International Green Network

Final document

Executive summary

The mission of the International Green Network (IGN) includes research, aimed at providing know-how, coordination and sponsorship for scientific collaboration, targeted training for a new generation of scientists from developing (as well as industrialised) nations, and the support of sustainable development. The IGN will assist industrial production in G8 nations, foster the development of novel competitive technologies, and address issues such as climate change, energy, and other environmental concerns from a chemical standpoint.

The International Green Network consists of eight research centres, one based in each of the G8 countries. Each research centre is responsible for the network within each G8 country, and its head scientist represents his/her nation in the IGN.

The primary goals of the IGN are a cleaner and safer environment through:

- the proliferation of research.
- high-level capacity building in science.

The second objective relates to:

- the improvement of regulatory frameworks and public policy design.
- the enhancement of public outreach and education.

The International Green Network will accelerate movement towards a sustainable energy and materials economy, by bringing together scientists, engineers, research institutions, firms, policy analysts and government regulators.

The International Green Network will address key policy issues by:

- developing policy tools to encourage research, commercialisation and deployment of various sustainable energy and materials technologies;
- ensuring the adjustment of existing regulatory régimes in the energy and materials fields to encourage innovation and performance improvements that point towards sustainability;
- developing incentive structures that reward early movers and encourage progress towards sustainable energy and materials initiatives;
- developing policies to promote public education and debate around issues related to the energy and materials sector.

Contents

1. Introduction

Chemistry is fundamental for the quality of life, and it is a driving force for technological, social, and economic development. In the second half of the 20th Century, problems associated with the industrial generation of chemical products, such as environmental pollution, safety hazards, and health risks, became increasingly evident. At the beginning of the 21st Century, however, it is clear that chemistry is also the scientific and technological tool that can prevent and ameliorate many of the environmental problems attributed to it. The question is: how? Green Chemistry is concerned with solving and preventing these problems, and some of the favoured approaches are summarised below:

- Through green (sustainable) chemistry, *i.e.* the worldwide, responsible use of chemistry. This implies a careful use of resources, including energy; that it is better to prevent (rather than remediate) pollution caused by chemical production; that new routes to products and the design of inherently safe products are needed, and that it is necessary to improve the safety, social acceptance, and economics of chemical processes and products. In short, to reduce the ecological footprint of industrial chemical production. Globally, this approach generates a better environment, improved health, economic benefit, and higher quality of life, and it is starting to catch on with the media and the public.
- Through training of scientists and engineers, and an open technology transfer amongst the G8 – knowledge which will also be shared with those in developing nations – on how science can be used positively without jeopardising the environment. This will create a generation of environmentally-conscious scientists able to address the challenges of technological development coupled with environmental safeguards.
- By the promotion of the public understanding of science. If chemistry becomes associated with a better quality of life, improved health, a sounder environment, more jobs, and technological development, then it will be correctly perceived as worthy of societal support. To date, chemistry has received a “bad press”, largely because chemists have failed to communicate with the general public in a manner that can be clearly understood.

Over the next few decades, the industrialised countries must take major steps to transform their energy and materials infrastructures along more sustainable lines. Environmental damage associated with the extraction and combustion of fossil fuels (including acid deposition, toxic releases and climate change) are well known, but patterns of water use, exploitation of biological resources, and chemical emissions are also unsustainable. Since the environmental pressures imposed by rapidly industrialising countries (such as China and India) are certain to rise in coming years, it is imperative that G8 countries take the lead in decoupling economic growth from environmental burdens.

The International Green Network (IGN) embodies the need for industrialised nations to find a common platform. It will take the lead in strategic planning, preparing discussion documents for governments on high profile environmental issues, and being responsive to requests of the Carnegie Group. A common strategy of this kind will benefit everyone, including national governments: by strengthening consensus in academia, in industry, and among the younger generation as well as the public, who are growing more sensitive to environmental and health issues. If a global solution is not found, then the efforts of individual nations will be squandered; pollution shows no respect for international borders!

2. Background

In 1990 the Carnegie Commission on Science Technology and Government of New York established an informal meeting of the science advisors and ministers of science of the G7 countries, the European Union, and the Soviet Union: it involved only principals, and there would be no formal notes taken, and it should be repeated at roughly six-month intervals. The group became known formally as "The Carnegie Group”. As candidate topics for strengthened international cooperation were selected, each in its broadest sense:

a) Energy
b) Protection of the global environment
c) Technologies for the developing world
d) Human welfare and nutrition.

