Interactive Solar Energy Exhibition

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Abstract

Public understanding of science PUS is a central concept among science communicators. In 2011 we introduced the acronym PURE, Public understanding of renewable energy. PURE is proposed as an important sub-concept of PUS. Four reasons for the importance of public understanding of renewable energy are: (i) The earth is a lonely planet in a vast space, (ii) The earth is a planet alive with a dead sister and a dead brother. (iii) Anthropogenic influence on the world's climate. (iv) One major source of greenhouse gases is combustion of fossil fuels, which has to be replaced by increased energy efficiency and renewable sources of energy. There are many channels that can be and are tried to achieve PURE, among them interactive exhibits in science centres. We have over the years built a number of interactive solar energy exhibitions and we suggest that an interactive exhibition could both be part of the newly established digital ISES Solar Energy Museum and a Science Center IRL in Strömstad or elsewhere.

Keywords: public understanding of science, public understanding of renewable energy, ISES Solar Energy Museum

1. Introduction: Public Understanding of Science

Public Understanding of Science (PUS) is today an established concept. There is even since 1992 a scientific journal with this name. A 3-fold definition of PUS given by Baur is
(i) "Debunking of superstitions, half-knowledge, complete and utter ignorance, misunderstanding and mumbo-jumbo, and virulent memes that give rise to anti-science."
(ii) PUS is to "improve science literacy, to mobilize favorable attitudes in support of science and new technology, to increase interest in science among young people and other segments of society, and to intensify public's engagement with science in general and for the greater good of society."
(iii) "PUS considers common sense as an asset" and PUS research should "chart out the public controversies arising from new developments and in different regions of the world" exemplified by "the impact of the climate of opinion on knowledge production." (Baur 2009)

Today, in the early 2020ies, with so much fake news abundant, PUS seems even more important than a dozen years ago.

During the planning of Sweden's first science center The Futures' Museum, one of the authors (Broman) gave following seven reasons for creating a science center:
(i) Give an insight that science is understandable.
(ii) Awaken curiosity.
(iii) Give people the courage to experiment.
(iv) Facilitate public understanding of science.
(v) Provide preparedness to withstand superstition and pseudoscience.
(vi) Amuse and entertain.
(vii) Provide aesthetic experiences. (Broman 1984, 2004, 2005).

Underlying the statements is the notion that PUS is important, which scientists happily believe, and we of course agree, but it is not as simple as that. There are e.g. so many different sciences (which in turn are divided into many disciplines). A rather popular notion is that "science" is that same as "natural sciences", but that is not the

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case. Science also "includes engineering and medicine, the social sciences and humanities, old and new disciplines with clear boundaries, but also ... fuzzy transdisciplinary techno-sciences" (Baur 2009).

It is also vital to identify target groups, since some may be more important than other. Loosely defined target groups frequently mentioned are young people (in the world of science centres often restricted to the "7-eleven group" of elementary school children), voting adults, and decision makers. Other interesting group may include teenagers, refugees, religious fundamentalists, senior citizens, people living in villages as well as cities, just to name a few.

It is also important to identify groups of science communicators. As an example, The European Science Communication Network ESCOnet, 2005-8 developed and conducted a series of workshops on science communication training aimed at young post-doc researchers (Miller et.al. 2009).

2. Public Understanding of Renewable Energy

PUS is important for a variety of target groups including common public. A presently important subset of PUS is Public Understanding of Renewable Energy. In 2011 we introduced the acronym PURE (Broman, Kandpal 2011, 2013): Public understanding of science PUS is a central concept among science communicators. Public understanding of renewable energy PURE was proposed as an important sub-concept of PUS. Four separate important questions for a PURE research project can be identified: (A) Is PURE important? (B) Which issues of PURE are the most important ones, according to renewable energy scientists? (C) What understanding of renewable energy has the general public today, worldwide? (D) How to achieve PURE?

