Walking the walk; meaningfully engaging people with engineering challenges

Connor McGookin[12], Brian Ó Gallachóir[12] and Edmond Byrne[12]

[1]School of Engineering, University College Cork, Ireland
[2]MaREI Centre, Environmental Research Institute, University College Cork, Ireland

connor.mcgookin@ucc.ie

Abstract

Barriers to the development of renewable energy generally involve non-technical as well as technical challenges, that are dynamic and context dependent. In the case of opposition to large-scale wind energy and overhead transmission lines for example, existing research reveals a complex and diverse range of conditions that shape public perception. However, conventional engineering practices tend to focus on least cost techno-economic evaluation methods such as cost benefit analysis. Here we use the case study example of Ireland's North-South interconnector project to demonstrate how a narrow focus on techno-economic analysis resulted in failure to adequately incorporate broader socio-political considerations. It demonstrates that the primarily technocentric worldview, which largely pervades engineering teaching and practices, can cause tensions and inertia, slowing the rate of progress along the low carbon transition. This, we argue, points to the need for a cultural / ethos change in engineering education and practice. Engineers should be encouraged and educated to broaden their perspectives and take a more reflective / pragmatic approach to engineering challenges that embraces the diversity of worldviews within our society. We hypothesise that the clear (and necessary) emphasis within engineering curricula on solving purely technical / mathematical problems may foster a reductionist hubris in engineering practice. To address this, contemporary fit-for-purpose curricula necessitate the inclusion of coursework that considers broader societal complexities, including so-called 'wicked problems' such as infrastructure projects, which involve placing engineering solutions in broader societal contexts.

1 Introduction

The European Union ambition of achieving carbon neutrality by 2050 will require radical changes in how we use and generate energy. An integral part of meeting this goal is the complete decarbonisation of electricity networks, which has prompted two fundamental transformations. Firstly, an increase in the levels of decentralised electricity generation due to small-scale systems like solar PV and secondly, a significant increase in the number of variable renewable sources being connected to the electricity grid. Both of these developments will require upgrades to the transmission network in order to ensure a stable and reliable supply of electricity into the future. In particular, dependency on variable sources of power necessitates an increase in the level of interconnection between countries, so electricity can be easily transported during periods when generators like wind turbines are unavailable. However, new installations of overhead transmission lines have sparked a significant amount of local opposition.

Literature on the topic of public perceptions to overhead high-voltage transmission lines has explored a number of differing reasons for local opposition, highlighting that public responses to infrastructure are complex and context dependant. Firstly, a significant number of studies focus on local beliefs and value sets, concluding that visual impacts on rural landscapes are a key driver of opposition to high voltage lines, so-called NIMBYism (Devine-Wright and Batel, 2013, Lienert et al., 2017, Tempesta et al., 2014), while others suggest that health-related concerns are the primary cause of resistance

(Stadelmann-Steffen, 2019, Bertsch et al., 2017, Wadley et al., 2019). Secondly, research on the institutions involved and the local planning process has highlighted additional considerations regarding procedural justice and the level of public trust in transmission system operators (Aas et al., 2017, Knudsen et al., 2015). Knudsen et al. investigating local perceptions of procedural justice in four electricity transmission grid projects from Norway and the UK, found that across all cases the level of local involvement in planning decisions was insufficient and unjust. (Knudsen et al., 2015) A key finding from both countries was the perception that the outcome had already been decided prior to the public being engaged.

The above literature highlights that the placement of overhead transmission lines is a very delicate matter requiring a careful engagement process to understand the social and political considerations of a project. These subjective design requirements make the design of large-scale infrastructure projects a highly complex wicked problem, which cannot be simply understood through the completion of a least-cost design process. This is precisely where conventional engineering approaches fall short. The reductionist hubris that dominates engineering practice means that the socio-political considerations are an afterthought. The engagement of the relevant public is primarily to encourage agreement with a particular solution, as opposed to a prerequisite that can provide insight into the context within which the system will eventually be placed.

