

## Wicked Problem Assignment

Artificial, oversimplified, well defined problems and case studies often neglect “*the social complexities of engineering practice*”  
Louis L. Bucciarelli, 2008

### Wicked Problems

Horst Rittel and Melvin Webber coined the term ‘wicked problems’ in a 1973 paper where they described the phenomenon as follows:

*“The problems that scientists and engineers have usually focused upon are mostly “tame” or “benign” ones. As an example, consider a problem of mathematics, such as solving an equation; or the task of an organic chemist in analyzing the structure of some unknown compound; or that of the chessplayer attempting to accomplish checkmate in five moves. For each the mission is clear. It is clear, in turn, whether or not the problems have been solved.*

*Wicked problems, in contrast, have neither of these clarifying traits; and they include nearly all public policy issues-whether the question concerns the location of a freeway, the adjustment of a tax rate, the modification of school curricula, or the confrontation of crime.’*

They thus summarize that ‘*it makes no sense to talk about “optimal solutions”*’ and indeed ‘*there are no “solutions” in the sense of definitive and objective answers.*’

Wicked problems are therefore more than just purely technical problems; they involve some societal aspect or interaction with people. Values and ethics are inherent in describing and in tackling wicked problems. They thus have a social aspect and though it may be tempting, it is a mistake to either i) ignore this societal aspect and/or ii) try to reduce the problem to a simpler one from which a unique or optimal ‘solution’ can be proposed. Technical solutions alone are therefore usually not sufficient in tackling wicked problems; non-technical and policy/value based approaches are required also. Resolutions of wicked problems *never* come from simple answers or simple thinking.

Tackling wicked problems thus requires collaboration, usually between stakeholders with different backgrounds, disciplines and experience. Such collaboration is required to develop a shared understanding around given problems as well as a shared commitment to the possible solutions. This does not necessarily mean agreement on the problem; rather it requires that stakeholders understand each other’s positions or ‘object worldviews’ well enough to have intelligent dialogue about the different interpretations of the problem, and to create collective intelligence which can be directed towards resolving the problem.

### Assignment Task

1. You are assigned a wicked problem about which you are asked to consider along with your group from the list outlined below.
2. You should meet with your assignment group during this and future sessions to consider the problem, research it and ultimately propose some options for resolution/s.\*
3. You and your group will write a short paper which outlines the problem, highlights the research you have carried out and your proposed options (3-5 pages; 1500-3000 words). Cite all relevant references.
4. Finally, you will present your ideas to your peers and lecturers on the module during a presentation session. Each presentation should last no more than 7 minutes and should involve input from all group members.

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\*In considering the problem, the following approach should be taken.

a) Identify your fellow group members.

b) Identify relevant stakeholders (various professionals and experts, users, community groups, etc.); at least one per group member but potentially a lot more. Assign each member of the group to one or more stakeholders.

b) For each member, research the problem extensively and the issues around it from the perspective of the respective stakeholder/s. Relevant knowledge of the problem may include technical and experiential (knowledge based on experience).

c) Draw up positions for each of the stakeholders in terms of i) problem definition (including scope and system boundaries of the problem) and ii) possible solutions based on this analysis. Try to define the values inherent in the position underlying each stakeholder and the ethical issues which arise. Write up a short (1-2 page) report addressing the above issues (including relevant cited references) representing each stakeholder for discussion with fellow group members and submission.

d) Meet as a group (during the designated sessions and outside them) to:

- present each other's proposals from c).

- discuss the various object world views and values inherent in each stakeholder to try to develop an understanding of all stakeholders positions among all group participants.

- develop a collective approach towards resolving the problem which incorporates all stakeholder positions and values as best as possible (if possible). The proposed outcomes may take the form of a number of possible options which are agreed upon among group members and/or may offer conflicting options emanating from opposing value sets.

e) Submissions and Presentation

- Collate the individual reports and references.

- Draw up a brief (3-5 page; 1500-3000 word) group report outlining the issues and possible options as agreed by the group based on the basis of the outcomes of d)

Print off 3 copies of each report and submit in class on the day of your presentation.

- Draw up and make a 7 minute group presentation with your team colleagues for presentation to your classmates and lecturers.

### Wicked Problem List

Consider and develop proposals on relevant problem. Basis is global unless otherwise stated

#### A. Energy (Ireland)

Some of the issues: Energy demand is rising and set to continue to rise. Increase supply? Reduce demand? Energy prices are rising. Burning fossil fuels result in greenhouse gas (ghg) emissions. Ireland has international obligations to meet with respect to ghg emissions. Renewables are not without problems. Nuclear is controversial.

