. Oasis Market stalls

**RE-SOURCE**
1. Toilet waste separation
2. Kitchen compost
3. Kitchen recycling center for organic separation
4. Biopod organic treatment - protein concentration for fish and small animals
5. Vermiculture
6. Street recycling system
7. High yield in-vessel composters
8. High yield vertical composters
9. Integrated landscape-window composting
10. Whole tent neighborhood vermiculture farm system
11. Lifecycle design organic food restaurants (keyed food sources in Plenitude)
Water balance in arid and semi-arid conditions requires traditional methods and an advanced understanding of ecotechnologies and landscape approaches. As with Plenitude’s approaches to energy and materials, the key is the multi-faceted use of saline ground water e.g., hydrogen salt water electrolyte, construction material cement and reinforcing, agriculture trace elements. The compelling economics of this approach is that each feedstock for one process is the by-product of another. As our sections attest, integrated urban planning creates a context for how these water resources are used. In a desert setting, fresh water is first used for potable purposes for humans and animals, then for crops, and finally for manufacturing. Plenitude’s unique contribution to understanding water in the broadest sense is that the globally abundant condition of salt water is used for multiple purposes: halophyte crops; greenbelts; fish species; animal feed derived from saline species. As coastal regions become more threatened, this approach will be an essential model.

**WATER BALANCE**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Million Gallons/YR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste Water Harvested</td>
<td>150</td>
</tr>
<tr>
<td>Amount Harvested from Text</td>
<td>100</td>
</tr>
<tr>
<td>TOTAL (Net Positive)</td>
<td>50</td>
</tr>
<tr>
<td>Amount achieved from Brine</td>
<td>-50</td>
</tr>
</tbody>
</table>

**ECOLOGICAL WATER FLOW**

<table>
<thead>
<tr>
<th>Metric</th>
<th>Million Gallons/YR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste Water</td>
<td>150</td>
</tr>
<tr>
<td>Additional Collected</td>
<td>100</td>
</tr>
<tr>
<td>Evaporation</td>
<td>50</td>
</tr>
<tr>
<td>Forest Treatment</td>
<td>50</td>
</tr>
<tr>
<td>Agriculture</td>
<td>-50</td>
</tr>
</tbody>
</table>

**MINERALS**

- Hydrogen
- Electrolysis
- Fresh water
- Trace elements
- Metals: Aluminum, Magnesium, Basalt
- Ceramic materials-MgO

**PLANTS**

- Urban urine separating toilet
- Pretreatment
- Salt water wetland
- Halophyte Green Belt
- Brine based fish/crestad-cides
- Salicornia Plant
**SOURCE**
1. Precipitation, Tent Roofs
2. Precipitation Mirrors
3. Precipitation Mirror Reradiation Moisture and Greenhouse Condensation
4. Path and Street Water
5. Major Thoroughfare Water Collection
6. Large Thermal Chimney Greenhouse Water
7. Greenhouse Surface Roofs
8. Underground Brine
9. Brine water from Mineral processing
10. Brine water from Urine processing
11. Green roof Collection on Farm Buildings

**PROCESS**
1. Processing/Storage under Greenway
2. Oasis Direct Storage
3. Cisterns around Oasis-indirect storage
4. Greenway around Large tents at ground connection
5. Electrolysis, RO Brine processing
6. Water Harvesting Treatment at Home Scale

**USE**
1. Residential
2. Commercial
3. Industry
4. Fresh water irrigation (drip irrigation)
5. Bioremediation enzyme bacteria and fungi phase
6. District Chiller and Evaporative Cooling
7. Vertical Vegetable and Herb Garden Community and Home Scale
8. Halophyte Agriculture
9. Brine water for MgO Phosphate Cement
10. Washing of Heliostat Mirrors
11. Washing Greenhouse/tent dye-sensitized PV
12. Salt water irrigation