In Ireland, and across Europe, infrastructure developments such as overhead pylons and wind farms have generated a significant amount of local opposition. According to a pan-European survey of local opposition to new transmission lines, 45% of Irish respondents chose "*definitely not accept without opposition*" compared to an EU-wide average of 33%. One interesting case to explore is the North-South Interconnector project, connecting the grids in Northern Ireland and the Republic of Ireland. Originally proposed in 2005, it is still stuck in a stalemate over a decade later. EirGrid Group, the state-owned company responsible for the management and operation of the transmission grid across the island of Ireland, see the project as vital to the development of the grid in order to ensure power system adequacy and manage the increased levels of variable renewable generation necessary to meet Ireland's decarbonisation targets. However, progress to date has been slowed by repeated planning applications sparking a significant amount of local opposition. This has been primarily organized through the North East Pylon Pressure group, which has campaigned for an undergrounding of the cables due to health and well-being concerns.

This paper will use the example of the North-South interconnector project to highlight how traditional engineering practices may hamper progress with key infrastructure projects. Section 2, provides an overview of the case study, focusing on the initial years of the project and developments that sparked tensions between the two sides. The ways in which engineering practices contributed to the tensions are then explored in Section 3. Section 4, reflects on the learnings that may be taken from this experience, in particular arguing that complex problems such as infrastructure projects necessitate a more holistic approach.

2 Case study; The North-South interconnector project

For the purpose of this paper, two key periods in the early development of the North-South interconnector project are discussed in detail; the initial public engagement (October 2007 – February 2008) and the first formal planning application (April – December 2009).

2.1 Initial public engagement, October 2007 – October 2008

In September 2007, EirGrid published a booklet on three potential corridors for the new overhead high-voltage line (OHL) connecting the grids between Northern Ireland and the Republic. A month later, in October 2007, a four-month public consultation formally began (EirGrid plc, 2007a). In line with this, three Information Open Days are held in effected areas, a telephone/email service is launched and a leaflet is distributed through local newspapers (EirGrid plc, 2007b). The North East Pylon Pressure (NEPP) formed in November 2007, amidst growing public concerns about health and environmental impacts, the group sought to mobilize a campaign for underground cables (UGC) (North East Pylon Pressure, 2008). Eirgrid then published a press release on the benefits of major electricity investment and returned for three more open days with discussion specifically focused on the issue of EMF and overhead / underground power transmission (EirGrid plc, 2007c).

Following closure of the public consultation process in February 2008, the Department of Communications, Energy and Natural Resources commissioned an independent study on the alternatives to overhead transmission lines, and held a one-month consultation on the topic. In total 522 stakeholder submissions were received, from inhabitants of affected areas and external consultants for groups opposing the project (Ecofys Germany GmbH, 2008). In May 2008, a comprehensive report on the merits of OHL versus UGC was published (Ecofys Germany GmbH, 2008). This study highlighted how international best practice, along with comparisons of techno-economic considerations and environmental impacts make OHLs the favourable solution. NEPP responded by commissioning a German consultancy, ASKON Consulting Group, to investigate the comparative merits of underground cables versus overhead lines for the proposed North-South interconnector (ASKON Consulting Group, 2008). In October 2008, ASKON published their analysis in a report, recommending two parallel underground AC cables on the basis that it would be cheaper and more reliable in the long-term.

The lines in the sand were by now drawn, with each side brandishing their own expert report highlighting the merits of their favoured solution. This marks the beginning of a stalemate that failed to reach a compromise; the contradictions between these two reports remain the point of tension during exchanges in the years to follow.

2.2 First formal planning application, May – December 2009

In February 2009, Northern Ireland Electricity and EirGrid published a report providing a detailed comparison of High Voltage AC UGC, High Voltage DC UGC and the OHL currently proposed (Parsons Brinckerhoff, 2009). RPS Planning & Environment on behalf of EirGrid, published in March 2009, a multi-criteria evaluation of the three OHL corridors originally proposed (RPS Planning & Environment, 2009). This evaluation identified the route that purported to meet the best balance between the various technical, environmental and community evaluation criteria. EirGrid announced a month later in a community brochure that they had chosen the preferred route corridor identified by RPS Planning & Environment (EirGrid plc, 2009a). In addition, a detailed technical document was published highlighting the various third party reports considered and responses to a number of NEPP submissions (Eirgrid plc, 2009b). The project was then moved to the next stage of planning, which involves meeting with affected landowners and discussing their concerns and mitigation options.

