Green Engineering: Principles and Practice

8th November 2022


Features
Insider's Opinion
How Denim Manufacturing Impacts the Environment
By Moni Omotoso - 1st June 2018
4223

Water pollution
The three processes that cause water pollution are the growing of cotton, dyeing and finishing the material and texturizing and finishing the product.

The use of chemical dyes in the production of 'distressed' denim is intensive. The denim is subjected to several chemical washes. Added to that, there are serious health risks to the workers through exposure to the harmful chemicals that are used to spray the material in pursuit of an 'acid wash'. Chemical run-offs from some of these manufacturers are also dumped into the water system, turning them indigo-blue such as the Pearl River in China.

Denim Sandblasting
This process involves taking fine sand and channelling it into an airgun, it is then sprayed at high pressure onto denim to create a worn, old look. It's a cheap, quick method that manipulates garments but its main ingredient, silica, is harmful to workers

A study by a leading apparel company concluded that one pair of denim jeans produces 44 pounds of greenhouse gas emissions—equivalent to burning over 21 pounds of coal.

https://fashioninsiders.co/features/opinion/how-denim-manufacturing-impacts-the-environment/

Green Engineering

- According to EPA: ‖Green Engineering‖ embraces the concept that decisions to protect human health and the environment can have the greatest impact and cost effectiveness when applied early to the design and development phase of an industrial process or product.
- The goal of the Green Engineering is to incorporate risk related concepts into chemical processes and products designed by academia and industry..‖.

Green Engineering is the process and design of products aiming to conserve natural resources leading to sustainability goals.

Also, green engineering aims to reduce the impact of processes and products to the natural environment.

The term —green engineering is applied to a variety of products, like houses, vehicles, consumer products (materials, electrical and electronic equipment) and devices that requires engineering technologies in the construction or making.

12 Principles of Green Engineering

1. Inherent rather than circumstantial
2. Prevention rather than treatment
3. Design for separation
4. Maximize mass, energy, space, and time efficiency
5. Output-pulled versus input-pushed
6. Conserve complexity
7. Durability rather than immortality
8. Meet need, minimize excess
9. Minimize material diversity
10. Integrate local material and energy flows
11. Design for commercial afterlife
12. Renewable rather than depleting

From Paul Anastas

Principle 1

- Inherent rather than circumstantial
- "designers should evaluate the inherent nature of the selected material and energy inputs to ensure that they are as benign as possible as a first step toward a sustainable product, process, or system"

Principle 2

- Prevention rather than treatment

  "it is better to prevent waste than to treat or clean up waste after it is formed"

  example: how to prevent pollution?

- Implementation of new technology
  - solvent substitution
  - eliminate toxic intermediates
  - new reaction paths/new chemistry

Principle 3

- Design strategy for separation and purification.;

  "many traditional methods for separation require large amounts of hazardous solvents, whereas others consume large quantities of energy as heat or pressure. Appropriate upfront designs permit the self-separation of products using intrinsic physical/chemical properties...."

  Ex; distillations and column chromatography

Principle 4

- Maximize mass, energy, space and time efficiency.

"products, processes, and systems should be designed to maximize mass, energy, space and time efficiency"

Principle 5

- Ouput-pulled rather than input-pushed

  "More energy or material ("input-pushed") can increase output, but the same output can be achieved by new designing where chemical processes are "pulled" (e.g. removing products from reaction system) without additional energy or material"

  condensation reactions with the production of water

Principle 6

- Conserve complexity

"Products with high complexity should correspond to reuse, products with minimal complexity are favoured for value-conserving recycling or beneficial disposition."

- More focused on products than processes
- Less complicated products can more easily be recycled
- If a product is complex then it should be designed to be reused

Computer chip vs paper bag

6 example: PCs

- IBM PC's used to be made with 15 different types of screws (unnecessary complexity)
- Replaced with 1 type of screw
- Easier to disassemble & recycle
- Why not reuse computers?
  - make modular
  - replace processors, memory...
  - economics...

Principle 7

- Durability rather than immortality;

  "It is therefore necessary to design products with a targeted lifetime to avoid immortality of undesirable materials in the environment.

However, this strategy must be balanced with the design of products that are durable enough to withstand anticipated operating conditions..

