

**KNOWLEDGE-BASED GREENING FOR A NEW
GENERATION OF PROCESSES, PRODUCTS AND
SYSTEMS: UTOPIA OR REVOLUTION?**

**1st International Conference
Energy & Environment in Ships 2015**

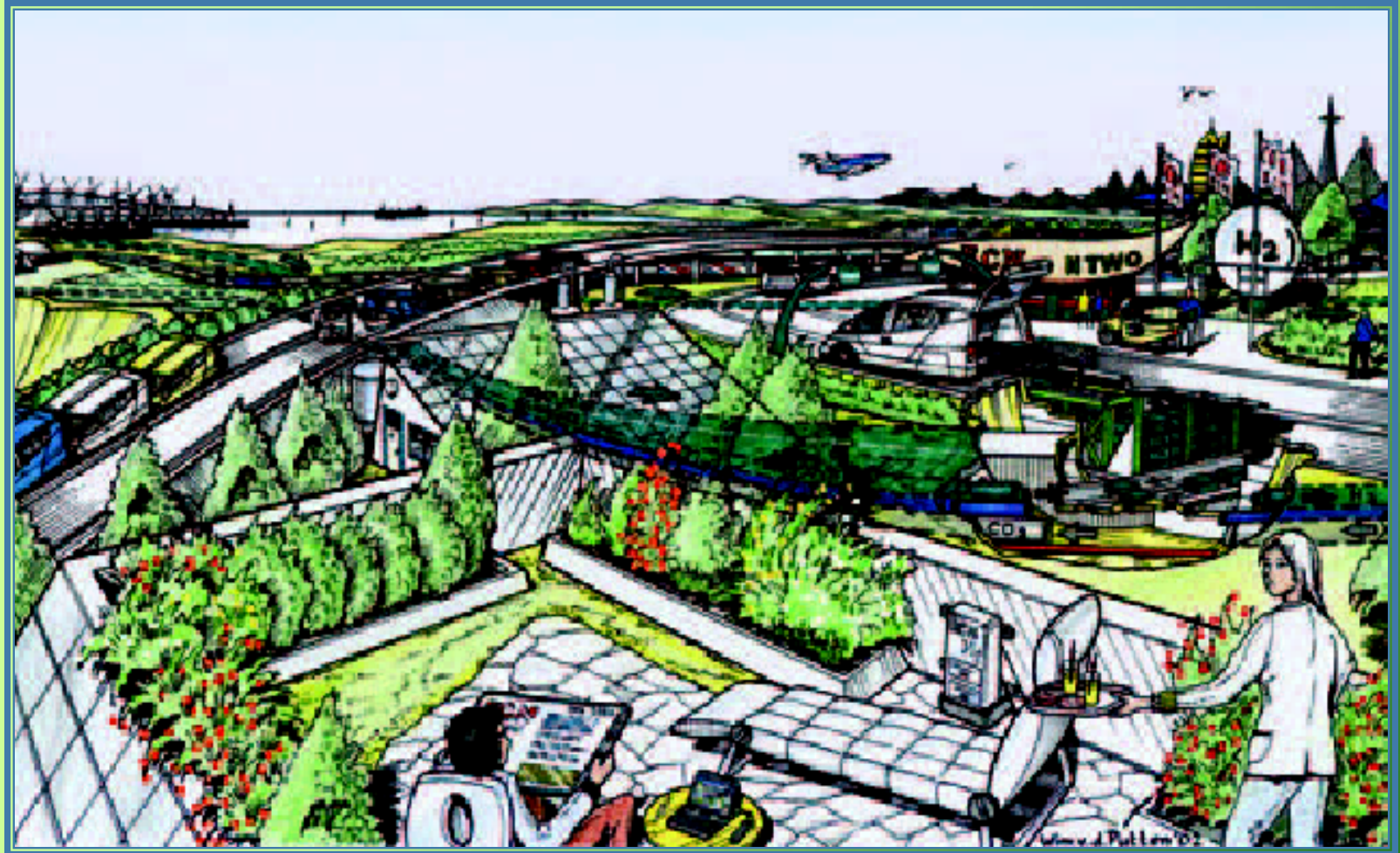
Emmanuel G. Koukios
National Technical University of Athens, GR

The Concept

According to Wikipedia:

- ❖ “Green economy” is an economy that results in improved human well being and social equity, while significantly reducing environmental risks and ecological scarcities.
- ❖ “Greening” is the process of transforming artifacts, such as a space, a lifestyle or a brand image into a more environmentally friendly version.
- ❖ UNEP Green Economy Initiative (2008).

A View of the Future – A Green Utopia?



