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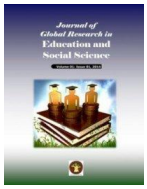

AN ENERGY LITERACY MATRIX: A TOOL FOR ADULT AND CONTINUING EDUCATION CURRICULUM DESIGN

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ABSTRACT

In this article the authors report on the outcome of a mixed methods study which assessed the renewable energy literacies of adults' in rural communities across Britain. The research team used a stratified sample survey (n=6000), interviews with householders (n=97), stakeholder interviews (n=7) and one focus group meeting to collect primary data. Data from the study highlighted a series findings: a) there is a clear disjuncture between individuals' awareness and understanding of energy related matters and government and industry rhetoric; b) there is a public appetite for more reliable (trustworthy) information on renewable energy; c) the public is not well informed about renewable energy debates and government schemes to save energy [1]. Responding to the findings an energy literacy matrix which can be used to plot knowledge of, against, knowledge about renewable energy sources has been developed. The literacy matrix provides a development education tool to focus adult educators' efforts on raising awareness and understanding of how local, national and global issues affect the everyday lives of individuals and communities.

Keywords: Energy literacy; adult education; energy literacy matrix; development education.

1. INTRODUCTION

There can be little if any doubt that climate change here on earth is a reality [2]; faced with an ever growing body of scientific evidence, even the fiercest sceptics of climate change are having to reconsider their position. The implications of climate change can now be seen in many sectors of life at local, national and international levels. Manifestations of climate change requires a fundamental rethink in many areas of society and calls for innovative technical and scientific solutions as well as new policy directions [3,4]; and perhaps most of all, engagement from everyone at a community and household level [5]. To achieve this the public need to be aware of the issues, the challenges and the language that is used in the sector; in short we all need to be energy literate [6]. This article is set in the context of these emerging challenges and is based on research work carried out across parts of rural England and Scotland as a part of the multidiscipline Rural Hybrid Energy Enterprise Systems (RHEES) project funded by the Engineering and Physical Sciences Research Council (EPSRC) (Grant No. EP/J000361/1). The research objectives associated with the 'community engagement' element of the RHEES project were to assess: the current values attached to bio-resources and rural hybrid energy; current and future energy needs and priorities; perceptions of the acceptability and viability of community rural hybrid energy sources, systems and

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schemes; public engagement with, and knowledge and experience of, rural hybrid energy; and, energy literacy levels amongst householders [1].

1.1 The Importance of being Energy Literate

Contemporary society contains many literacies; gone are the days when being literate meant simply being able to read and write to ensure empowerment, enlightenment and the ability to function in society. It is commonly recognised that there now exists a plethora of literacies far beyond the new literacies purported by Street [7,8], Gee [9,10], Barton and Hamilton [11], and others in the 1990s. Literacies are now complex, fluid, every changing and growing in number. They are essential on a local, national and international basis. They are politically necessary as well as socially essential if both individuals and communities are to access services and entitlements.

In an ever growing consumer-led economy and the rapid rise of the knowledge sharing economy, it is increasingly important that the general public know and understand the language that was once reserved for the professions within a particular industry or sector. For example, it could be argued that when a single national utility company was the only company supplying gas - to households - it did not really matter whether we, the general public working outside of the industry, understood the language of tariffs, how to calculate the kilowatts per hour, standing charges (and if they are in days, hours, weeks), billing options, comparing the market and so on; we had no other choice. Competitive pricing, deals, payment options etc. were irrelevant. Today, understanding the many sectors now in private ownership, including the energy market is vital, it's a skill we all need and that includes having the appropriate literacy; together they equate to consumer power. Power to choose, power to change your supplier, power to demand a better deal, power to look for a more ethical deal. We are now fully fledged consumers, whether we like it or not. However, the power of the consumer can only be fully achieved when the consumer is fully informed and able to operate with confidence within the market (literate), when the information we have is reliable and trustworthy, when we know how to recognise when this is not the case and we are in a position to ask the right questions to fill in our knowledge gaps.