There are many channels that can be and are tried to achieve PURE: Newspapers, TV programs, social media, books, interactive exhibits in science centres, lessons in the school. Different media attract different target groups. Loosely defined target groups frequently mentioned are young people (in the world of science centres often restricted to the "7-eleven group" of elementary school children), voting adults, and decision makers. Other interesting groups may include teenagers, refugees, religious fundamentalists, senior citizens, people living in villages as well as cities, just to name a few.

2.1. Importance of Public Understanding of Renewable Energy (PURE)

Four reasons for the importance of public understanding of renewable energy are:

(i) The earth is a lonely planet in a vast space, not as crowded as the impression one gets from science fiction movies. For humans to move from a destroyed earth to another hospitable planet is just impossible. Present ideas to inhabit planet Mars seems to us utterly unrealistic,

(ii) The earth is a planet alive with a dead sister and a dead brother. Venus is too hot for life due (also) to too much greenhouse gases, while Mars is too cold due (also) to too little greenhouse gases.

(iii) Anthropogenic influence on the world's climate, in particular climate warming due to release of greenhouse gases like carbon dioxide (CO_2) and methane (CH_4) is generally agreed upon among scientists, especially within IPCC.

(iv) One major source of greenhouse gases is combustion of fossil fuels, which has to be replaced by increased energy efficiency and large-scale worldwide dissemination of appropriate technologies for harnessing renewable sources of energy.

A reasonable conclusion is that public understanding of renewable energy is important. An important task of an initiative on PURE would be to identify pros and cons in this respect. There are also several attendant questions: What do professionals - researchers, planetarians, teachers - say? How interested is the public - and different target groups - in renewable energy, and what do they already know? Which disciplines in renewable energy science are more important than others? A very crucial role exists of common people in the success of this objective of large scale harnessing of renewable sources of energy, since as adoption as well as design, developing, manufacturing etc, would require their participation.

2.2 Approaches and Means to Achieve PURE

There are of course several different channels that can be and are used in conveying attitudes towards and knowledge of renewable energy subjects listed above. Different media certainly attract different target groups. One of the important tasks is to assess the potential role that science centers with interactive exhibits can play in enhancing PURE. It is worth mentioning that all science centers are not identical – there is a great difference between large science centers (like Nehru Science Centre in Mumbay, Cité de Science and Technologie in Paris or Exploratorium in San Francisco) and smaller ones (like Ekohuset in Strömstad and Molekylverkstan in Stenungsund; both Sweden and the medium-sized Regional Science Center in Dehradun, Uttarakhand, India,).

It is well established that a combination of watching a planetarium show and doing experiments related to the show is very useful (Pettersen 1995, cited in Broman, Kandpal 2013). Traditionally, planetariums used to be devoted basically to astronomy using a classical opto-mechanical star projector. However, today planetariums increasingly concentrate on edutainment shows with astronomic content, using all-dome video technique. Shows related to climate change and its solutions would be easily produced using modern planetarium projectors and would fit nicely under the planetarium dome. Two further opinions on interactivity are listed below:

Michael Spock, former Director of *Boston Children's Museum*, borrowed the Chinese philosopher Confucius' proverb as a motto for the museum: I hear and I forget, I see and I remember, I do and I understand (cited in Ott 2001).

William Glasser wrote: We learn 10% of what we read, 20% of what we hear, 30% of what we see, 50% of what we both see and hear, 70% of what is discussed with others, 80% of what we experience, and 95% of what we teach (Glasser 1990).

An important component of achieving PURE is likely to be interactivity and hands-on experience, and useful environments for this are science centers. Some examples of this are shown below in photographs from the Teknoland outdoor science center 2000-2001: Yourself a sundial, Toddlers' Teknoland, Solar energy surfaces, The greenhouse, The solar heated chess board, Solar energy popcorn, and Solar energy calculators.