During the Carnegie Group meeting hosted by Canada on June 2nd-3rd, 2005, a research and training network on Green-Sustainable Chemistry was proposed by the

Italian Minister for Education, Research, and University, Mrs. Letizia Moratti. The initiative was unanimously approved and was named as: The International Green Network. The Interuniversity Consortium "Chemistry for the Environment" (INCA; Marghera, Venice, Italy) was indicated as its hub.

The mission of the International Green Network (IGN) includes research, aimed at providing know-how, coordination and sponsorship for scientific collaboration, targeted training for a new generation of scientists from developing (as well as industrialised) nations, and the support of sustainable development. The IGN will assist industrial production in G8 nations, foster the development of novel competitive technologies, and address issues such as climate change, energy, and other environmental concerns from a chemical standpoint.

This Green Chemistry approach has been recently endorsed by the award of the 2005 Nobel Prize for chemistry (http://nobelprize.org/chemistry/laureates/2005/press.html).

3. Structure

The International Green Network consists of eight research centres, one based in each of the G8 countries. Each research centre is responsible for the network in its own G8 country, and its head scientist represents their nation in the IGN. The INCA Consortium in Italy is the hub of the IGN, supported closely by BIGCAT in the Queen's University of Belfast.

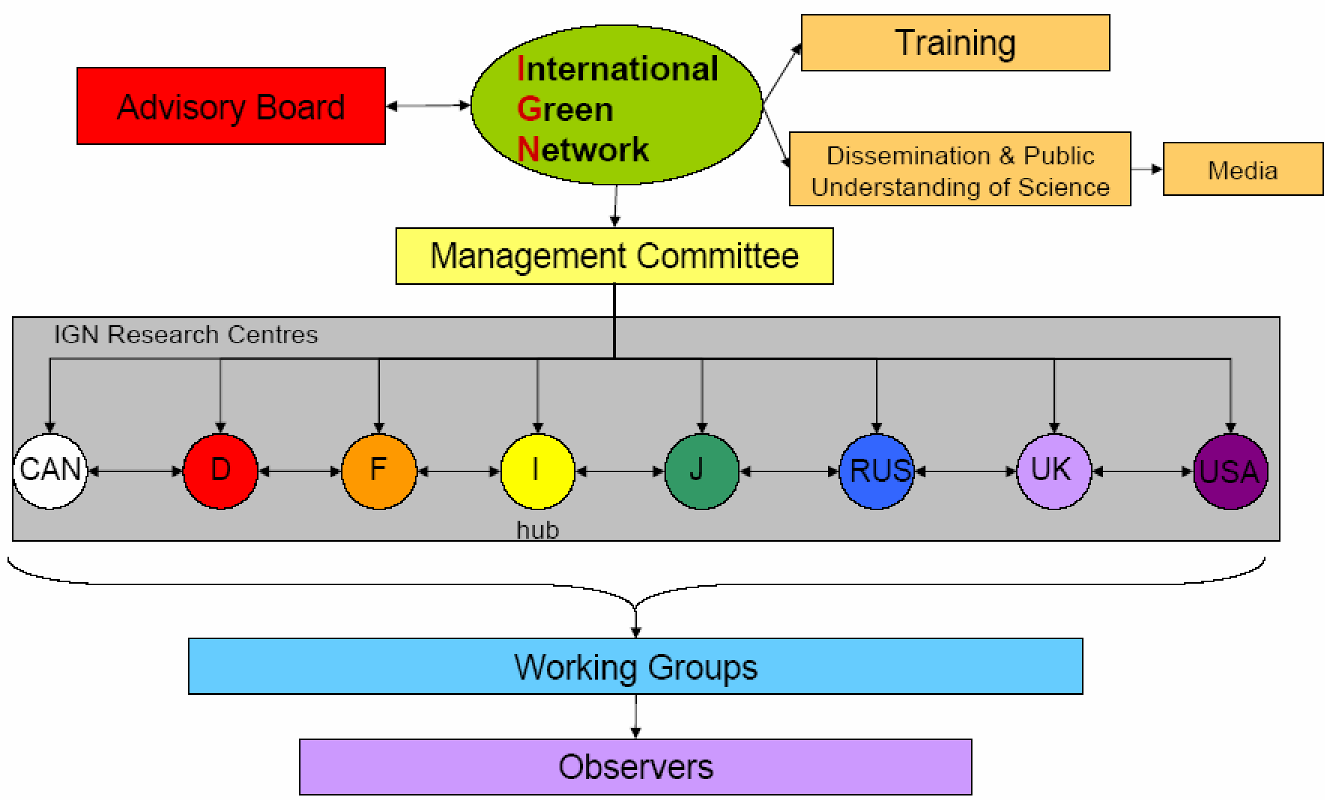
The structure of the IGN is shown schematically in Chart 1. The IGN is composed of one leading scientist nominated by his/her G8 Government Minister, who will be the head of their own National IGN Centre. The IGN in return keeps the Carnegie Group, as its reference point, updated on matters concerning green chemistry. The IGN avails itself of an Advisory Board (AB) comprised by 10 renowned scientists (+ 1 chair) selected from academia (*e.g.* Nobel laureates in the fields of chemistry and physics), from the chemical industry (pharmaceutical, petrochemical, heavy chemistry, light chemistry, consumer goods, mining, tanning, manufactured goods, *etc.*), and will include an expert in business and economics, a science policy expert (from IUPAC), a media person, and perhaps a member of the US Fulbright board. The AB will offer unbiased and expert guidance related to the goals of the IGN. A Management Board comprising the director and vice-director of the IGN, plus 2 board members (by rotation), will be the interface between the IGN and the Research Centres.