**RE-SOURCE**
1. Flipped Mirror Reradiation Evaporative Retention
2. Fresh water Food Aquaponics, Fish Waste Water used by plants
3. Wetlands using Reed plant species for treatment
4. True Species for human Waste treatment (grey and black water)
5. Green roofs for Human Waste Treatment
6. Waste Water Greenhouse condensate
7. Brine Waste Water from Halophyte plants into Brine Shrimp Farm
8. Food Aquaponics-grey water for Tilapia
9. Select animals use non-fresh Water Sources
10. Urine resourced as Fertilizer
11. Ground Water Saved for Historic Towns
12. Toilet/Urine Separation
Plenitude has a diverse renewable energy mix that emanates from the essential desert climatic principles: shade, breeze (nocturnal flushing), night-time re-radiation, phase change, mass. Once these strategies are fully employed, we add more active approaches: solar concentrating heliostats, wind generated electricity, dye sensitized photovoltaics imbedded into the tent fabric, thermal chimney-based wind, on-demand hydrogen for backup. Unlike most solar zero energy efforts we factor the transportation system into the system energy equation, beginning with the essentials: human power whenever possible, walkable distances, and pedestrian friendly conveyance such as slow trolleys circling the city’s entire circumference. The energy/transport approach is grounded in time-honored approaches such as the gravity-powered pump storage to power the gravity driven Rail to Road Pods (RRpod™). This capitalizes on the need to cost justify the tower with multiple uses: a hydrogen elevator takes users to the gravity anchored RRpods that, when released, travel up to 3 ½ miles. If needed to go further distances, a small hydrogen engine takes over. The RRpods are lifted using electrical generation provided by the thermal chimney wind systems.

DATA SHOWING ENERGY BALANCE

<table>
<thead>
<tr>
<th>GWH/yr</th>
<th>Residential</th>
<th>Commercial</th>
<th>Water Process</th>
<th>Solar Electric</th>
<th>Solar Thermal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.0-1.9</td>
<td>2.0-2.9</td>
<td>3.0-3.9</td>
<td>4.0-4.9</td>
<td>5.0-5.9</td>
</tr>
<tr>
<td></td>
<td>Lowest</td>
<td>Highest</td>
<td>Lowest</td>
<td>Lowest</td>
<td>Lowest</td>
</tr>
<tr>
<td></td>
<td>-20</td>
<td>-15</td>
<td>-10</td>
<td>-5</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>5</td>
<td>10</td>
<td>15</td>
<td>20</td>
</tr>
</tbody>
</table>

RENEWABLE ENERGY SOURCE

Fig 3.1 Hydrogen
Fig 3.2 Solar Chimney
Fig 3.3 Earth building
Fig 3.4 Wind turbines
Fig 3.5 Human Power
Fig 3.6 Solar tracking optic system
Fig 3.7 Solar Thermal
Fig 3.8 Wind & up Draft
Fig 3.9 Water
Fig 3.10 Earth Power
Fig 3.11 Earth Thermal
Fig 3.12 Earth Chimney
Fig 3.13 World Solar Map
Fig 3.14 World Wind Map
Fig 3.15 World Earth Map
ANOTATED SYSTEM DIAGRAM OF ENERGY FLOW

SOURCE
1 Community shade vent system
2 Integrated dye-sensitized solar PV
3 Greenhouse tent dye-sensitized solar PV
4 Fiber optic daylight tracker
5 Multifunctional updraft thermal chimney raises hydrogen pods for gravity release
6 Combined solar high temperature absorber with vertical axis wind system
7 Green roofs for constant temperature
8 Thermally designed caliche/hemp walls
9 Ground based cooling tunnels for core neighborhoods
10 Night time flattening of mirrors to hold ground temperature
11 Heliostat mirrors tilt on poor direct solar days for heating community buildings and agriculture
12 Solar greenhouse drying for earthern construction
13 Solar greenhouse drying for crops
14 Lang lasting shade system made from basalt for courtyards
15 Multifunctional multiangular solar heliostats