Thomas Moore: Utopia, 1516



The Alphabet of Greening – 26 Letters

1° PART: A - to – M

- A. Substitution of fossil organic industrial feedstocks by biobased ones**
- B. Complete utilisation of raw materials – “zero-waste” target**
- C. Recycling of materials**
- D. Reduction of the amount and volume of any waste generated**
- E. Resource saving by making long-life products**
- F. Use of renewable or recyclable feedstocks, incl. renewable energies**
- G. Rational use of energy**
- H. Systematic saving of energy**
- I. Design of low energy-consumption systems**
- J. Emphasis on water economy, as well as other critical resources**
- K. Application of soft production/conversion energy systems**
- L. Systematic utilisation of agricultural and agro-industrial residues**
- M. Enrichment of the agricultural/productive soils in organic matter**

The Alphabet of Greening – 26 Letters

2° PART: N - to – Z

- N. Rational use of chemical fertilisers & other chem. inputs in farming
- O. Land use: priority of food vs. fuel production
- P. Priority to cover the energy needs of agricultural and food production
- Q. Optimal utilisation of wastes
- R. Increasing the bio-degradability of wastes
- S. Reducing the industrial scale of operations to meet ecosystem limits
- T. Design of “closed”, circular or integrated production systems
- U. Application of biosciences and biotechnologies whenever possible
- V. Decentralisation of prod. activities accord. to space-planning criteria
- W. Early participation of key stakeholders in decision and policy making
- X. Securing social acceptance
- Y. Improving health and quality-of-life impacts
- Z. Reduction of GHG (greenhouse gases) – Limit climate change effects

Greening – A Brief History

THE GREENING PATH

1972: “Limits to Growth” - Club of Rome Report

1973: E.F. Schumacher’s “Small is Beautiful”

1970s: Oil Crises - Research on Renewable Energies

1980: “The Third Wave” by Alvin Toffler

1987: “Our Common Future”, UN/Brundtland Report

1988: Intergov. Panel on Climate Change (IPCC)

1990s: Climate Change debate – UN Earth Summits -
Rio Agreement (1992) - Kyoto Protocol (1998)

2000s: Greening Strategies and Policies

Pathways to Greening – Major Examples

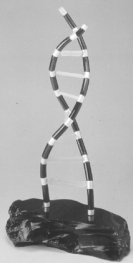
- ❖ **Appropriate, Alternative Technologies**
- ❖ **End-of-Pipe solutions vs. Life-Cycle ones**
- ❖ **Clean(er) Technologies, Eco-Technologies**
- ❖ **Clean, Smart, ... Products**
- ❖ **Low Carbon – Non-Fossil Resources**
- ❖ **Water-, Energy-, Resources-, Wastes Management**
- ❖ **Environmental Engineering & Management**
- ❖ **Organic Systems**
- ❖ **Grass-Roots Societal Experiments**
- ❖ **Sustainable Development**
- ❖ **Bio-Greening, BioBased Economy, Bioeconomy**