A significant part of the energy literacy gap is around renewable energy sources and their use in the future, particularly as many of our fossil fuels become unaffordable or environmentally challenging [see the Department for Energy and Climate Change announcement that all UK coal-fired power stations will close by 2025 [12]].

2. RESEARCH METHODOLOGY

The project, funded by the Engineering and Physical Sciences Research Council (EPSRC) ran between 2012 and 2015 (with an extension until 2017) and consisted of nine work packages. Between them they encompassed a range of disciplines including science, technology and social science. Led by the University of Nottingham, RHEES was a consortium of six UK universities. This article comes from work package two which looked specifically at community engagement with renewable energies. RHEES also had a parallel project running in India funded by the Indian Department of Science and Technology (DST) which was led by the Indian Institute of Science (IIS) in Bangalore, with mirroring work packages.

The overarching objective of the project was focussed on bridging the urban rural divide (BURD) in terms of renewable energy production in the community. It was particularly interested in exploring how to make rural living a more sustainable option in both India and the UK.

Work package two took a mixed methods approach to the research. This involved household postal surveys, interviews and observations. Data collection occurred between October 2013 and July 2014. The three case study sites of Lincolnshire (Lincs), Derbyshire Higher Peak (DHP) and Easter Ross (ER) were selected from within two rural regions of Britain originally identified in the RHEES research proposal; the East Midlands and Northern Scotland. Work package two further identified eight rural settlements to be investigated; three each in Lincolnshire and Derbyshire Higher Peak and two in Easter Ross, all with resident populations fewer than 10,000 [1].

Data collection consisted of four main stages: A stratified postal survey sent to 6,000 households (stratified in terms of the type and age of dwelling). We received 747 valid returns; a response rate of 12.5%;

- Face to face follow-up interviews with 97 householders who had indicated on the survey a willingness to participate in the interview phase;
- Face to face interviews with seven stakeholders (e.g. local government); and,
- One focus group consisting of 10 residents in the Lincolnshire area interested in issues, or active in the area, of renewal energy.

2.1 Energy Literacy Matrix

In response to the data the work package two team devised an Energy Literacy Matrix (ELM) to help

identify where energy literacy mismatches lie and extend the baseline data energy questionnaires can provide in some settings [13]. It is envisaged that policymakers, the scientific community, adult educators, schools and other interested stakeholders might utilise the matrix to help identity and close any knowledge gaps and hence facilitate better public engagement with the renewable energy agenda in the future. Here the matrix is used to indicate the energy literacy levels of interviewees in this case study but it can be adapted and applied to any group of people or individuals. In the latter instance the percentage could be calculated using a simple renewable energy survey that tests an individual's awareness, knowledge and understanding levels. It also has the potential to be used both as a framework to measure the success of any future communication strategies (particularly those that are government-led) and as a learning assessment tool to help educators, and learners measure the effectiveness of interventions aimed at improving energy literacy levels. This could be achieved by using the survey tool before and after an intervention or awareness raising campaign.

Literacy assessment tools are now widely available and commonly used across a range of fields, including ICT, digital media, genetics, science, health and general literacy, to test an individual's understanding and ability. For example the Arkansas literacy intervention Matrix [14] is well established as is the Verizon Lifespan literacy matrix [15]; and Garthwaite, Francs and Ward [16] have explored the complexity of scientific literacy.

Our ELM maps an individual or a community's knowledge and understanding of an energy concept with that of their awareness. We have used a sliding high / low scale and attached percentage ranges that equate to each of the five scales, for clarity. The energy literacy matrix presented as Figure 1 has been completed using both the interview (*italicised text*) and the survey data (underlined text) from the RHEES research study to illustrate how it might work; at least in the initial stages of assessing energy literacy.