The NEPP group responded in May 2009, publishing, "*A Powerful Challenge; Achieving a green grid for a green island*" (North East Pylon Pressure, 2009). The report launched an attack on EirGrid accusing them of being biased towards an OHL solution and questioning the objectivity of the experts that produced reports on their behalf. It also called for an All-Party Electricity Infrastructure Committee to be established as well as a re-evaluation of EMF compliance levels with reference to a government report on EMF health effects. (Department of Communications, 2007)

Following a number of landowner consultations, a set of recurring questions about health and property values were published within a frequently asked question (FAQ) document in July 2009 (EirGrid plc, 2009d). Later that year, in December 2009, despite the significant amount of local concerns expressed regarding well-being and environmental impacts, EirGrid submitted a formal planning application to the state board, An Bórd Pleanála. (EirGrid plc, 2009c) In addition, an updated FAQ document was released in January 2010, addressing some additional queries that had been received since the previous edition (EirGrid plc, 2010b).

2.3 As it stands

Following the withdrawal of the original planning application in June 2010, (EirGrid plc, 2010a), there were no significant developments until July 2011 when the Minister for Communications, Energy and Natural Resources appointed an International Expert Commission to investigate the possibility of UGC (Normark et al., 2012). This marked the beginning of a re-evaluation period that lasted up to June 2015 when a revised (OHL based) submission was made, which was subsequently granted planning permission in December 2016. However, the NEPP have continued the fight, appealing the decision in the High Court and most recently the Supreme Court (Hussey, 2019).

Throughout the period of 2011 – 2018, both EirGrid and the Irish government again commissioned a number of different expert reports. An independent commission was formed twice, investigating the possibility of UGC (Normark et al., 2012, Normark et al., 2018). EirGrid updated previous analysis comparing the cost of OHL versus UGC (Parsons Brinckerhoff, 2013) and both separately commissioned consultants to explore the impacts of OHL developments on property values (Insight Statistical Consulting & Corr Consult, 2016, KHSK Economic Consultants, 2018). However, none of these actions served to relieve the tensions.

3 Analysis; Key causes of conflict

The two key causes of tension that will be discussed in this section may both be seen to emerge from the technocentric worldview that dominates engineering education, in particular we highlight how conventional engineering practices meant the public were not meaningfully engaged with the project.

3.1 Prioritising techno-economic assessment

As noted earlier, a perception locally that key design considerations have already been decided by the transmission system operator before the public engagement process takes place leads to a lack of trust and feelings of exclusion (Knudsen et al., 2015). This issue emanates from the way in which engineers tend to approach design problems. A full technical feasibility study and cost assessment will likely be carried out prior to the project being made public and a consultation being opened. This means that socio-political considerations are not given equal weighting to the techno-economic considerations. The engagement of the public is somewhat tokenistic, as its purpose is not to understand local knowledge and beliefs but rather to encourage compliance with a particular project or development.

This is quite apparent in the case study example. EirGrid identified three potential OHL corridors before beginning its public consultation. The exclusion of UCG from the original proposal and early statement by EirGrid that its policy is to develop OHLs is one of the key points that sparks the formation of the opposition group. (North East Pylon Pressure, 2008) In the words of NEPP;

- "*they have approached the projects solely on a one-dimensional engineering basis*" (North East Pylon Pressure, 2009)
- "*There is a significant weakness in the approach by EirGrid of focusing solely on technical and engineering aspects of grid performance and development*". (North East Pylon Pressure, 2014)

The use of cost-benefit analysis (CBA) to argue for the OHL solution then only stands to deepen the divide between the two groups. As seen in other studies on pan-European transmission plans, CBA is often represented as robust objective evidence, but in reality is underpinned by a series of value judgements and thus is not the 'neutral' means of representing a problem that it may often be characterised as (Schmidt and Lilliestam, 2015). This affirms the local community's suspicions that the transmission system operator is biased towards a particular solution rather than easing tensions.

3.2 Engineering arrogance

A direct consequence of the approach discussed in Section 3.1, is that engineers tend to view the world as an objective truth that is based on indisputable facts. However, reality is not an objective truth or fact but rather *"includes the ways in which the people involved with the facts perceive them"*. (Freire, 1982) When dealing with projects such as large-scale infrastructure projects that must be situated in broader socio-political contexts, efforts to address the concerns raised by the public, only stand to add to growing tensions whenever expert knowledge is used to provide a counter argument against local opinion. This infuriates the community, who feel an institution that is supposed to work for the good of the public has ignored their concerns. The engineer that has been trained and educated to believe everything can be solved through rational explanation finds her/himself at odds with a public who are gripped by fear of the unknown. Fears, concerns and beliefs are inherently normative characteristics, which cannot be simply overcome with quantitative evidence. Conversely, the significant amount of quantitative evidence gathered to provide a rational case for the OHL solution is irrelevant to NEPP, as their trust has already been lost.