Ex : Disposable Diapers"

Principle 8

- <u>Meet Need, Not Excess</u>

  "design for unnecessary capacity or capability (e.g., "one size fits all") solutions should be considered a design flaw"

- Don't over design things; Extra size means wasted material and energy (Ex. Water-chlorine)

- Global auto industry has 80 million vehicles/yr capacity for market of <60 million/yr

Principle 9

- Minimize material diversity

  "options for final disposition are increased through upfront designs that minimize material diversity yet accomplish the needed functions"

Reducing multiple components in products increases the possibility of useful reuse or recyclability

Ex: Most of the consumer products

Principle 10

- Integrate Material and Energy Flows

"design of products, processes, and systems must include integration and interconnectivity with available energy and materials flows"

Ex. Local industries

Principle 11

- Design for commercial afterlife

  "To reduce waste, components that remain functional and valuable can be recovered for reuse and/or reconfiguration".

Various other big industrial companies have introduced green engineering design features in their products for easy repairs, recyclability or reuse after maintenance (AT&T, General Electric, IBM, Procter & Gable, Whirlpool, etc).

Ex. Mobiles, computers, electrical equipment
Conversion of old factories to housing

Principle 12

- Renewable rather than depleting

"Material and energy inputs should be renewable rather than depleting"

- Don't want to deplete our natural resources
- Need resources to be there for future generations
- Energy: solar, wind, hydroelectric, geothermal, biomass, hydrogen (fuel cells)

GE: Defining the Principles

1. Engineer processes and products holistically, use systems analysis, and integrate environmental impact assessment tools
2. Conserve and improve natural ecosystems while protecting human health and well-being
3. Use life-cycle thinking in all engineering activities
4. Ensure that all material and energy inputs and outputs are as inherently safe and benign as possible
5. Minimize depletion of natural resources
6. Strive to prevent waste
7. Develop and apply engineering solutions, while being cognizant of local geography, aspirations and cultures
8. Create engineering solutions beyond current or dominant technologies; improve, innovate and invent (technologies) to achieve sustainability
9. Actively engage communities and stake-holders in development of engineering solutions

Green Building / Architecture

Green building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction

Green Transport

Any means of transportation that has low impact on the environment
Ex: walking, cycling,, carpooling, car sharing, and green vehicles

Green Skills

The knowledge, abilities, values and attitudes needed to live in, develop and support a sustainable and resource-efficient society" (Cedefop, 2012)

Green Audit

Process of systematic identification, quantification, recording, reporting and analysis of components of environmental diversity of various establishments. It aims to analyze environmental practices within and outside of the concerned sites, which will have an impact on the eco-friendly ambience.

Green Bank

Means developing inclusive banking strategies which will ensure sustainable economic development, combines operational improvements, technology and changing client habits in banking business

SBI - generation of green power by installing windmills

PNB- reducing emission and energy consumption

BOB- Preference to green projects that earn carbon credits- ex-Solar

India - two dedicated clean energy finance institutions — the Indian Renewable Energy Development Agency (IREDA) and Tata Cleantech Capital Limited (TCCL).

Green Certificate

A tradable asset which proves that electricity has been generated by a renewable (green) energy source. .

Green Energy Corridor (GEC)

Synchronizing the electricity produced from renewable resources, such as wind and solar, with the conventional power stations in the grid.. .

Green Tourism

Small-scale tourism which involves visiting natural areas while minimizing environmental impacts

Green Website - Green Web foundation

The web hosting solution powered by environmental friendly resources such as renewable energy.

Example: EvenGreener. blubolt PRO; City Museum. Atomicdust PRO

One Central Park (Sydney, Australia)

https://edition.cnn.com/style/article/green-buildings-world-sustainable-design/index.html