Research and training will be carried out at the IGN Centres, located at the parent organisations of the IGN leading scientists. The IGN oversees research, and research collaborations between the IGN Centres. Research between IGN Centres will be coordinated and carried out through "Working Groups", which also constitute the link with the non-G8 countries involved in common research projects and in research training. The IGN will coordinate research training, and dissemination towards the scientific community and towards society. In this context, it should be stressed that one of the principal goals of the IGN is public understanding of science, social acceptability of chemistry, and outreach towards industrialised non-G8 nations (*e.g.* Australia, Spain, and South Korea), nations whose economies are developing at an accelerated rate (*e.g.* China and India), and developing nations (*e.g.* Ethiopia, Chile, and Indonesia).

The first general goal of the IGN is a cleaner and safer environment through <u>technology</u> and <u>research collaborations</u> in the field of chemistry. This will be achieved mainly through guided scientific research, training, and transfer of knowledge, and through the involvement of non-G8 countries. Excellence in research is therefore crucial, and it can be achieved only by securing the best scientists for the network. The scientific goals of the IGN will address all four of the areas originally identified by the Carnegie Group (page 5).

The second objective is the dissemination and public understanding of science. This will be done through publications, media attention (*e.g.* positive news stories and TV documentaries), workshops, museum displays, a website, and any other effective means which will attract attention and inform the public.