The perception locally that EirGrid were approaching this from a narrow technocratic perspective and were determined to enforce their desired solution was continually reinforced by the failure to address local concerns. Supported by a number of expert reports, EirGrid firmly upheld OHL as the '*best'* solution, and were (likely unintentionally) quite dismissive of NEPP concerns. As discussed in Section 2.2, the FAQ documents produced explicitly highlighted that potential health and environmental impacts are in line with 'best practice' and reference a number of reasons the public are misinformed. This attitude is perceived locally as indifference towards genuine local concerns and ensured that NEPP believe EirGrid have never given any meaningful consideration to the UGC alternative.

4 Discussion; Lessons for engineering education

"Traditional reductionist models of engineering education seek to extinguish context and uncertainty and reduce complexity across socio-economic and ecological domains. They therefore constitute a wholly inadequate response to the need for fit-for-purpose, twenty-first century graduates required to address broader sustainability issues." (Byrne and Mullally, 2014)

The case study example highlighted in this paper has demonstrated how traditional engineering practices are inadequate in the face of contemporary challenges around critical energy infrastructure projects. To address this, modern curricula must include coursework that considers broader societal complexities, including so-called 'wicked problems'. (Rittel and Webber, 1973) The wickedness of societal challenges such as energy and infrastructure projects means that they do not have a definitive solution, contrary to the majority of engineering coursework that focuses on solving purely technical design challenges that can be reduced to a definitive mathematical understanding.

One means of achieving this integration into engineering education is through problem-based learning, including within coursework specific assignments that will expose students to broader social, environmental, ethical and political contexts. As was found to be the case by Byrne et al., most progress to date with EESD has been through *'strategically embedding case studies or flagship courses'*. (Byrne et al., 2010) Indeed, problem-based learning has been shown to be a valued means of developing professional skills (Beagon et al., 2019) and there are a number of recent examples highlighting its use in teaching 'socially responsible design'. (Bissett-Johnson and Radcliffe, 2019, Cote and Branzan Albu, 2019, Martin et al., 2019) However, renewals to curriculum of this manner can be a slow process over a number of decades. (Desha and Hargroves, 2012) Thus, they are inadequate in the face of pressing sustainability challenges such as climate change.

Addressing sustainability in this way means that it is just an interesting aspect of a student's education rather an ethos that is central to their engineering practice. (Mulder et al., 2013) More transformative examples of embedding sustainability may lie in degree programme, school or college-wide initiatives (Sheehan et al., 2012). The crosscutting nature of sustainability challenges make them a unifying issue that can effectively drive more meaningful educational innovation (Fourati-Jamoussi et al., 2018). Furthermore, an ethos change of this manner will require introducing multi/inter/trans-disciplinary learning, which will importantly expose students to the variety of disciplinary approaches and help broaden understanding of the diversity of worldviews that make up our society. At present multi/inter/trans-disciplinary practice is generally only introduced at a postgraduate level during research (Klaassen, 2018). This means it reaches a very limited amount of graduates, with those entering the workforce maintaining conventional disciplinary prejudice and bias. Earlier intervention during engineering education is essential if we are to build the necessary societal capacity for addressing sustainability challenges. (Byrne and Mullally, 2016) Multi/inter/trans-disciplinary practice facilitates a critical reflection on disciplinary approaches that can foster a greater level of respect for alternative perspectives.

5 Conclusion

Addressing contemporary sustainability challenges such as the growing threat of climate change, will require that engineers look beyond purely technical analysis, and instead seek to appreciate how different solutions may have a broader considerations when placed within our society. This is particularly apparent with regards to large-scale energy infrastructure projects that have generated widespread local opposition. As demonstrated in this case study example, the reductionist hubris that dominates engineer practice risks adding to public discontent, as local communities often poorly perceive it as arrogant and dismissive. Modern (fit-for-purpose) engineering curricula must include introductions to more holistic approaches as well as introducing multi/inter/trans-disciplinary practices. Engineers are necessarily technical experts and should remain so, but it is important to recognise our own inherent biases and respect the alternative perceptions our solutions will encounter when placed into an active society. Furthermore, in responding to contemporary sustainability challenges it is essential that engineers more critically reflect on their role within society, giving greater thought to how engineering design and practice may support or hinder progress towards ambitions such as a low carbon energy system.

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