3. Educating the General Public

Ordinary people are the ultimate users of energy from the sun and accordingly need basic knowledge and understanding to make use of this new technology and be motivated to use it. A number of ways to educate large populations are readily available. Some proven examples include:

Mass media. This includes newspapers, weekly magazines, radio, and TV. You address professional journalists, and if you manage to teach them some basic facts, they will frequently make a good job in popularizing what they have learned.

Exhibitions. We have built both Science Centre exhibitions (1986 and 1990 on solar energy for the Futures' Museum in Borlänge, Sweden) and travelling exhibitions (Alternative Energy 1976, Solar Energy Exhibition 1989). Also Falun Science Centre (1992-2001) and the outdoor Science Centre Teknoland (2000-2001 in Falun, Sweden) included renewable energy exhibits. The educational value of an exhibition is greatly improved if it provides hands-on experiences. To complement the recent ISES virtual Solar Energy Museum with hands-on exhibits in several places – maybe one of them in Strömstad, Sweden – is hereby proposed.

Trade fairs. Another kind of exhibition is the trade fair with commercial and institutional exhibitors. Such fairs can range in size from the one hundred square meters or so of exhibitions that accompany SERC's Solar Energy Days and exhibitions by Solar World Congresses to the multi-acre exhibition of the UN Conference on New and Renewable Energy Sources of Energy in Nairobi 1981. Such fairs contain up-to-date technological information for many categories of visitors and should be made available both to professionals and to the general public.

Popular lectures, etc. General admission popular lectures sometimes attract good-size crowds, especially if arranged as debates or panel discussions, or if a well-known speaker is featured. Lectures can also be video-taped as webinars, and can, with appropriate solar powered equipment, be shown just about anywhere.

Community college courses. These are excellent in giving interested individuals more-than-basic knowledge. The aim of such courses can even be that every participant builds his own solar collector or any other device.

Social media have recent years grown to be common channels for spreading information and have to be used for reaching especially younger audiences.

Other examples of contributing towards PURE include renewable energy education and training in a 2015 Egyptian village with a program consisting of public presentations, group discussions, simple solar kits, children competitions, technical training workshops, exhibits with working models, working systems, video-training systems, a community library, and organization of regional training workshops with the objective of familiarizing women in developing countries with renewable energy development and technology (Arafa 2017).

Another approach of community college type of educating people that is popular in Sweden is called study circles. A typical study circle consists of a circle leader - the teacher - and 5 to 10 participants. Especially during the nineteen nineties, knowledge about solar heating was spread in many locations in Sweden in this form, where each study group built a solar heating system at one of the participants' house, using a popular build-yourself solar collector kit (Börjesson et.al. 1994). A thorough investigation of this kind of education is presented in a case study (Henning 2000).

4. Interactive Solar Energy Exhibitions

We have over the years built a number of interactive solar energy exhibitions, presented among others at the ISES Solar World Congresses in Denver 1999 and in Göteborg 2003. In the present paper we suggest a modern interactive exhibition that could both be part of the newly established digital ISES Solar Energy Museum as well as a Science Center IRL in Strömstad or elsewhere. Useful experiments that can be included were published in 2016 by us (Kandpal, Broman 2016).

Some of the gadgets developed at Indian Institute of Technology Delhi in early 1980’s to offer school level experiments which could be adapted for science center use include:

1. Measuring altitude of the Sun
2. Absorption of solar radiation by different colors - solar heating of water in beakers
3. Absorption of solar radiation by different colors – melting of ice cubes kept in trays coated with different color paints
4. Greenhouse effect
5. Effect of orientation of the transparent wall on the enclosure air temperature
6. Arrangement to measure reflectance of reflecting materials and transmittance of glazings
7. Movement of focal line of a linear Fresnel reflector
8. Rise in temperature of water in the can at the focus of a conical concentrator
9. Composite parabolic trough with a rectangular channel absorber

(Kandpal, Broman 2016)

Examples of Activities Developed and Presented in Teknoland 2000-2001 (the outdoor Science center in Falun Sweden):

Fig.1 A set up to demonstrate greenhouse effect being built at Teknoland. Exhibit label: A higher temperature can be experienced inside the greenhouse (as compared to temperature outdoors) demonstrating the greenhouse effect.