PROCESS
1 Phase change magnesium oxide (MgO) plaster
2 On demand aluminium-magnesium battery
3 Greenway cooling for tent and thermal chimney
4 Oasis heat sink
5 Wet sand heat sink
6 Cistern heat sink
7 Auto / truck hydrogen conversion

USE
1 Passive heating / cooling of buildings
2 Passive lighting
3 Fiber optic full spectrum task lighting
4 Colored light for plant growth
5 Courtyard cooling using shade
6 Courtyard cooling using mist
7 LED lighting
8 Microwave

RE-SOURCE
1 Waste CO2 for greenhouses
2 Light from dye-sensitized PV increases plant growth
3 Water from hydrogen battery
4 Wall/floor release/absorb constant temperature
5 Ground cooling aided by waste moisture from hydrogen absorption chillers
6 Exported energy from Plenitude used by historic desert towns
7 Improved living standards for permanent renovation
8 Non-polluting firing methods for traditional brick firing
KEY SYSTEMS FOR BIOREMEDIATION

1. **Enzyme**
2. **Bacteria**
3. **Fungus**
4. **Mushroom**
5. **Reeds**
6. **Poplar tree**
7. **Phytoremediation**
8. **Mercury**
9. **Cadmium**
A principal trigger Plenitude’s material base is brine resulting from treating saline underground water. The “mok” well also serves as a vertical industry within a center pivot distribution system. This creates a low energy, fast-setting, saltwater mix concrete in large, 10-ton piles. All material sources are first analyzed using the Plenitude Periodic Table that screens for toxicity. The chosen elements are non-toxic and exhibit a means of by-product balancing is calculated using the Carbon Dioxide Intensity Ratio. Due to its performance attributes of ultraviolet resistance, basalt is also incorporated into all tent and shade surfaces. Finally, Plenitude’s materials are non-toxic and exhibit a means of by-product balancing is calculated using the Carbon Dioxide Intensity Ratio. Due to its performance attributes of ultraviolet resistance, basalt is also incorporated into all tent and shade surfaces. Finally, all materials have a low carbon footprint with the exception of the basalt fiber used for advanced magnesium oxide (MgO) cement reinforcing. The basalt’s carbon intensity is compensated by its ability to replace steel as a permanent reinforcement.

---

**EMBODIED CARBON FOOTPRINT FOR PLENITUDE**

**CONCEPTS USED BY PLENITUDE**

**CDIR: Carbon Dioxide Index Ratio**

Open building system protocol

Industrial Ecology network diagrams for Morocco

---

**EMBODIED CARBON FOOTPRINT FOR PLENITUDE**

**Fig 5.1 Bio based Materials - Heavy Metal Sequestration**

**Fig 5.2 Basalt-brine reinforcing fiber, cloth, rebar**

**Fig 5.3 Quick connects for components floor wall plaza**

**Fig 5.4 Open building system**

**Fig 5.5 Caliche Block materials for Historic Repair**

**Fig 5.6 MgO cement used for monoque construction (non freshwater concrete)**

**Fig 5.7 Inter-locking light weight flexible partition system**

**Fig 5.8 Morocco Basalt Deposits**

**Fig 5.9 Morocco Hemp Cultivation**

**Fig 5.10 Morocco Phosphate Deposits**

**Fig 5.11 Morocco Saline Soils**

---

**LOW CARBON MATERIALS**

**LIVING BUILDING CHALLENGE Requirement Index**

- **Red List:**
  - Heavy Metal Sequestration
  - Basalt-brine reinforcing fiber, cloth, rebar
  - Open building system components floor wall plaza
  - Caliche Block materials for Historic Repair
  - MgO cement used for monoque construction (non freshwater concrete)
  - Inter-locking light weight flexible partition system

---

**PERIODIC TABLE**

Used as a reference for distinguishing Poisonous elements from Useful Elements

---

**CDIR = (CO2e - CO2s) / weight of material**

Positive ratios indicate net carbon dioxide sources; negative ratios indicate net carbon dioxide sinks.