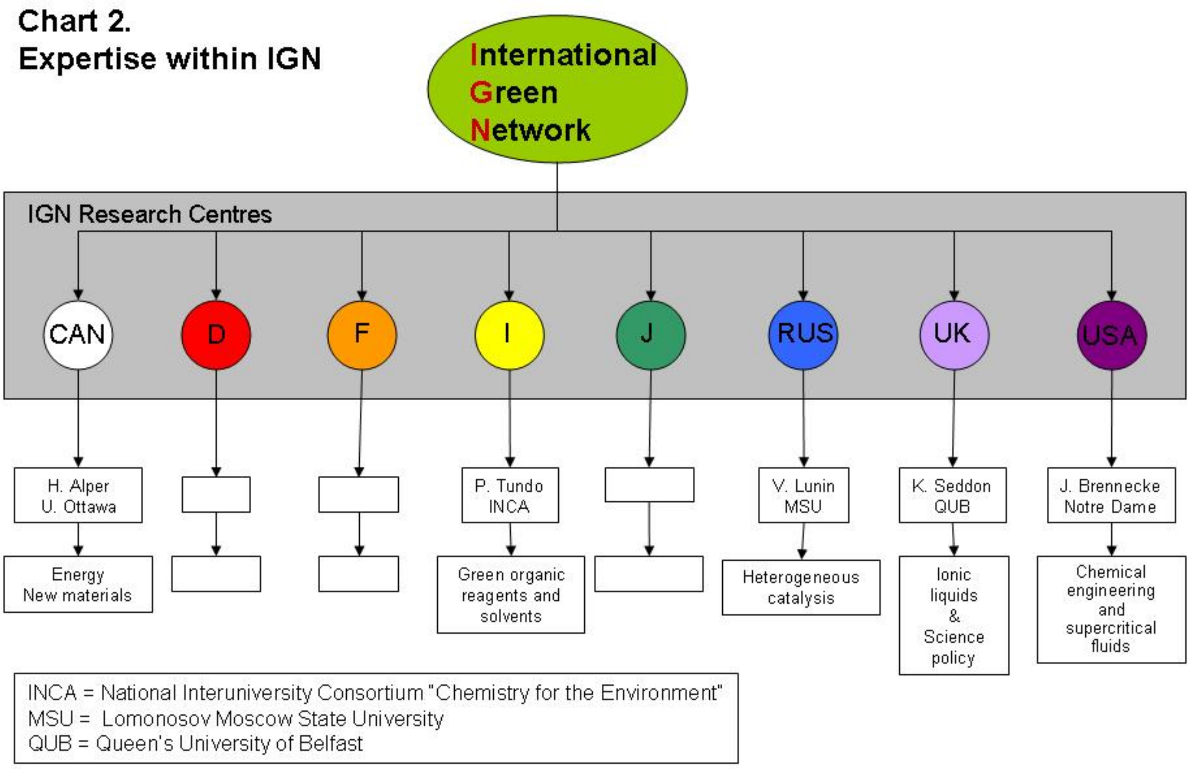
Chart 1. IGN Structure



A IGN meeting is planned twice each year, between the IGN scientists, and should take place in the days preceding the Carnegie Group meeting.

4. Scientific Programmes

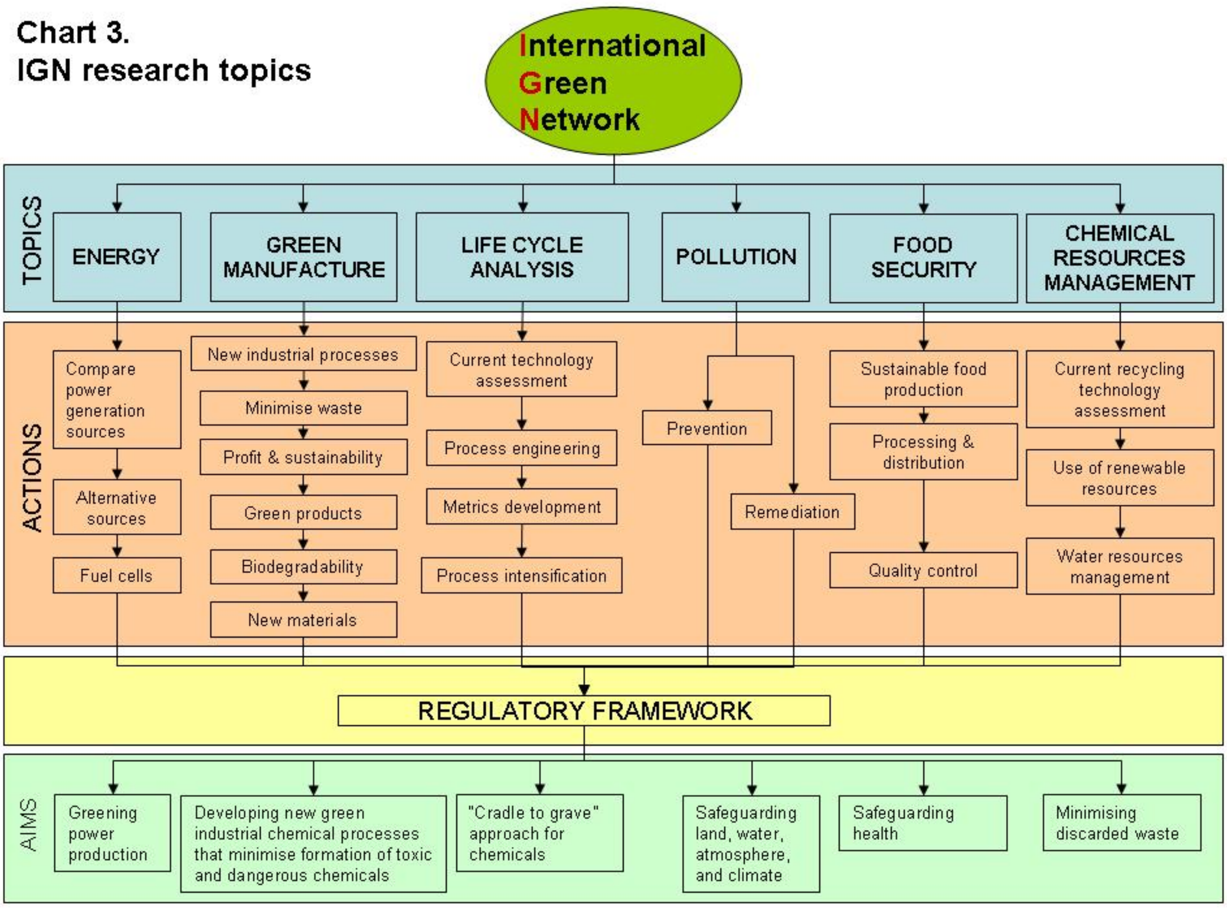
The scientific competencies of the IGN Centres encompass a wide range of subjects involved with the application of chemistry for environmental safeguard. To date, five out of eight IGN Centres have been officially identified, and are shown in Chart 2.