12+1 Reasons for Including Greening in an EU/MED Strategy

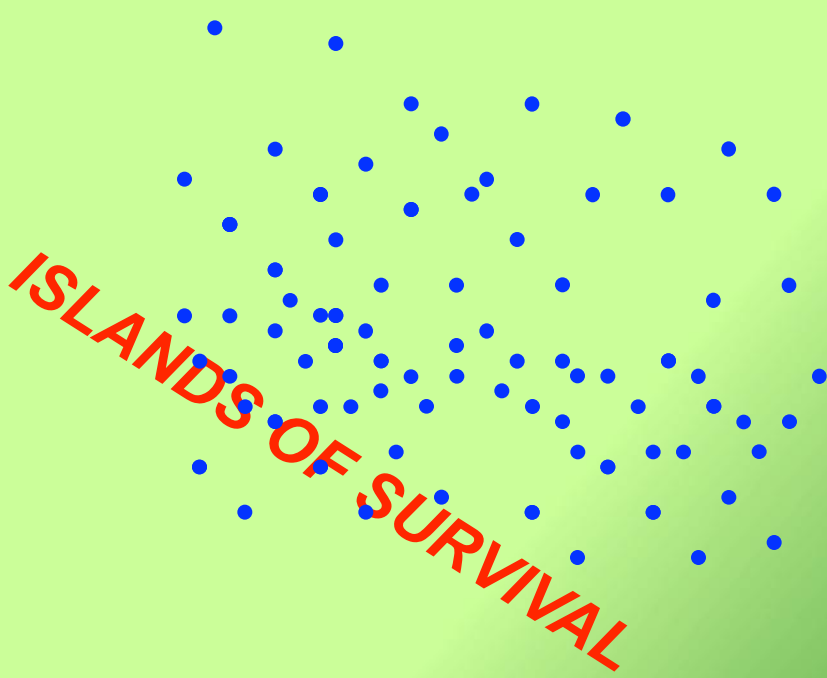
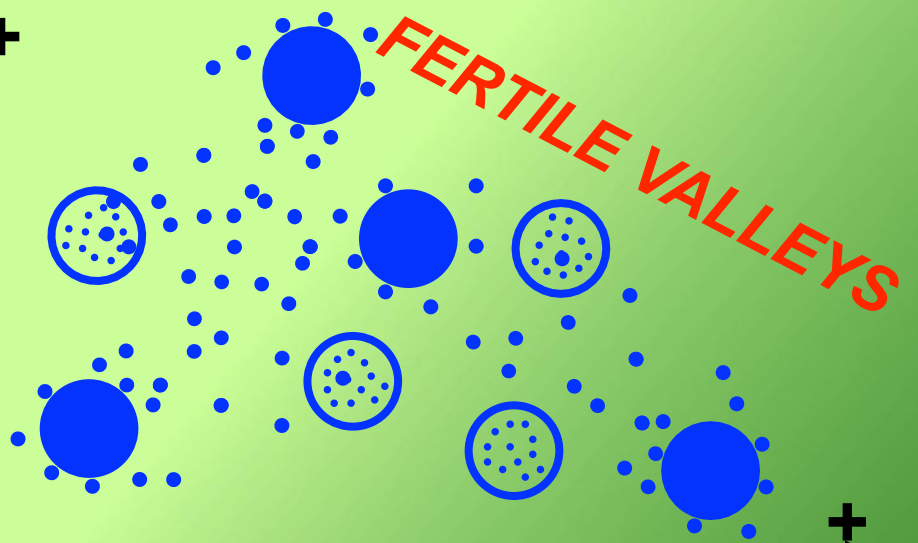
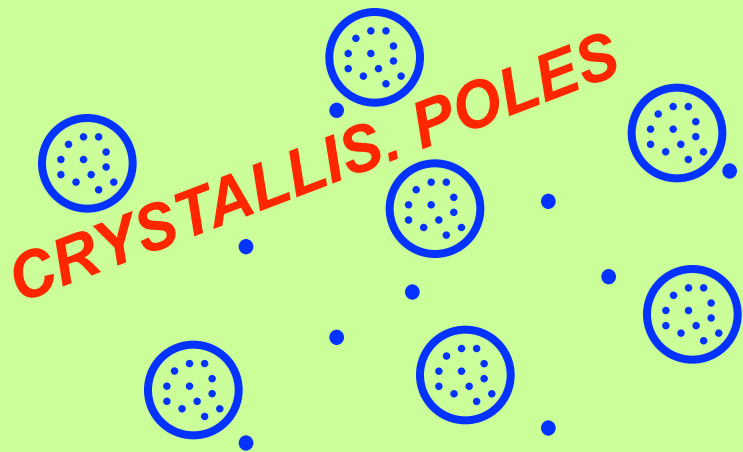
- I. HIGH STAKES: FOOD, FIBRE, LAND**
- II. CHANGE DYNAMICS**
- III. INNOVATION POTENTIAL**
- IV. ENVIRONMENTAL ASPECTS**
- V. CLIMATE CHANGE**
- VI. SUBSTITUTION**
- VII. SOCIO-ECONOMIC ASPECTS**
- VIII. QUALITY & SECURITY**
- IX. BUSINESS OPPORTUNITIES**
- X. POLICY COORDINATION**
- XI. EUROPEAN VALUE**
- XII. GLOBAL DEVELOPMENT**
- XIII. A SMART MOVE...**

GREENING OF THE ECONOMY: MAPPING THE LANDSCAPE - 4 SCENARIOS

Greening Sciences & Technologies	ECONOMY: Areas of Application							
	A1	A2	A3	A4	Am
B1								
B2								
B3								
B4			B4/A3					
...								
Bn								



S&T EXCELLENCE / S&T POLICIES



Implementing Greening Within a Multi-Policy Environment

KBBE-Relevant EU Policies

- Europe 2020
- ERA
- CAP, CFP
- Maritime
- Public Health
- Energy
- New Functional Biomaterials
- Environment
- Industrial Competitiveness
- Regional Development
- International Development
- Crisis/Recovery Management

Technological Synergies for Greening

- **INFO:** Modelling & management of complex systems
- **BIO:** Bio-greening, “smart” solutions
- **NANO:** Selectivity, miniaturization
- **HYBRIDS:** Info – Nano – Bio, tailored solutions
- **CHEMISTRY:** Green, molecular solutions
- **INDUSTRY:** Circular, Ecology, Flat hierarchies
- **ENERGY:** Renewables, rational use, soft solutions
- **POLLUTION:** De-coupling from economic growth
- **ECONOMIES:** Scale vs. Scope, externalities
- **COGNO:** Decision-making, behaviour patterns