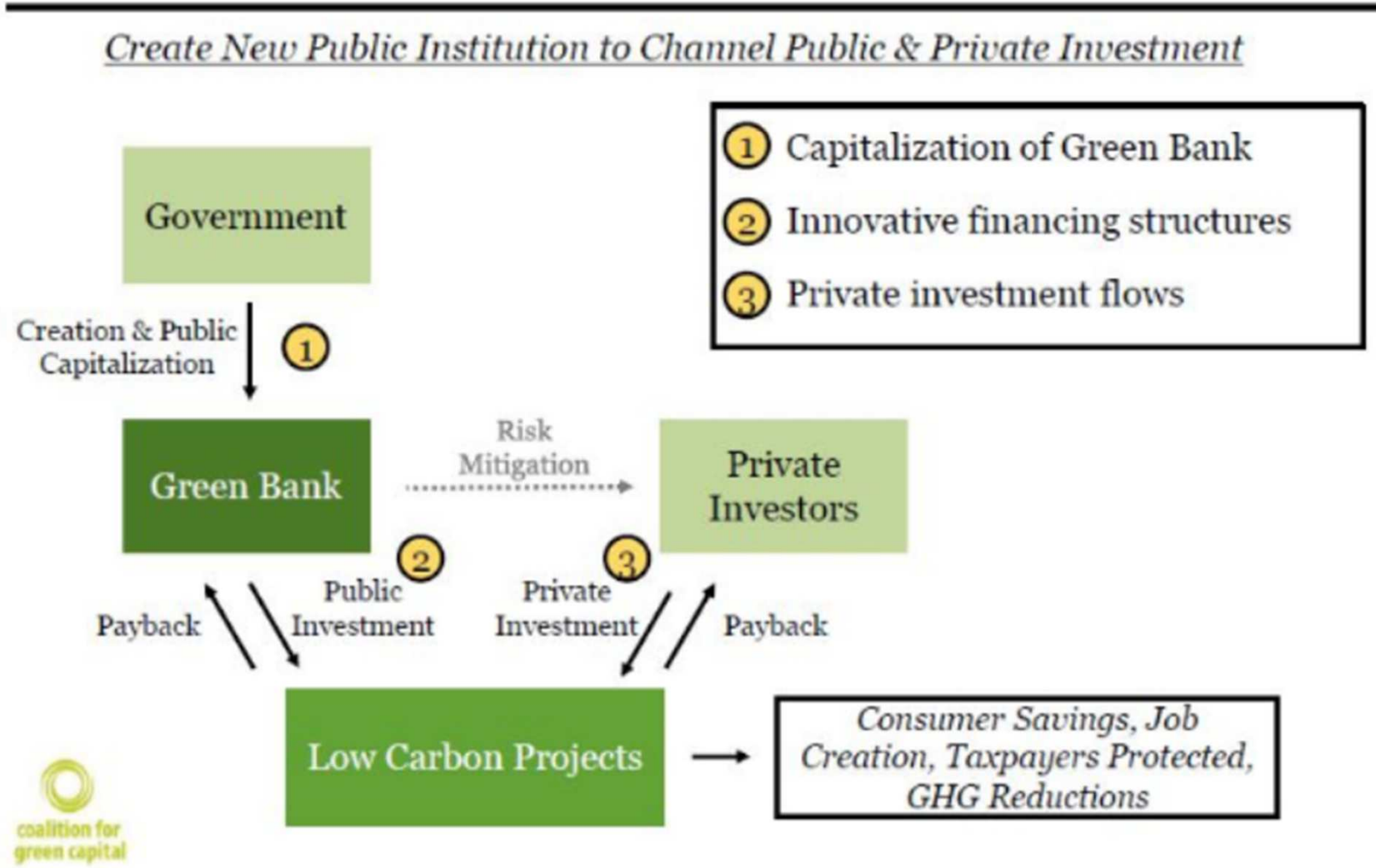
The twin towers of the World Trade Center in Manama, capital city of Bahrain, use the wind to full advantage

https://edition.cnn.com/style/article/green-buildings-world-sustainable-design/index.html

Suzlon One Earth was built using only recycled and nontoxic materials. The design lets in fresh air and natural light to all parts of the campus