It is anticipated that competencies in the fields of energy, pollution (in particular atmospheric), and pharmaceuticals will be added in the near future. It should re-emphasised that IGN is a consortium of the world's best scientists – the problems we are tackling are those of the highest priority for a sustainable future for our planet. This was stated also to *Chemical & Engineering News* (October 10, 2005) by Prof. Paul Anastas – director of the American Chemical Society's Green Chemistry Institute – who commented on the 2005 Noble prizes: "… the best chemists in the world are doing green chemistry, and green chemistry is simply a part of doing good chemistry".

Chart 3 shows an overview of the scientific topics that will be dealt with in the IGN.

Six major areas are identified that have chemistry as a basis or as a key component. All the topics outlined in Chart 3 are linked, and actions in one area must take into consideration the others as well. If not, it will not attain a meaningful environmental impact. Chart 2 represents the "vertical" organisation within each G8 country, and Chart 3 represents the "horizontal" research topics. Each research topic will represent contributions from research teams comprised of each interested IGN Centre. Each centre has the freedom to recruit other expertise, as required. This team work is going to be crucial to obtain our goals.



The following is a description of the actions to be undertaken by the IGN. Most, if not all, are interconnected, and some – but not all – of these connections are explained.

4.1 Energy. Movement will be towards a carbon neutral energy system. Key elements in the transition towards such a future include the development of renewable energy technologies; innovation in energy storage and movement; advances in energy efficiency and demand reduction, and advanced fossil fuel technologies. The goal of greening power production will require a critical assessment of available and prospective energy sources, from a chemical standpoint. It is likely that, given the competencies of the IGN, major emphasis will be placed on studies concerned with: (a) the improvement of the efficiency of solar and photovoltaic cells, (b) fuel cells, (c) biotransformations, (d) energy storage, and (e) a critical evaluation of various National energy strategies. Energy is connected with **pollution**, especially carbon dioxide, sulfur dioxide and nitrogen oxides production: we need cleaner methods for power generation. Energy is also connected to the other topics: with **green manufacture**, as one of its goals is to reduce energy requirements for production processes; with **life cycle analysis,** that includes process engineering and intensification; with the **management of chemical resources**, that involve a more efficient design and utilisation of chemicals.

4.2 Green manufacture. This topic relates to the design of intrinsically clean chemical processes and industrial targets, and to the design of benign chemical products, in order to minimise the impact on the environment, maximise profit, and achieve sustainability. Here chemistry has a predominant *role*, and connections can be made with most of the other topics of the IGN. It encompasses the prevention of **pollution**, through the greening of processes, and includes **life cycle analysis** and the design of efficient processes and safe products (non-toxic, biodegradable, *etc.*). An important sector addressed by green manufacture will be that of pharmaceuticals, an industry among the most polluting. New and improved routes to pharmaceuticals will be a major target, particularly through the development of new chiral syntheses, an area which was recognised with the 2001 Nobel Prize to Knowles, Noyori, and Sharpless.