Promoting Greening by Research

The 7 “Golden Rules”

0. An emerging space for vital innovation
1. Better understanding of complex phenomena involved
2. Planning and implementing knowledge-based actions
3. Environmental biotechnologies as a potential research flagship
4. Design of environmentally compatible solutions, drawing upon other novel RTD areas and approaches
5. Significant role in social and economic development, and key opportunity field for international cooperation
6. Responding to societal concerns, and assessing risks
7. Research to be accompanied by appropriate information, communication, dissemination and crisis-management components

Skill Needs for the Green Economy

The 7 “Golden Rules”

0. STRATEGIC ISSUE - MULTI-PLAYER ACTIONS
1. RADICAL CHANGE: shift in socio-economic structures, cultures and lifestyles, knowledge modes, and organisation patterns
2. MUTUALLY TRANSFORMING PROCESSES: by learning and cognition
3. KNOWLEDGE: cognitive and affective elements
4. ALL CRITICAL FLOW SYSTEMS: molecular, energy, materials, information, financial, and human
5. TO DO (1): Introduce Greening skills through problem-oriented University curricula
6. TO DO (2): Add an extra layer to the existing professional education systems
7. TO DO (3): Use the KIC (Knowledge & Innovation Communities) concept as new instrument for change

A Challenge: Fragmentation vs. Integration – Managing Risks - Role of Vision & Regulation



Societal Factors – Consensus Building

Decision Criteria – Short List

Stakeholders (a) – (f) were asked to rank their priorities in the following decision making criteria 1-9 (with 1 and 9 being the most and the least important criteria for each stakeholder):

- Return on Investment
- Annual revenues
- National economy
- Regional/Local Economy
- Application of New/Innovative Technologies
- Employment
- Environment
- Political and institutional benefits
- Other criteria

Map/Monitor Stakeholders Response

Quantification by Preference Vectors

Decision criteria	Rank of Each Interest Group/Stakeholder for the Decision Criteria							Overall Ranking of Importance
	(a)	(b)	(c)	(d)	(e)	(f)	Total	
1	4	1	2	8	9	4	28	III _A
2	1	2	1	4	5	8	21	I
3	6	6	6	5	2	5	30	IV
4	2	8	5	1	3	6	25	II _B
5	7	4	3	6	8	1	29	III _B
6	3	7	4	2	4	2	24	II _A
7	5	5	7	3	7	3	30	IV
8	8	3	8	7	1	7	34	V
9	9	9	9	9	6	9	51	VI

Map/Monitor Stakeholders Response

Use of preference vectors to identify strategic alliances between actors

	(a)	(b)	(c)	(d)	(e)	(f)
(a)		22.0	12.0	14.0	28.0	22.0
(b)			16.0	30.0	34.0	26.0
(c)				24.0	32.0	20.0
(d)					24.0	18.0
(e)						36.0
(f)						

An Example: Reduction of the Shipping Fuel Costs and the Associated Emissions

Solution-1: A New Concept

- **Thermorefinery Technologies Inc. is proposing a new concept to help reduce the costs as well as the emissions associated with the use of marine fuel oil in the shipping industry**
- **Substitution of the marine fuel oil used today with:**
 - **Clean bio-oil/synthetic fuel oil (syn-oil) produced from the pyrolysis of clean biomass/waste/coal materials that have been pretreated using the Thermorefinery “smart” leaching pretreatment technology, OR**
 - **Clean biomass/biocoal/coal/synthetic coal to be used in combustion/ gasification cycles installed in the vessels to produce gas and/or electricity to run the ship engines**

An Example: Reduction of the Shipping Fuel Costs and the Associated Emissions

Solution-2: Smart Pretreatments

- **Thermorefinery Technologies Inc. has developed a pretreatment technology that can use any kind of low quality biomass, waste and coal material to produce clean biomass, biocoal, coal, syncoal that can be used as feedstock in pyrolysis, combustion and gasification concepts**
- **In that way a high quality feedstock that is free of reactive alkali metals, chlorine, sulfur, phosphorus and heavy metals is produced that can be used for the production of clean biomass, coal, biocoal, syncoal, as well as clean and stable biooil/syn-oil, that can be used to replace diesel and other fossil fuels in conventional engines.**

Concluding Remarks

- **Greening (Gg) is symbiotic with sustainable DEVELOPMENT based on economic and societal innovative solutions**
- **The main Gg path is through PRODUCT innovation, which could revitalize sectors and regions, by smart interdisciplinary applications**
- **The PROCESS innovation-based Gg path should focus on novel technologies for clean solutions**
- **SYSTEM innovations (e.g., GREEN SHIP/PORT) offer possibilities for combined product/process innovations**

Thank You!

FOR MORE INFORMATION:

koukios@chemeng.ntua.gr