#### B. Water (Dublin)

Some of the issues: Water demand is rising and set to continue to rise. Increase supply? Reduce demand? Domestic water tariffs imminent following on from EU directive. Investment to reduce leaks. Proposal to draw water from Shannon via midlands bogland reserve. Local opposition.

#### C. Nanotechnology and nano particles

Growing technology with myriad applications. Great technological and economic opportunities abound. However very little parallel study into potential negative health effects, despite known effects of similar nano particles such as asbestos particles which lead to lung disease.

#### D. Traffic

Traffic disruption has significant social and economic negative consequences. Higher car ownership and use leading to exacerbation of problem. More and bigger roads required? Drawbacks and opposition to this? Other options? Planning and political consequences?

#### E. Sea level/flood protection

Globally sea level rise is evident and faster than previous models have predicted as a consequence of global warming. Large percentage of global population at risk. Netherlands have had this problem for centuries – how have their solutions worked? Irish coastal cities including Cork at risk. Proposed Clontarf 2-3m high sea flood barriers. Residents objections due to visual impact. Impacts up/down stream of such barriers? Which areas to prioritize and how to do so? Resource allocation issues?

#### F. Electronics waste

Vast amounts of electronic waste being generated globally. Increasing with consumerist society. Much of it transferred from wealthy North to be dumped in world's poorest areas. Hazardous waste threat.

#### G. Plastics

Plastics are ubiquitous with myriad of uses and applications necessary for modern life. Mainly oil based production. However, many not recyclable/recycled and not very degradable. Plastic waste a huge problem, particularly in oceans where it gathers and kills bird and sea life and gets into food chain. Concerns over toxicity of many plastics, particularly when recycled. Biodegradable plastics from non oil sources a very minor segment of market.

#### H. Hazardous Waste

Problems over how to dispose of hazardous waste. Should polluter pay? Should waste be disposed of locally/nationally? Poorer places/places with lower environmental regulations end up with more hazardous waste production and disposal? Local opposition to incineration. Safety fears? Is hazardous waste always necessary? Can it be reduced? How? Costs?

#### I. Food Processing

'Race to bottom' towards cheap, convenient processed food with extended shelf life based on ever more efficient use of raw materials or processes has led to manufacturers consider cheap, modified, reliable, easily substituted and often unhealthy sources of food constituents such as fats,

carbohydrates, proteins and preservatives in developing processed foodstuffs. This has often led to very long global supply chains and with social, economic and ecological implications for local producers and habitats. e.g. cleared natural forests for soya bean and palm oil plantations to produce cheap food ingredient sources. What are the issues here and how might they be addressed?

### **J. Food Production; Ireland**

Ireland has ideal land and climate for food production, particularly dairy and beef. With global rise in food prices accompanying expanding global population and EU milk quotas soon to be deregulated/abolished, the Republic's government have launched an initiative called 'Food Harvest 2020', which aims to increase dairy and beef production by up to 50% between 2010 to 2020, mainly for export markets. On the other hand food imports have risen to several billion euro per annum in many cases displacing foods previously produced locally. Food Harvest 2020 targets will be achieved by more intensive farming, larger farms, fewer farmers, increased technological and scientific inputs, increased fertilizer and energy requirements and increased greenhouse gas emissions, including substantial amount of methane produced by cows. International multinational food producers have identified Ireland as place of increasing opportunity. Already the Republic produces a huge proportion of the world's infant formula. However, this growth conflicts with the greenhouse gas emissions targets Ireland has signed up to for 2020 under Kyoto. More intensive agriculture also puts increasing pressure on ecological resources including water quality. But Ireland is a very small island incapable of feeding the world. Moreover Ireland is seen internationally as clean 'green island' with ecologically high standards and quality food. Does the Food Harvest 2020 approach threaten this image and mean that we are joining a race to the bottom by producing cheaper mass production of commodity food products through greater efficiencies and economies of scale? Would it be better to instigate a national strategy promoting a non-intensive ecologically sound artisan local producers (farmers and small businesses) of high quality labour intensive premium food products which command high prices? Internationally Irish food could thus be marketed and branded as Swiss watches or Belgian chocolate to fully realise the green island image. This would promote smaller farms and businesses, more jobs in each and less intensive more ecologically sound farming methods producing less but higher quality food focused particularly on local markets. Is this a viable option as a primary food production model? Change of track required? Serious difficulties, drawbacks? What sort of strategy or strategies might be considered appropriate?

### **K. Food Production; Global**

Global food players are targeting developing markets, in many cases displacing local produce and suppliers. This is driven by an increasingly globalized market economy which promotes ever larger multinational companies at the expense of local farmers, producers and processors while also concentrating wealth and inequality. Moreover, wealthy northern nations exploit food resources from poorer states. For example, Europe uses up all its own fish stocks by summer of each year and buys fishing rights from Pacific island governments sending massive super trawlers to the area to fish for European consumers, thus displacing local subsistence fishing boats.