The ELM was found to be limiting in respect to the survey responses and worked better with the interview data. This is because survey data can only be as a result of a *one-way* response to questions whilst interview data is richer and allows for a *two-way* response, a dialogue to take place in which the participant's awareness of a concept can be cross-checked with their knowledge and understanding through further questions and discussions; something that is not suited to survey data. Therefore, we would suggest that survey data alone provides an overly simplistic view of energy literacy levels amongst the general population and that the matrix is more suited to settings where issues can be explored in more depth e.g. household interviews and/or community meetings.

		Knowledge & Understanding →				
		Very low (<10%)	**Low** (11-30%)	**Moderate** (31-55%)	**High** (56-84%)	**Very high** (85+%)
Awareness ↓	**Very low** (<10%)	*-New fuel poverty definition* *-Hybrid cars* *-Hybrid household systems*				
	Low (11-30%)	-Green Deal -Cash Back				
	Moderate (31-55%)	*-Hybridity* *-Community AD* -AD / -FiTS		*-Energy security* *-AD systems* *- Biomass / fuels*		
	High (56-84%)	-wave or tidal	-Solar -Wind		*-Food v food*	
	Very high (85%+)	*-Fracking*	*-Old Fuel poverty definition*			*- Fuel poverty*

Figure 1. Energy Literacy Matrix showing energy literacy levels based on RHEES survey and interview data [1]

Using the findings from the RHEES project household interviews, the following section provides an explanation as to why the research team allocated individual energy literacy concepts a specific place on the ELM.

3. STUDY FINDINGS AND DISCUSSION

Based on the data gathered during the 97 household interviews, this section considers interviewees understanding, knowledge and awareness of the following energy literacy concepts and debates: definitions of fuel poverty; food versus fuel; energy security; anaerobic digestion systems; and hybrid energy systems. It also considers where each one fits within the energy literacy matrix presented earlier as Figure 1.

3.1 Fuel Poverty

The research found a *high* level of energy literacy amongst interviewees regarding both awareness and an understanding of the general concept of fuel poverty. The vast majority of interviewees (93%) had heard of the term fuel poverty and were able to articulate, at least in principle, what they thought it meant. However, relatively few (11%) knew the full official government definition. Used by policymakers since 2001, it states that a household is fuel poor if it needs to spend more than 10% of its income on fuel to maintain a satisfactory heating regime, which is usually taken to mean 21 degrees for the main living area, and 18 degrees for other occupied rooms. Whilst none of those interviewed initially identified themselves as being in fuel poverty, on reflection and clarification of the 10% of household income definition, several concluded that they must 'officially' be living in a fuel poor household. This tended to be the older interviewees' living on a single state pension.

In July 2013 the government published a new definition of fuel poverty. Based on a Low Income High Costs (LIHC) framework, the new definition no longer works on a percentage of income but states that a household is fuel poor when 'their income is below the poverty line (taking into account energy costs); and their energy costs are higher than is typical for their household type,' [17]. The new definition also uses a 'fuel poverty gap'. This is "...the difference between a household's modelled bill and what their bill would need to be for them to no longer be fuel poor" [17]). None of the householders interviewed were aware of the new definition. Further, almost everyone interviewed found it difficult to understand, complicated and unhelpful calling it 'vague', 'unclear', 'meaningless', 'rubbish', shocking', 'gobbledegook' 'a politicians definition', and 'typical government spiel'. This suggested a very low level of energy literacy, both in terms of awareness and understanding, amongst the interviewees regarding the new fuel poverty definition. The language used by many interviewees suggested a mistrust of those in authority and in particular government and the big six energy companies. The public's difficulties in accessing trustworthy, reliable information on climate change and energy policy is a longstanding problem for the sector (e.g. Soden [18]). Despite the efforts of government departments, the regulator (ofgem) and the energy companies this research suggests the difficulties remain.

Employing this new definition, the governments' fuel poverty report published in August 2013 estimated the number of households suffering from fuel poverty had *decreased* by 80,000 when comparing figures from 2010 with 2011. The majority of interviewees we talked to about the reduction were surprised by this fall, particularly in light of the rising costs of household fuel. There were high levels of scepticism amongst interviewees as to why the definition had been changed, many believing the change to be a cynical attempt to reduce the number of households in fuel poverty.