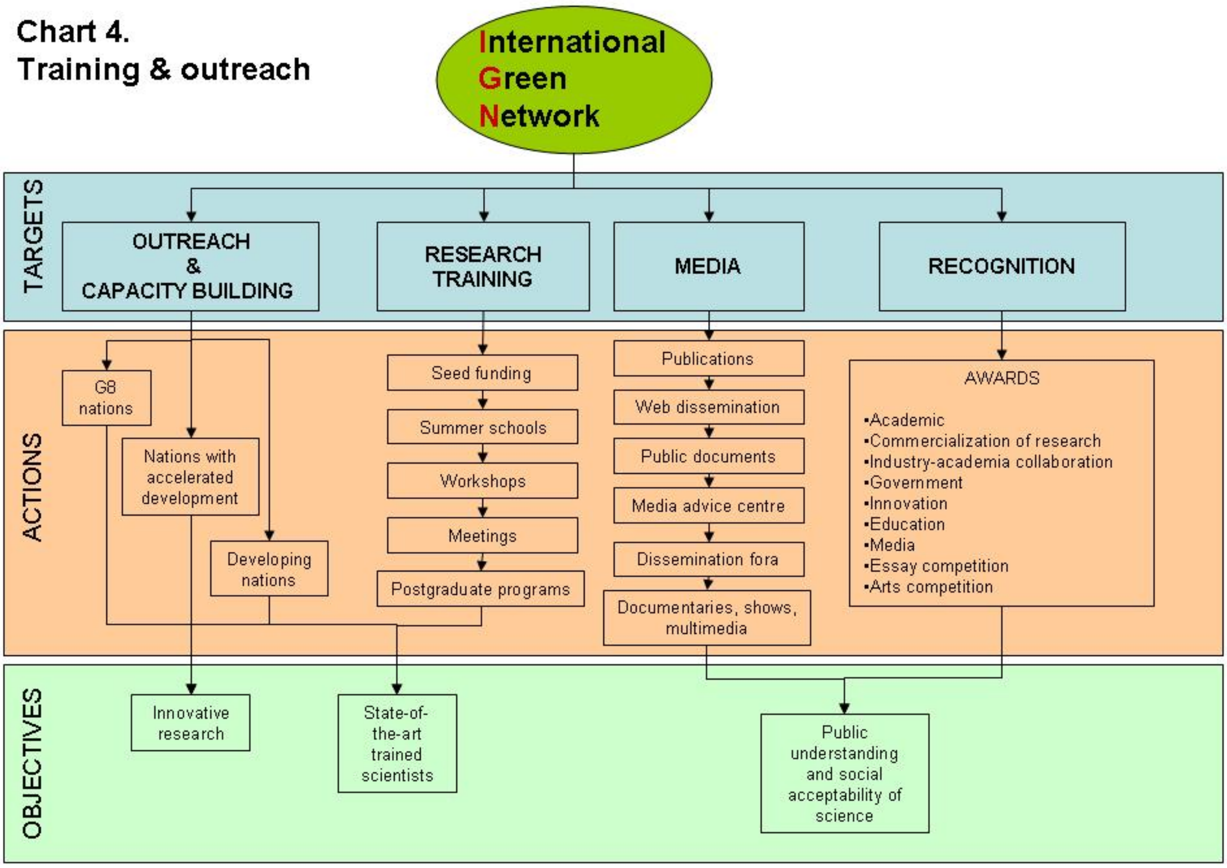
4.3 Life cycle analysis. This area is based on following the fate of chemicals from the raw materials, through the production processes, to the product, and on to the disposal and recycling of any intrinsic waste: the so called "cradle-to-grave" approach. Each step has to be analysed for "greenness", and the whole process must be environmentally compatible and safe throughout. It includes saving **energy**, avoiding **pollution**, implementing **green manufacture**, and **management of chemical resources** and wastes.

4.4 Pollution*.* Two distinct actions are considered here: prevention and remediation. The former is tightly connected with **green manufacture**, whose primary objective is the design of greener production processes, as well as with **life cycle analysis** that focuses on the engineering aspects, and with the design of green products, aimed at producing safer chemical products that will reduce environmental impact and improve safety. Remediation includes actions to reduce existing pollution, to clean damaged sites, and to improve the **management of chemical resources**, *e.g.* through recycling. However, we are concerned only with the remediation of historical contamination; the principles of green chemistry demand that all new processes do not generate significant levels of waste. Land, water, the atmosphere, and climate are the targets of these actions. In particular for the atmosphere and climate, prevention aims at reducing the impact of chemicals such as CFCs, CO_2, greenhouse gases, SO_x, NO_x, particulate metals, and dangerous effluents, *e.g.* from the mining, pulp and paper, and tanning industries. Remediation will address issues such as POPs, pesticides, dangerous waste (plastics, computers, atomic, military, aircraft fuels, rocket fuels, landfills, *etc.*), and toxics present in the environment. Along with research, all aspects of pollution will necessarily involve issues connected with: energy policy, legislation, public awareness, education, *etc.*

4.5 Food security. Focus here will be on the contribution of chemistry towards food safety. This involves sustainable agriculture (including the management of water resources and carbon sequestration in global soils), processing, control, and management of foodstuffs.