### **L. Atmospheric Carbon; Global**

Tyndall found that gases such as carbon dioxide are greenhouse gases (ghg) act to trap heat in the atmosphere. Higher levels of ghg thus contribute to global warming effect. Atmospheric ghg levels have consistently been rising since the industrial revolution causing global warming and accelerated anthropogenic climate change. Despite global concerns, levels are still rising in line with rising fossil fuel exploration and use. Atmospheric ghg levels depend on i) amount being put in and ii) amount being taken out. Consider options for each and how these might be best achieved in reality. Reduce ghg emissions? 'Carbon moratorium? (e.g. convert fossil fuels such as methane to hydrogen gas and solid carbon, burn former and re-bury latter\*). Sequestration? By technical means? By natural means? (e.g. grow more trees and bury wood\*). Reduce demand for stuff/energy/ghg burning? Other options? How best achieved, particularly in light of growing global population and even faster growing consumption demand (of materials/energy)?

*\*For example, see respective papers by Gerhard Kreysa, DECHEMA chief executive and chemical engineering professor*

### **M. Local flooding events (Ireland)**

Increased average precipitation (up 10% in Ireland since the 1970's according to the EPA) and localised intense and extreme rainfall events are an ever more common feature of ongoing global warming. The effects of this are exacerbated by development of land, particularly in flood prone areas along with corresponding draining systems and factors such as increased amount of poor permeability/paved surfaces in urban areas often at the expense of grassy areas and domestic front gardens to create car ports. The latter issues were highlighted by a Danish based PhD student of architecture in a letter to the Irish Times on October 27 2011 in the aftermath of Dublin flooding who suggested *'It is imperative that policy-makers avoid large scale engineering solutions as it is engineering-thinking that has led us into this problem in the first place.'*<sup>1</sup>

### **N. Atmospheric Carbon; meeting Ireland's legal and ethical obligations**

Ireland has signed up to international agreements to substantial reductions atmospheric ghg emissions over the coming decades. However, the substantial decreases required mean that achieving these targets will not be possible with a business as usual approach through gradual and incremental cuts and efficiency improvements. Initiatives such as Food Harvest 2020 will actually result in increased ghg emissions. A radical change in how we do things may be required as well as a systemic approach to the issue. This may require an examination of what we value which can then underpin technological as well as non technological initiatives.

### **O. Safety; Car design**

Safety is a huge issue in car design. Generally the focus is on car drivers and passengers rather than on other road users and pedestrians. Noting that risk is inherently subjective in that behaviour is a function of perceived risk, how might cars be made safer so as to reduce road deaths? What are the issues to consider?

### **P. Safety; Chemical plant**

Chemical plants are among the safest work places in terms of fatal accidents despite the hazardous nature of many of the materials and processes (toxic materials, high pressure, temperature conditions, etc.). This is due to strong safety culture that emanates from high perceived risk. Nevertheless accidents can and do happen. How might processes and working procedures be made more safe?

### **Q. Safety; Nuclear power**

Nuclear power can help meet energy demand without large ghg outputs. Can be built and operate very safely during 'normal' operation. However, tightly coupled unforeseen events which are not designed for ('unknown unknowns') can and do happen sometimes leading to accidents and wide ranging consequences (e.g Fukushima, Japan 2011). Hence public and governments (Germany, Japan, Belgium) have become wary of this technology and are phasing it out. Also, waste processing and disposal issues. Examine issues around safety and risk.

### **R. Safety; Road**

How can road safety be improved? Consider caution and risk taken by users is a function of perceived risk. Better engineering design? More or less signage/traffic lights, etc? What role, if any can knowledge gained from both psychology and engineering combined play?

### **S. Fossil Fuel Natural Resource Exploitation**

Despite concerns over atmospheric ghg levels, commitments for reduction and increasing exploration and exploitation costs of fossil fuels in ever harsher areas is continuing unabated, promoted both by governments and companies that stand to gain financially e.g. Canadian tar sands, areas becoming accessible through melting ice in Greenland, Alaska, North Pole, deep sea exploration and exploitation, west coast of Ireland. Driven by rising fuel costs and national energy

security concerns. However, pose substantial ecological (e.g. 2010 BP Gulf of Mexico incident) and environmental risks (total ghg emissions).