Despite official figures at the time indicating that 2.28 million households (or 10%) in England were fuel poor, [17], with this figure standing around 20% for households across the three study areas, very few interviewees (9%) actually knew anyone who was living with fuel poverty. However, many interviewees felt they probably did know people who were fuel poor but that they were not admitting to it. One interviewee commented 'it kind of gets hidden away' (ER). Another interviewee who regularly helped with a local food bank in Lincolnshire said he had not heard of anyone asking for help with fuel. However, by the time interviews were conducted in DHP and ER a small number of interviewees did mention they had heard of people visiting food banks asking for food that did not need to be cooked, leading these interviewees to surmise this may be an indication that fuel poverty was a real issue for some in their community.

3.2 Fuel versus Food

Two-thirds of interviewees (66%) had heard of the phrase 'fuel versus food' mostly in relation to the so called 'eat or heat' debate but also concerning the growing of crops for fuel. Some interviewees were able to identify local examples (e.g. coppice willow) used to produce wood chip fuel.

To 'eat or heat' came to public attention in October 2013 when, in reaction to the proposed increases in household fuel prices by the Big six, Sir John Major [19] warned that some families would be facing the choice of either eating or heating in the winter. The *lowest* awareness of this debate occurred in Lincolnshire with just 43% of interviewees aware of the issues. However, in DHP and ER awareness was much greater (both at 78%). Whilst a few interviewees felt it to be predominantly media hype and scaremongering others perceived it to be: 'fundamentally wrong' (DHP) especially when considering Britain is one of the richest countries in the world; that people 'shouldn't have to make such decisions'; and it is 'not a debate we should be having in a civilised society' (Lincs). Other concerns mentioned around this issue included the selling of food in smaller packs by the supermarkets to make it more affordable, to reduce waste and the need to educate young people to cook believing home cooked food is cheaper (and healthier) than pre-packed or takeaway foods.

The practice of growing bio-fuels instead of food crops on agricultural land is another aspect to this debate. It is one which has been in the public domain for some time. There was less awareness and understanding of the food versus fuel debate (44% of interviews) in terms of bio-fuels than for the 'eat or heat' debate. Many were strongly against this practice believing it takes too much land that is needed for food; 'it's not right when people are going hungry' (DHP). It was also seen as 'ludicrously expensive', not a good use of resources with one interviewee feeling it to be '…a rather silly way of generating fuel' (ER). Others felt it to be a potentially helpful way forward if it was economically viable, especially for farmers and if it did not damage the environment. Some interviewees were 'morally conflicted' finding this a difficult issue to reach a conclusion citing rising fuel and food prices.

Overall, the energy literacy awareness and knowledge and understanding in relation to the fuel versus food debates, particularly around using land for growing bio-fuels, could be described as *high*, particularly in Britain's biggest food producing county: Lincolnshire [20]. However, it was considerably lower than for fuel poverty.

3.3 Energy Security

Where we get our energy supplies from and how reliable our supply is, was a term that just over half of all interviewees (55%) had come across in the press or other media. Therefore, overall energy literacy awareness levels here can be classified as *moderate*; lower than for fuel poverty, and, eat or heat debates but higher than for the bio-fuels debate. However, there was a marked difference between the three case study areas. Around two-thirds of interviewees in the two English case study areas were aware of concerns about energy security as a term whilst for ER, in Scotland, it was much lower with less than one-third of interviewees being aware of energy security. Although we can only speculate about why this difference might so clear it be attributed to the fact that Scotland has its own natural energy supplies in terms of North Sea gas and oil reserves (some of which were close to the area of the case study). The 500 council house estate at ER1 was built in the early 1970s for the workers constructing the Invergordon aluminium smelter and the infrastructure and rigs for the Fortes North Sea oil field, therefore energy in that region of Scotland might be seen as more secure and reliable and less of an issue.