4.6 Chemical resources management*.* This refers both to starting materials and to products of chemical processes. Managing them implies that one must consider the use of renewable resources, as well as of resources which are recovered as waste or by-products of existing technologies. It also includes recycling of wastes and by-products, plus the management of all resources used in a process, starting from energy, water, air, *etc*. This area is linked tightly with **energy**, **life cycle analysis**, **green manufacture**, and the **design of benign products**.

5. Education, Training and Outreach



Training, education, and outreach activities will be as important as research itself in the IGN, based on the assumption that there cannot be good research without good researchers, and that a positive perception of chemistry is indispensable if green recommendations are to be adopted by the general public.

Outreach and capacity building will be carried out on a regular basis, for young researchers operating both within the G8 countries, and elsewhere. Since each Nation is faced with different problems (*e.g.* industrial production, chemistry and agriculture, widespread pollution, water management, draughts, *etc.*), each perceives green chemistry from a different standpoint. There is thus a need for diversification to meet specific requirements, and programmes tailored to the needs and resources of each country.

Research training will be achieved by establishing shared doctoral programs, summer schools (such as the Summer School on Green Chemistry, held annually in Venice since 1998 by INCA: http://www.unive.it/inca), advanced workshops on specific topics, international annual conferences (the first will be held at the end of 2007 on "Energy and Chemistry"), by establishing seed funding to encourage innovative research, and by creating "task forces" of scientists from the G8 nations who will travel to the developing countries for two-week intensive courses and practical training. A fellowship program will also be established, on the lines of the US Fulbright scholarships, for the exchange of researchers between the partner countries. All the above actions will be coordinated by committees from within the IGN, since IGN will form partnerships with any new centres of excellence created in the developing nations. An example of the kind of excellence centres which could collaborate and benefit from the IGN are being created by the African Union, with UNESCO, in the field of natural sciences.

The **media** have a key *role* to play, including all activities aimed at outreach, dissemination and improving the public perception of chemistry. Included are therefore: publications, web dissemination (through a dedicated web site managed by IGN that should contain: news, conference information, position announcements, research projects, links, a bulletin board, a newsgroup, mailing list, *etc.*), production of public documents, production of documentary programmes for television (such as DVDs produced by Prof. Harold Kroto), and attempts to link the arts to green chemistry. A regular (monthly, or bimonthly) chemistry lecture series by renowned scientists should be established in a site that will attract attention, based on the model of the highly successful series of lectures, called Bacon and Eggheads, that is held monthly in Canada's parliament. A media representative should also serve in the Advisory Board.

Awards for meritorious achievements in chemistry will be established. Examples of prizes for different categories will include: for academic research, for industrial research, for industry-academia collaboration, to non-G8 countries, to developing countries, to governments, for education, for the media. One could also consider awards for an essay competition and for an arts competition related to chemistry. These will be publicised and explained and serve to increase awareness by non-specialists and the public.

6. Impact

On the energy side, movement will be towards a carbon neutral energy system. Key elements in the transition towards such a future include the development of renewable energy technologies (hydro, wind, solar, wave, biofuels, geothermal, *etc.*); innovation in energy storage and movement (decentralised grid architectures, hydrogen and fuel cells); advances in energy efficiency and demand reduction (commercial and domestic lighting and space heating/cooling, transport, co-generation and district energy systems, *etc.*), and advanced fossil fuel technologies (carbon sequestration).

On the materials and processing side, the move will be towards the elimination of toxic, bio-persistent, and dissipative substances, and their replacement by alternative products and processes.