---

**RECOGNITION**

- **CDIR:** Carbon Dioxide Index Ratio
- **Open building system protocol**
- **Industrial Ecology network diagrams for Morocco**

---

**LIVING BUILDING CHALLENGE Requirement Index**

- **Red List:**
  - Heavy Metal Sequestration
  - Basalt-brine reinforcing fiber, cloth, rebar
  - Open building system components floor wall plaza
  - Caliche Block materials for Historic Repair
  - MgO cement used for monoque construction (non freshwater concrete)
  - Inter-locking light weight flexible partition system

---

**EMBODIED CARBON FOOTPRINT FOR PLENITUDE**

**Fig 5.1 Bio based Materials - Heavy Metal Sequestration**

**Fig 5.2 Basalt-brine reinforcing fiber, cloth, rebar**

**Fig 5.3 Quick connects for components floor wall plaza**

**Fig 5.4 Open building system**

**Fig 5.5 Caliche Block materials for Historic Repair**

**Fig 5.6 MgO cement used for monoque construction (non freshwater concrete)**

**Fig 5.7 Inter-locking light weight flexible partition system**

---

**LOW CARBON MATERIALS**

**LIVING BUILDING CHALLENGE Requirement Index**

- **Red List:**
  - Heavy Metal Sequestration
  - Basalt-brine reinforcing fiber, cloth, rebar
  - Open building system components floor wall plaza
  - Caliche Block materials for Historic Repair
  - MgO cement used for monoque construction (non freshwater concrete)
  - Inter-locking light weight flexible partition system

---

**EMBODIED CARBON FOOTPRINT FOR PLENITUDE**

**Fig 5.1 Bio based Materials - Heavy Metal Sequestration**

**Fig 5.2 Basalt-brine reinforcing fiber, cloth, rebar**

**Fig 5.3 Quick connects for components floor wall plaza**

**Fig 5.4 Open building system**

**Fig 5.5 Caliche Block materials for Historic Repair**

**Fig 5.6 MgO cement used for monoque construction (non freshwater concrete)**

**Fig 5.7 Inter-locking light weight flexible partition system**

---

**LOW CARBON MATERIALS**

**LIVING BUILDING CHALLENGE Requirement Index**

- **Red List:**
  - Heavy Metal Sequestration
  - Basalt-brine reinforcing fiber, cloth, rebar
  - Open building system components floor wall plaza
  - Caliche Block materials for Historic Repair
  - MgO cement used for monoque construction (non freshwater concrete)
  - Inter-locking light weight flexible partition system
**SOURCE**
1. Waste phosphate & MgO carbon-balanced cement
2. Caliche from high calcium carbonate soils
3. Silicone sand
4. Brine metals (iron/aluminium/magnesium)
5. Basalt from mineral extraction
6. Hemp fibers and oil
7. Oily plants - cactus, Yuahubi, Salicornia, Creosole Bush
8. Bioremediated land to build on

**PROCESS**
1. High temperature kiln, basalt fiber
2. Medium temperature kiln, MgO cement
3. Low temperature kiln - bio-based material drying
4. Electrolysis
5. Plant oil extraction
6. Monomer spin weaving
7. High temperature fusing (basalt) using solar
8. Foamed MgO/phosphate cement
9. Hemp fiber/MgO block
10. Hydrogen firing for traditional clay crafts

**USE**
1. Structural monocque support mirrors
2. Vertical industry support tower
3. Thermal chimney tower
4. Greenhouse support systems
5. Pond walls and pond bottoms for enzyme and bacterial processes
6. Pond and cistern linings
7. Encapsulation of heavy metals using MgO/phosphate concrete
8. Cables for tents and thermal chimney
9. Fine and coarse aggregate for all cementitious processes
10. Bio-based plastics for greenhouses and tent membranes
11. Hemp bio-based resins for monocque R-R pods
12. Electrolysis plates/aluminium and magnesium
13. Water harvesting
14. Caliche block replacement of adobe