Once energy security was explained the majority of interviewees (56%), who expressed an opinion (for many said they did not know enough about it to comment), felt it was an important issue. One interviewee commented, 'it worries me a lot. We are rather dependent upon unsettled parts of the world for our oil, gas and coal.' (ER). Interviewees main concerns centred on the potential for energy supplies to be disrupted or cut off altogether. Linked to this was the issue of UK storage capacity and not being in control of our energy prices. One interviewee commented, 'I don't think we have energy sovereignty' (Lincs). (The alleged use of energy supply by Russia as a political tool in Eastern Europe was topical at the time of the study.)

A small number, (9%) of interviewees did not feel energy security was an issue. The main reasons for this included the perception that the UK will always have coal to fall back on and that whilst companies may be in a different country (for example Russia) they are commercial enterprises and, as such, rely on customers for their income stream. Therefore disrupted or suspended supplies would only serve to damage their profits.

Whilst not a renewable energy but rather a potential new source of energy, interviewees were asked what they thought about, and knew about fracking. All but five (5%) interviewees had heard of Fracking; mostly because of extensive and continuing media coverage. However, few knew very much, if anything, about the process itself. Therefore, in relation to fracking, energy literacy awareness was very high but their knowledge and understand as *very_low*.

Nearly one-third (32%) of interviewees declined to comment on whether fracking was a good idea as they

did not feel well enough informed of the debates surrounding fracking to form a valid opinion. Of those who did comment (47%) nearly two-thirds (63%) felt it was something that should be pursued albeit with a number of caveats attached before they would be completely comfortable with the process going ahead locally. Positive comments for fracking included: 'We have got to swallow it and hope they just make a tiny dent in the landscape' (DHP); 'it's the next answer' (ER); 'it fills a gap' (Lincs); and 'it will have to come. If we want everything then we have to do it' (Lincs). Several interviewees viewed it as a short-term solution but nevertheless one that would be worth investigating and 'an important bridge' whilst alternative energy sources were explored and developed. On balance those in favour felt it was a source of energy worth pursuing, as long as it was done safely and with consideration for the environment. Three interviewees commented on the impact fracking had made in reducing fuel prices in the USA.

Those against fracking raised many concerns (as did some of those in favour), predominantly about its environmental impact and that it is largely untested in the UK. Interviewees felt the case for fracking still needed to be proven with one interviewee commenting 'it's a bit of an unknown' (DHP), another seeing it as 'a get out of jail free card' (DHP). It was seen as potentially dangerous, for example it might pollute the water table or result in earthquakes, and that it could be costly. Several interviewees were able to cite the alleged relationship between fracking and earthquakes around the Blackpool area of Lancashire. One interviewee called it 'scrapping the barrel' (DHP). Interviewees were also concerned about local impact and even those in favour admitted they might not be so keen if fracking was proposed locally: 'if they came to the bottom of my garden I might change my mind' (DHP). NiMBYism (not in my back yard) was highly prominent in discussions around fracking. Some interviewees did not trust the companies' motives for being involved and did not believe it would necessarily lead to cheaper household fuel. Others felt fracking would allow the focus to remain on consumption levels rather than addressing the more sustainable need to reduce energy use.

3.4 Anaerobic Digestive Systems

Over a third of all interviewees (37%) and nearly half of all survey respondents (46.2%) were aware of Anaerobic Digestion (AD). The majority of interviewees that were aware of AD (86% or 32% of all interviewees) were able to articulate the concept or principles of AD, usually by relating it to composting or farming. Those interviewed in DHP had the highest level of understanding (52%), whilst those in ER the lowest (22%). However, only two interviewees knew it had the potential to be employed to generate community energy and was fully versed with the technology. Therefore, interviewees exhibited a *moderate* level of energy literacy in relation to general AD awareness and understanding but a very low levels of energy literacy in relation to its community possibilities. Several stated that their information on AD had come predominantly from the media; most notably by listening to BBC Radio 4s daily drama The Archers or watching the BBC 1 weekly programme Country File. After clarification and explanation of the AD concept, perceived issues with community AD included: start-up costs; ensuring sufficient, quality feedstock; finding a community space and a neutral site for the digester; reliability of the energy produced; and the age of the community. A particular concern here was whether or not an older rural community would be physically able to operate a digester. Other concerns involved the potential 'smell' of biogas production and increased road traffic in transporting green waste (fuel sources).

