Understanding the socio-technical system associated with a change in the supply, distribution and consumption of electricity from AC to DC voltage

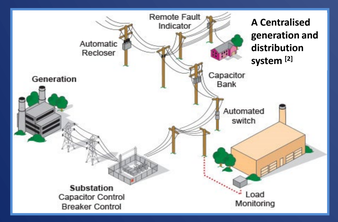
Niche innovation: Autonomous DC voltage electrical systems

Reasons and advantages of using DC voltage [1]

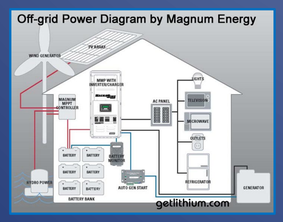
1. All household goods that use electronics operate using direct current (DC) Voltage.
2. White goods like fridges and freezers can and do operate on DC voltage.
3. If appliances are alternating current (AC) voltage devices, but are powered from DC renewable sources, then multiple conversion losses will occur
4. DC only systems eliminate the inverter and all the external and internal AC-to-DC power converters which themselves use up energy.
5. The total energy used by the appliances should be less than their AC equivalents. Therefore the amount of PVs or the size of the renewable energy generators needed to power the house will be smaller.
6. DC technology have less moving parts, are more robust, and last longer than AC equivalents
7. LED and halogen lights can operate directly off DC voltage

Economics and socioeconomics [1]

1. Appliances that don't need AC-to-DC converters will be smaller, use less raw materials in their manufacture, have a smaller carbon footprint, and cost less to manufacture than their AC equivalents.
2. With economies of scale in manufacture there is no reason why a DC appliance should be more expensive than an AC appliances.
3. In emerging markets there are 1.4 Billion people who are not connected to an electric grid [16] A minimalistic DC home should give them a large increase in living standards quicker and cheaper than a complete centralised AC grid connection.
4. DC only loads allow for smaller energy generators, which decreases the cost and increases the proliferation of decentralised energy generation from renewable sources.
5. Proliferation of DC systems offers the opportunity for economic growth
6. Decentralised energy generation from renewables in turn increases greatly Energy Independence for the householder and for the country.
7. The more microgeneration the greater the level of Energy Security.



A Centralised generation and distribution system [3]



Why is the electrical system a Socio-Technical System?

There are many interactions between people and the technology throughout the life cycle of the electricity system, these interactions will be affected by the decision to use DC voltage. Therefore DC voltage not only changes the *technical system* but it will also have effects on *people*; from policy makers, to manufactures/installers to end users, as well as on the *rules* and *regulations* that surround decision making, installation, the end use and maintenance. There is also the effect this will have on *societal goals*, like carbon footprint energy poverty, resilience of supply and sustainability.[3]

The process of transition from an AC to a DC System

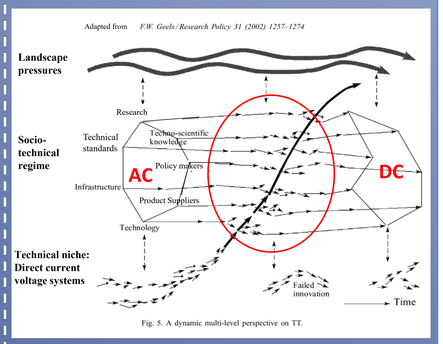


Fig. 5. A dynamic multi-level perspective on TT.

For a niche technology (in our case DC voltage) to be successful, it has to be able to demonstrate that it can alleviate/solve landscape pressure that are out of the control of the system itself. All the networks of people that are associated with the incumbent system will have to change their working practices and attitudes towards the new technology. The process of change will cause de-alignment and re-alignment of their whole systems[18]. A catalyst for this process could be their will to work towards an energy goal of Energy Independence with Security.