Fig. 2 Yourself a Sun-Dial Exhibit at Teknoland. Exhibit label: Stand straight on a grey stone so your shadow points towards the white stone. What time is it? Since the sun's path over the sky changes a little from day to day, the places of the stones have to be changed from time to time. (Please don't move any stones yourself, let Teknoland's personnel do the adjustments!)

Fig. 3 Solar Heated Chess Board at Teknoland. Exhibit label: Walk around barefoot and feel the difference between black and white squares! Also play. 4 against 1: Two players, white and grey. You play only on white squares. Place the four white pieces along one edge. Place the gray piece at the opposite edge. The players take turns in moving a piece to one adjacent white square. Gray player begins. White is only allowed to move ahead, never back. Gray wins if it manages to pass behind the white pieces. White wins if white shuts up gray so it cannot move. (No piece may jump over another piece.)

Fig.4. Playhouse with PV electricity at Toddlers' Teknoland. Exhibit label: In the house there is a radio, which gets the required electricity from a solar panel on the roof. Cover the solar panel to quiet the radio.

Fig.5. Solar Surfaces Demonstrated at Teknoland. Exhibit label: Feel the different surface temperatures! A black surface absorbs more sunlight than a white or a metallic. A surface turned towards the sun than one that is turned away from the sun. Glazing prevents radiation from the surface. A painted surface radiates heat easier than a metal surface and is therefore cooler.

Fig. 6. Making popcorn using a solar concentrator at Teknoland. Exhibit label: When the sun is visible, rays directly from it can be concentrated into a small area. A reflecting parabolic mirror creates almost a point. A near-parabolic mirror like this one produces a slightly wider spot. The concentrated light gives high temperature, so with a frying pan on that spot it is possible to fry pancakes or pop popcorn. Caution: This exhibit is dangerous and may only be handled by Teknoland's staff!

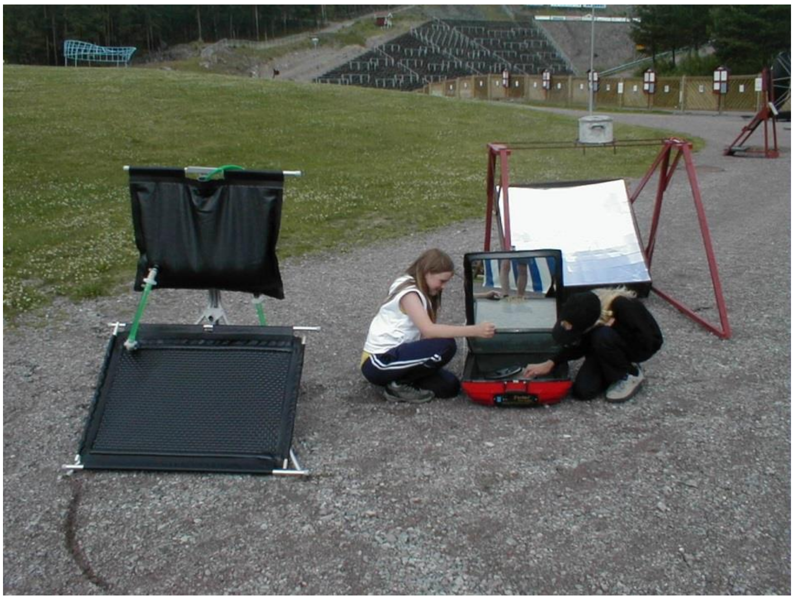

Fig. 7. Principles of solar collection and solar cooking being investigated by school children.

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