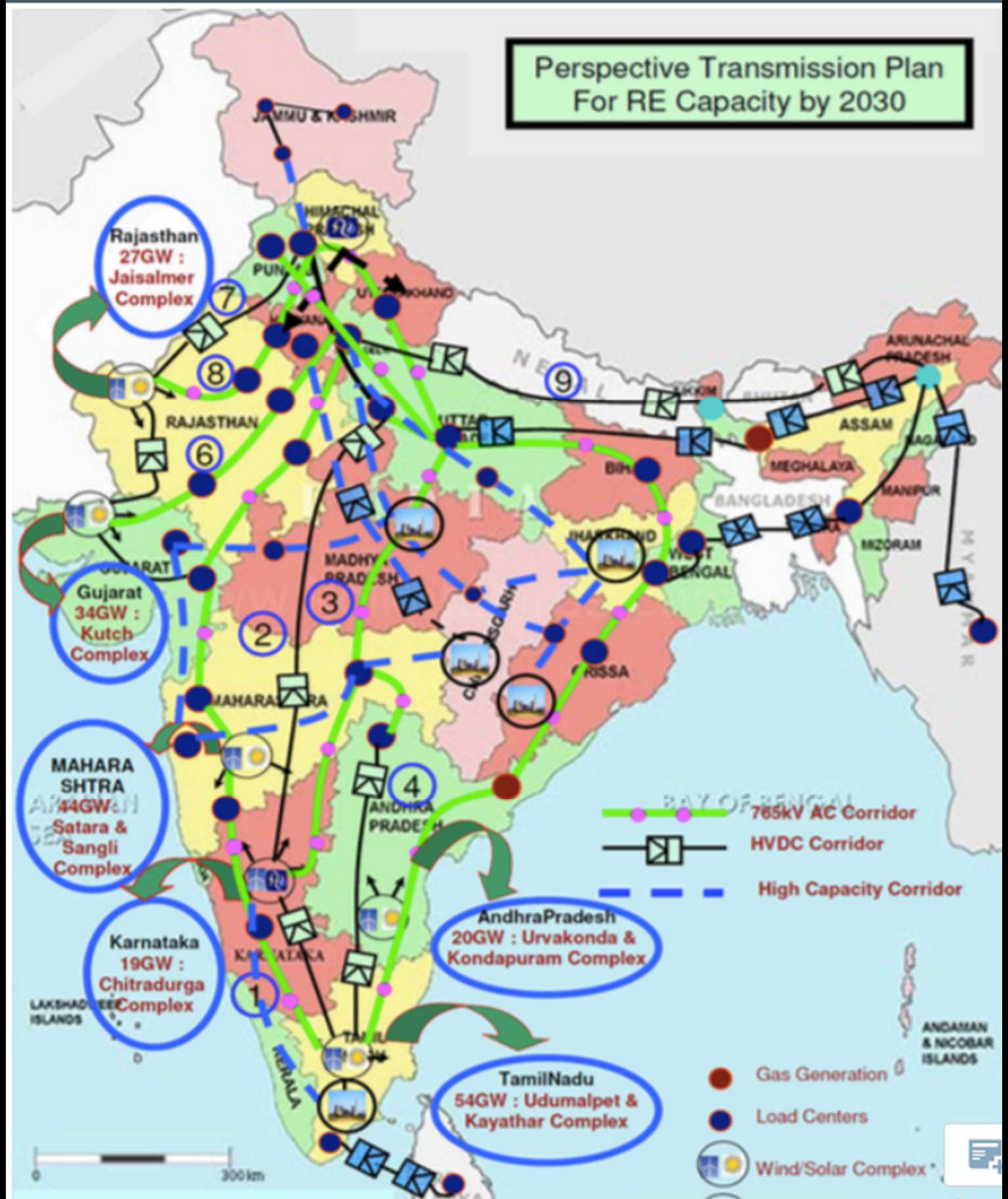
https://edition.cnn.com/style/article/green-buildings-world-sustainable-design/index.html

Basic Green Bank Model



Credit: Coalition for Green Capital

https://betterbuildingssolutioncenter.energy.gov/sites/default/files/Green_Banks_FINAL.pdf


Perspective Transmission Plan
For RE Capacity by 2030
Rajasthan
27GW :
Jaisalmer
Complex
Gujarat
34GW :
Kutch
Complex
MAHARA
SHTRA
44GW :
Satara &
Sangli
Complex
Karnataka
19GW :
Chitradurga
Complex
AndhraPradesh
20GW : Urvakonda &
Kondapuram Complex
TamilNadu
54GW : Udumalpet &
Kayathar Complex
765kV AC Corridor
HVDC Corridor
High Capacity Corridor
Gas Generation
Load Centers
Wind/Solar Complex *
RAJASTHAN
GUJARAT
MADHYA PRADESH
MAHARASHTRA
KARNATAKA
ANDHRA PRADESH
TAMIL NADU
KERALA
ORISSA
JHARKHAND
BIH
WEST BENGAL
ASSAM
MEGHALAYA
MANIPUR
MIZORAM
ARUNACHAL PRADESH
BANGLADESH
NEPAL
BHUTAN
BAY OF BENGAL
ANDAMAN & NICOBAR ISLANDS
LAKSHADWEEP ISLANDS
0
300 km