**RE-SOURCE**
1. Open building systems/reuse of elements
2. MgO is nutrient fertilizer
3. Hemp as renewable resource
4. Oily plants as renewable resource
5. Rehabilitation of land using waste organics
6. Improved earth technologies like caliche
7. Improved reinforcing of old structures using fast setting cements
8. Iron replacement for reinforcing old structures with basalt rebar
9. Repair of old roofs with more permanent materials
10. Reusable carbon-balanced cement using MgO phosphate
11. Reduced use of fresh water with brine based cements
SUSTAIN-A-BILLS (a wearable currency)

**Lifecycle Monitoring System**

- Sensors (hobo) send data to computer
- Smart watch
  - Sends individual’s information
  - Linked to sensors and central computer
  - Sends QR codes

**Typical Life Event Sequence**

- **SOURCE**
  - Water quality levels use
  - Photovoltaics use generation
  - Solar thermal consumption production
  - Food wastewater whole cycle

- **PROCESS**
  - Air, water, food, energy, and materials with respective implementations

- **USE**
  - Buildings, landscape, water, and transportation
  - Energy: potential, mechanical, conversion between forms of

- **RESOURCE**
  - Materials and preparation
  - Building structure

**City**

- Multi-facility city EcoBalance selective implementation diagram

**World**

- World EcoBalance by proportional achievement

**Fig. 3.1 Heliostat Mirrors**

- Whole cycle
  - SOURCE
  - Recirculation of air
  - Human exhale used by flora
  - Waste water gardens
  - Bamboo
  - Solar air collector
  - Thermals

- Whole cycle
  - Productive leisure and time
  - Community engagement
  - Exercise armature creation
  - Animal species established

- Whole cycle
  - Biofuel supply increased
  - Biofuel consumed
  - Biochar produced
  - Electricity produced

- Whole cycle
  - Air, water, food, energy, and materials with respective implementations
  - Groups I, II, and III with respective implementations
  - Facilities N, E, S, and W with respective implementations

- Whole cycle
  - Air, water, food, energy, and materials with respective implementations
Beauty + Spirit + Education are combined as a single petal: beauty inspires; the inspired mind is more receptive to education, yielding superior pedagogy. In Plenitude, we inspire by transforming a devastated site into an exceptional one through awe-inspiring manifestations of a community of the future. The inspired mind wants to learn more; its momentum is viral, and becomes a model to share with the world.
Once there was a world of great promise, a shining blue-green jewel-like planet that bedazzled the heavens when seen from a hundred thousand miles in space. This verdant world, inhabited by a remarkable variety of plants and animals, had become a sort of miracles of miracles in the cosmos, for most planets are forbidding and sterile or a flaming molten mass.

But this one had seemed just right for an unprecedented undertaking. The Deity had chosen it for a great experiment, to be a prototype for future worlds. It was the start of a celestial redevelopment plan for all of space, and everything in creation seemed to hold its breath awaiting the outcome of this incredible venture.

A steward had to be provided to give direction, to husband the resources, and so the Deity provided a new species he called a human being. He gave him a good brain with foresight and a conscience, a set of values and a desire for fine things.

This human was given domination over the animals and the plants, over the rivers and the lakes and the oceans and the good earth beneath his feet. He was given clean fresh air with just the right ingredients to breathe and beauty every place he looked. He was given a whole world full of microbes and bacteria, invisible to him, but working for him day and night to maintain the soil that fed him, to keep his waterways clean and to remove the surface debris, keeping the ground he walked on sweet and clean.

Everything the Deity could contrive for his needs and aspirations was given him. This the richest experiment the celestial power could bestow held all the promise for the rest of space in times to come.

The word was sent out that Earth was to be observed by all monitors of space to note her progress. Toward the end of the first celestial day of almost five billion years, an official report was sent to the Heavenly Halls, a progress report on the state of the world. The report is now under study.
Plenitude...