By understanding how landscape pressures and niche innovations combine to change the regimes, we can enable the transition to DC voltage systems

The regime networks associated with the AC electrical system [3]

Technical aspects of the system

Technical System (T)
T1. The Electrical Supply system (Independent of grid or feed in?)
T2. The whole smart electrical system in the house
T3. All smart (electrical) loads

Social aspects of the system

Standards Network (ST)
ST1. International Standards
ST2. Electrical regulations
ST3. Building regulations
ST4. Communications protocols
ST5. Health & Safety
ST6. Accreditation
ST7 Electro Magnetic Compatibility

Research Network (RE)
RE1. Research Bodies -funding (academic/industrial)
RE2 Standards Organisations [16]
RE3. Educators/trainers
RE4 Accreditation bodies
RE5 Institutions (IET, BRE)

Societal Network (SN)
SN1 Standards Organisations [16]
SN2. Regulators
SN3. Research Bodies (academic/industrial)
SN4 Industrial Lobbyists, trade association & Unions
SN5 Academic publications & the media

Policy Makers Network (PM)
PM1. Central Government
PM2. EU Policy Makers
PM3. Local Government
PM4 Funding Bodies / Financiers
P1.Energy Policy
P2. Decarbonisation
P3. Energy Security
P4. Energy Independence
P5. International Treaties
P6. Taxation

Supplier Network (SU)
SU1. Manufacturers
SU2. House builders
SU3. Installers
SU4 .Superstores
SU5 Utilities

User Network (U)
U1. End users
U2. Installers
U3. Maintenance engineers

The conventional landscape pressures on the energy system

We have identified **Continuity of supply** to be most fundamental underlying landscape pressure on the regime networks.

These 7 landscape pressures differ from country to country, each driving a unique set of energy policies

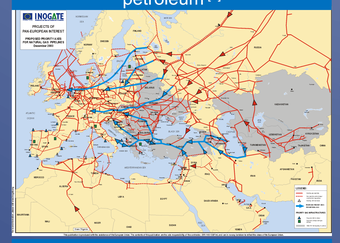
1. Peak Oil
2. Universal access
3. Carbon footprint
4. Fuel poverty
5. Energy security
6. Energy independence
7. GDP growth

We have identified nine landscape pressures that are connected to everyday societal problems which can be alleviated by using distributed direct current systems

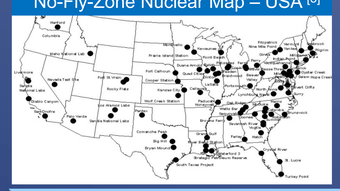
1. Maintaining continuity of supply
2. Maintaining a high standard of living
3. Homeland security
4. City resilience
5. Disaster risk reduction
6. Disaster management
7. Quicker recovery from disaster
8. Environmental sustainability
9. More sustainable food chain

Why is our goal that, everyone should have Energy Independence with Energy Security? …

Energy Independence: European dependence on Russian gas and petroleum [4]

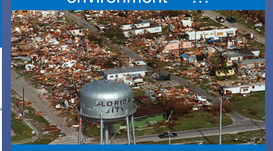


Homeland Security 10/30/2001 No-Fly-Zone Nuclear Map – USA [5]



Weather related national disasters causes Infrastructure damage [6] …

… and destruction of the built environment [7] …



…which leads to blackouts and brownouts

Water related national disasters…

… cause destruction of the built environment [8] …

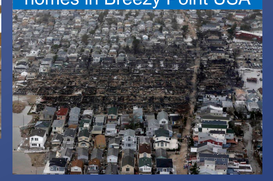
..and huge economic losses[9]

A Solar energy system can provide **Energy Independence** with **Energy Security** [10]

And help in post **disaster recovery** [11]

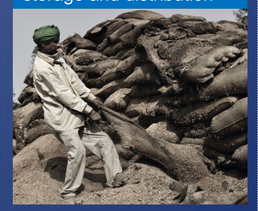
In a disaster having to **evacuate your home** due to loss of electricity creates more refugees [12] and can cause psychological trauma

Hurricane Sandy 2010[13]: An electrical fire destroyed 126 homes in Breezy Point USA



Food Spoilage: Due to inadequate refrigeration [14]