New energy and materials technologies will be critical to economic success, public health and welfare, and environmental protection in the coming century. Mastery of renewable energy, clean fossil technologies, and less-toxic industrial processes will be important for securing competitive advantage. Countries that take the lead, hold key patents, build their knowledge infrastructure, and develop techno-industrial clusters in key energy and materials areas, will be the leaders of the future in securing jobs, investment opportunities, and export markets. Policies to accelerate the development of the new energy and materials economy – that can place the G8 nations at the cutting edge of this movement – should be of critical long term interest to government.

By bringing together scientists, research institutions, firms, policy analysts and government regulators this network can contribute to accelerating movement towards the sustainable energy and materials economy.

This network will favour:

- the development of research.
- high level capacity building in science.
- the improvement of regulatory frameworks and public policy design.
- the enhancement of public outreach and education.

By putting the G8 Research Centres in this critical and emergent sector into contact, it will allow a collegiate framing of problems and solutions, the enhancement of contemplative and introspective practices among participants, and a facilitation of communication with external bodies - including political and economic leaders, the media and the public. We wish to emphasise, however, that each G8 country has its own infrastructure, and each country is free to achieve the goals of the IGN as appropriate to that structure and national policy and regulations.

APPENDIX A: Estimated Costs

Calculated based on:

No of countries	8
No of years	4

Currency = US Dollars

		Cost per country per year	Total per country for 4 years		Total for 8 countries for 4 years
	Endowed chair*	200000	800000		6400000
Costs for IGN Centres	Post-doc researchers*	200000	800000		6400000
	Equipment	200000	800000		6400000
*Includes consumables	TOTAL	600000	2400000		19200000
		Hub costs per year	Hub costs per year per country		
	Outreach	106500	13312.5		426000
	Exchanges	1522500	190313		6090000
Shared Costs	Travel	27000	3375		108000
	Conferences	750000	93750		3000000
	Schools	750000	93750		3000000
Management	Labour	300000	300000		1200000
	Office	25000	25000		100000
Output		1000000	1000000		4000000
	TOTAL		4119500	**TOTAL**	**37124000**

Breakdown and explanation of estimated costs

The table of Appendix A details expected costs of the IGN. Costs are based on the hypothesis that 8 countries will participate in a 4 year project. It is divided in two sections.

The upper section called "**Costs for IGN Centres**" shows costs that will be upheld by each Centre for its endowed chair, researchers, and equipment. They were calculated based on a 200,000 USD cost for a chair, 100,000 USD for each of two researchers, per year, plus equipment.

The bottom section "**Shared costs, management, and output**" highlights costs that will be upheld by the IGN hub (INCA) for the common activities. They were calculated based on the expected activities, and on average costs for travel (1500 USD), living expenses, and number of persons.

Exchanges refers to scientific research visits (15 each year). **Travel** is intended for Advisory Board meetings (once a year for 3 days). **Conferences** will be two per year with 150 participants. **Schools** are training schools for young researchers (two each year with 150 participants). **Outreach** refers to training from industrialised to developing nations (3 task forces each year).

Management indicates costs for running the structure, while output includes all dissemination activities (publications, multimedia, web, DVDs, *etc.*)

Exchanges of researchers	
Travel	1500
Living	100000
No. Of people	15
	1522500

Travel for AB mem	
No of AB members	10
Travel	1500
Living	400
Days	3
	27000

Conferences	
No of Conferences	2
No of Participants	150
Cost per participant	2500
	75000

Schools	
No of Schools	2
No of Students	150
Cost per student	2500
	750000

Outreach	
No of teachers	5
Travel	1500
No of days	14
Living	400
No of trips	3
	106500

APPENDIX B: Infrastructure

The IGN will initially avail itself of existing infrastructure, *i.e.* laboratories of the IGN Centres. An added value will be the creation in the IGN Centres of a “International Green Network Room”, such as a lecture room, a meeting room, or a laboratory.

In particular, the hub of the IGN will be in the INCA Laboratory of Marghera (Venice, Italy). The Director of the IGN will be Prof. Pietro Tundo, Chair of Organic Chemistry at the University of Venice and President of INCA. Dr. Alvise Perosa, assistant professor of Organic Chemistry at the University of Venice, will act as *aide* to the management board. INCA will provide a meeting room and two offices for a scientific assistant and an administrative manager.

Prof. Kenneth Seddon, Chair of Inorganic Chemistry at the Queen’s University of Belfast and Director of QUILL, will act as Vice-Director of the IGN. QUB will also make two rooms available for a scientific assistant and a web designer.