Awareness of bio-fuels to generate energy was somewhat *higher* than it was for AD with 44% of all interviewees having heard the term and just over one-third (36%) having a good grasp of the technology. However, there was wide variance between the three case study sites with *greatest* awareness in ER (70%), *least awareness* in DHP (30%) and a *moderate awareness* in Lincs (40%). Energy literacy awareness and understanding of biomass could therefore be described, in the terms of the ELM as *moderate*.

3.5 Hybrid Energy Systems

Whilst many interviewees (42%) had some understanding and knowledge of, or could make an educated guess what, the concept of a hybrid energy system might entail (a mix of conventional and renewable energy sources to meet energy need), just 5% of interviewees had specifically come across the term in the context of a domestic setting. Hybridity was most commonly known to interviewees in relation to cars (20%). Therefore, it could be said that energy literacy awareness levels were *moderate* concerning the term 'hybrid', low in relation to cars and very low in terms of household systems. For all three areas of hybridity understanding was very low.

In the majority of cases it was necessary to explain hybrid energy systems to the interviewee using a series of diagrams and examples. However, interviewees soon grasped the basic concept and once explained nearly half of all interviewees (48%) felt such domestic systems would be a good idea and could help to meet future energy needs in society.

Interviewees readily accepted that we currently have a nation hybrid energy supply chain (gas, nuclear, wind etc.) but had never really thought about it at a local level e.g. a community wind turbine complimenting a more established national energy supplier. It would appear that the terminology was the issue rather than the principle. The most reluctant were the very elderly who found it both a difficult concept to grasp and felt it was 'too late' for them. Other issues raised included the cost of such systems and the need to develop better ways of storing the energy produced until such time as it is needed. Producing energy close to where it will be consumed was also considered important. However, some felt it would be better to design houses that are more energy efficient from the outset with one interviewee seeing renewables as more of a 'sticking plaster' than a long-term solution.

It was clear from the household interviews that people want and need more and better quality, reliable information on current and likely future energy challenges and on the availability and development of renewable alternatives to be able to make informed energy choices. The ELM discussed in this article is potentially an important tool in identifying and addressing this need.

4. CONCLUSION

The findings of the RHEES project [1] make it clear that there is a disjuncture between individuals' awareness of energy related matters and the terminology used by both policy makers and the industry and their knowledge and understanding. Whilst awareness amongst those interviewed was frequently moderate to high they were not well informed about either the renewable technologies available or the current debates surrounding related issues. Knowledge and understanding of how such new technologies operate, their benefits and possible challenges was often lower than their awareness; largely due to wide-spread but often inaccurate media reporting and scepticism amongst the interviews of information sources. Therefore, the study found a need for better and more trustworthy information. This is crucial if government wishes to engage the general public in future renewable energy initiatives. The current debate on fracking in the UK is a case in point. Many of those we interviewed felt they were not in a position to decide if fracking was a positive or negative way forward largely because they felt they did not have enough reliable information about the process and its potential environmental consequences.

To conclude, we would like to invite readers of this article to test the ELM in real-life educational settings across the sector and let us know how they used it, how effective it was, difficulties with the matrix and where improvements could be made. We would be particularly interested to know of the different educational settings it has been tested in, what has worked well and been well received and where it hasn't been helpful. We would also be interested to know if it has had any positive effect in terms of improving energy literacy levels, raising awareness of the renewable energy debate or if it has facilitated changes to energy-related behaviour.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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