### **T. House building standards –thermal (Ireland)**

Housing stock in Ireland is hugely energy inefficient. Among the construction industry generally there is little understanding or application of building methods which result in well insulated and ventilated housing up to passive grade standards. Thermal bridging, dampness and condensation are common problems with housing stock, most of which was built over the past couple of decades. EU and national standards are rising but often there is little overlap or understanding between engineers, surveyors, architects, developers, builders, inspectors and others involved in the building process. Even grants schemes aimed at improving insulation can exacerbate issues, particularly when carried out on sub standard houses by those with little understanding of building physics. How can Ireland develop a stock of housing with top class thermal and ventilation standards, up to and at passive levels, at least for new builds?

### **U. Computers and Artificial Intelligence**

Artificial Intelligence (AI) is a rapidly developing area of computer and complexity science, as computers can be programmed to learn based on their environment and context. However, as robots become more advanced, both the applications and the algorithms used must incorporate more and more subjective, value based and ethical options. For example the use of robots for military and war purposes and the use of computer to control functions of the brain. Investigate the state of the art, current and future directions in this area. Identify the key issues and what role/s can and should engineers play?

### **V. Abandoned industrial waste sites**

Resource exploitation such as mining and fossil fuel extraction make large profits for corporations and shareholders but in doing so can result in gross environmental damage during the exploitation phase, particularly in vulnerable parts of the globe and where there is poor environmental law and enforcement. The same often applies for many heavy industries with a substantial environmental footprint. There are often also significant environmental legacy issues with waste stockpiles, wholly inadequate waste provisions and potential for leaching of toxic waste. Local communities and future generations (who often don't share in the economic benefits nor have any say in the intrusion) and ecologies are left to deal with the mess created. Local example includes Irish Ispat steel site in Cork harbour near Cobh. Responsibilities of engineering?

### **W. Resource exploitation under extreme conditions; Safety and environmental issues**

Resource exploitation under extreme conditions is becoming increasingly common particularly as fossil fuels sources become scarcer and energy prices increase e.g. deep sea oil drilling, tar sands in Canada, oil exploration in Alaska, Greenland and the North Pole. However, while this subverts global requirements to reduce atmospheric greenhouse gases, it also poses heightened ecological and safety risks (e.g. destruction of natural habitats and threatening of species in northern areas, Gulf of Mexico oil spillage leading to loss of human as well as destruction of animal life and habitat)

### **X. Water quality and treatment (Ireland)**

Ground water in Ireland generally poor, particularly considering it is a relatively sparsely populated island. Development, agricultural and industrial issues are implicated. Treatment of municipal sewage and water systems often do not produce water of appropriate quality. Chemicals that are added to reduce coliforms however raise toxicity concerns.

### **Y. Electricity power transmission (Ireland)**

Considerable work is ongoing in upgrading the electricity power transmission grid within and across Ireland as well as linking with Great Britain. This is aimed at aiding energy security as well as

facilitating grid connectivity for a growing and variable renewables sector. Eirgrid are the organisation responsible for the grid across the whole of Ireland. However, some of the high voltage power connectors have attracted controversy, such as for example the planned 400KV connector between Meath and Tyrone. Landowners in particular argue that such high voltage lines should be not be placed overhead for safety, aesthetic, environmental and health reasons. An elderly Offaly landowner was jailed in 2011 for refusing access to the ESB to her land for the felling of part of her native wood to install 110 kV overhead power lines. An expert review was commissioned in 2011 to review the case for, and cost of, undergrounding (all or part of) the Tyrone-Meath power lines. Identify the issues associated with power transmission particularly in relation to the changing power source mix. Identify options.

### **Z. Traffic control**

Traffic lights and road signage are recognised as important features of road safety. However, extremely busy junctions shared by vehicular, cycle and pedestrian traffic in Far Eastern cities sometimes have no traffic lights and have little or no accidents; on the contrary traffic flows very smoothly. Experimental approaches in the UK, Scandinavia and the Netherlands where traffic lights have been removed from busy junctions and where roads have been redesigned without a plethora of signs and markings have often coincided with a marked improvement in traffic flow and safety as people act more as ‘people’ and less as ‘controlled machines’, so that new hierarchies are spontaneously and naturally formed, placing most vulnerable users at the top. Similarly unplanned traffic light failures at busy junctions often result in smooth flow. Investigate the issue and potential traffic control design implications.

### **References:**

Rittel, H, and Webber, M. (1973) Dilemmas in a general theory of planning, *Policy Sciences*, 4, 155-169.

[http://www.uctc.net/mwebber/Rittel+Webber+Dilemmas+General Theory of Planning.pdf](http://www.uctc.net/mwebber/Rittel+Webber+Dilemmas+General+Theory+of+Planning.pdf)

**Presentations:** 30<sup>th</sup> November (A to M) and 7<sup>th</sup> December 2011 (N to Z)

**Value:** 40 marks (out of 100 for the module)