Crop Wastage:
In Indian 21 Million tonnes of wheat is wasted each year due to inadequate storage and distribution [15]



… Because many of these societal problems (which are landscape pressures) can be alleviated by the use of distributed DC voltage electrical systems

University of Salford MANCHESTER

Moshe C. Kinn & Carl Abbott
School of the Built Environment
University of Salford
Manchester
M5 4WD
England

References and Notes

1. Kinn, M.C., *Benefits of Direct Current Electricity Supply for Domestic Application, in School of Electrical and Electronic Engineering Faculty of Engineering and Physical Sciences*. 2011, The University of Manchester. p. 165.
2. https://www.aep.com/about/IssuesAndPositions/Distribution/SmartGrid/DistributionGridManagement.aspx
3. M. C Kinn. *Understanding the socio-technical regime networks associated with a change in the supply, distribution and consumption of electricity from AC to DC voltage*. DRAFT 2014.
4. http://www.mappery.com/map-of/Europe-Proposed-Natural-Gas-Pipelines-Map
5. http://cryptome.org/faa-snafu.htm
6. http://wodumedia.com/hurricanes-and-typhoons/workers-repair-a-row-of-fallen-electric-poles-in-wenling-china-on-august-8-2012-after-typhoon-haikui-made-landfall-haikui-caused-more-than-1-billion-in-damage-afpgettyimages/ Workers repair a row of fallen electric poles in Wenling, China on August 8, 2012, after Typhoon Haikui made landfall. Haikui caused more than $1 billion in damage. (AFP/Gettyimages).
7. http://www.nola.com/hurricane/index.ssf/2012/06/children_of_hurricane_andrew_s.html the aftermath of Hurricane Andrew: The water tower stands over the ruins of Florida City, Fla., on Aug. 25, 1992.
8. http://www.westernmorningnews.co.uk/Taunton-woman-s-home-castle-s-island/story-20410037-detail/story.html Aerial view of a house on the Somerset protected by a flood barrier. The house had previously been the most flooded house in the area until owner, retired naval officer Douglas Billington, built an earth wall around the property.
9. http://www.propertytribes.com/effect-flooding-on-property-prices-t-10050.html
10. http://www.dailymail.co.uk/news/article-2591111/Aerial-photos-Somerset-dried-February-flooding.html Father-of-two Mr Notaro kept the worst of the Somerset flood waters of March 2013 at bay with a seven-foot-high mud dam he constructed with diggers around his four-bedroom home.
11. http://www.phcrestoration.com/water-damage-repair-services-raleigh-north-carolina
12. http://www.boston.com/news/weather/gallery/katrina_evacuation_2?pg=10 After Hurricane Katrina 2005 refugees began filling up cots on the floor of the Astrodome Thursday. The Astrodome, which quickly filled, was the planned destination for many evacuees.(AP Photo)
13. http://intentblog.com/4-amazing-photos-of-hurricane-sandy-aftermath/ An charred hole in Breezy Point, Queens, The destruction of 126 homes was caused by a fire started during Hurricane Sandy 2013. (*Photo via AP*) *See also* DRAP, *The City of NEW York Community Development Block Grant – Disaster Recovery (CDBG-DR) Action Plan Incorporating amendments 1-4*. 2012. p. 245.
14. J.Gustavsson, C.C., U. Sonesson, *Global food losses and food waste* 2011, FAOUN.
15. IMECHE, *Global Food Waste not want not*. 2013. p. 31.
16. We note that there are people working on Standards operate in more than one network and therefore provide a connection between the different networks .
17. Gea, *Global Energy Assessment - Toward a Sustainable Future*. 2012, Cambridge University Press, Cambridge, UK and New York, NY, USA and the International Institute for Applied Systems Analysis, Laxenburg, Austria.
18 Geels, F.W., *The multi-level perspective on sustainability transitions: Responses to seven criticisms.* Environmental Innovation and Societal Transitions, 2011. 1(1): p. 24-40.