WORKSHOP

OPEN SOURCE SMALL WIND TURBINES

15th January 2016, Mälardalen University

REPORT

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WORKSHOP

15 JAN 2016

OPEN SOURCE SMALL WIND TURBINES: FUTURE ENERGY PROFILE @ MDH

FOR:

Everyone interested in small wind turbines

WHEN:

15th January 2016, 9:00-17:00

WHERE:

Room Beta, Mälardalen University, Västerås

SCOPES:

- To support small wind turbines manufacturers in R&D
- To support the owners of small wind turbines
- To promote open source projects for facilitating and boosting the small wind turbine market in Sweden

PROGRAM

9:00-9:15. Welcome & Introduction. Prof Jinyue Yan, Director of Future Energy Profile at Mälardalen University.

9:15-9:30. A Swedish perspective of the small wind turbines market. Sven Ruin, Teroc AB and Swedish Windpower Association.

9:30-9:45. Regulations on installing small wind turbines in Sweden. Olivius Patricia, Västerås stad

9:45-10:00. Developing a heat pump system driven by wind power to supply heat to the distributed end-users. Hailong Li, Mälardalen University.

10:00-10:30. TEA/COFFE BREAK

10:30-10:45. Optimization of hybrid power systems.
Pietro Elia Campana, Mälardalen University

10:45-11:00. Energy storage systems: An overview.
Anders Lundblad, Royal Institute of Technology and Mälardalen University.

11:00-11:15. Renewable materials for renewable energy: Wind power and wooden towers.
Marcus Ulmefors, Innoventum AB.

11:15-11:30. Internet of things for energy monitoring. Javier Campillo, Mälardalen University.

11:30-11:45. The Open Source Hardware Model – Examples and Experiences.
Carl Bärstad, Quirkbot and Open Source Hardware Association.

11:45-12:00. Small Wind Electric Systems Using Hugh Piggott's Designs. Jay Hudnall, Ti'eole.

12:00-13:00. LUNCH

13:00-13:15. Small wind turbine research and development at Linköping University.
Simon Schütte, Linköping University.

13:15-13:30. What the Swedish Windpower Association can do for you.
Ulla Hedman Andrén, Swedish Windpower Association.

13:30-15:00. Brainstorming

15:00-15:30. TEA/COFFE BREAK

15:30-17:00. Open discussion.

FOR MORE INFORMATION, PLEASE CONTACT

Prof. Jinyue Yan, 021-103134, jinyue.yan@mdh.se
Sven Ruin, 0221-60160, sven.ruin@teroc.se
Pietro Elia Campana, 021-101469, pietro.campana@mdh.se

FOR FORMAL REGISTRATION, PLEASE CONTACT:

Swedish Windpower Association, smaskaligt@svensk-vindkraft.org

FUTURE ENERGY

SVENSK vindkraft

MÄLARDALENS HÖGSKOLA
ESKILSTUNA VÄSTERÅS

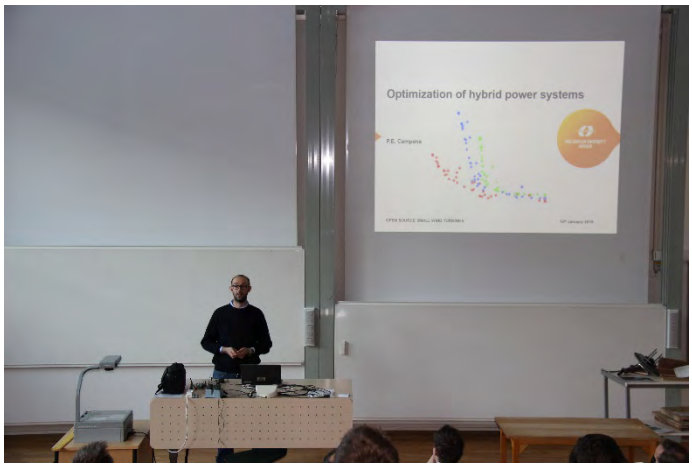
The workshop is organized by Mälardalen University and Swedish Windpower association

PRESENTATIONS


Future Energy


A SWEDISH PERSPECTIVE OF THE SMALL WIND TURBINE MARKET
Sven Ruin, TEROC AB and Swedish Windpower Association


Regulations on installing small wind turbines in Sweden


Optimization of hybrid power systems
P.E. Campana

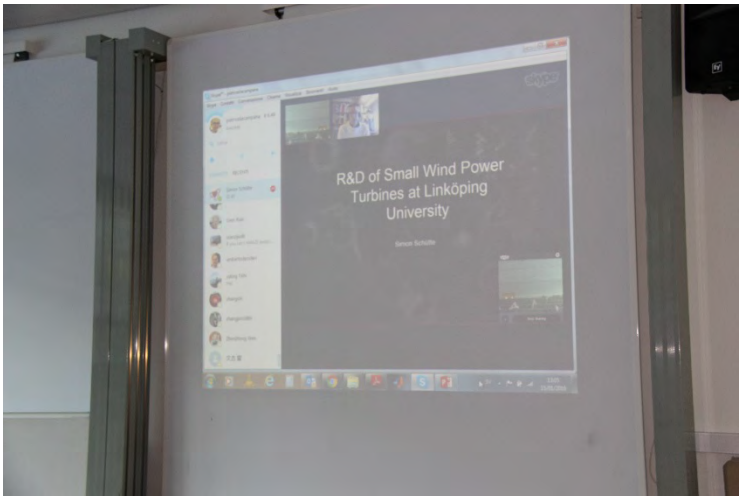

INNOVENTUM
Mälardalen Högskola
Svensk Vindkraftförening
15/01/2016 Västerås


(ELECTRICAL) ENERGY STORAGE SYSTEMS: AN OVERVIEW
Anders Lundblad


Open Source Web-Enabled Variable Monitoring
Javier Campión, Doctoral Candidate


open source hardware
IN EDUCATION


TI'ÉOLE
Where does small wind go from here?
Jay Hudnall
jay@tieole.com
TI'ÉOLE


R&D of Small Wind Power Turbines at Linköping University


vindkraft

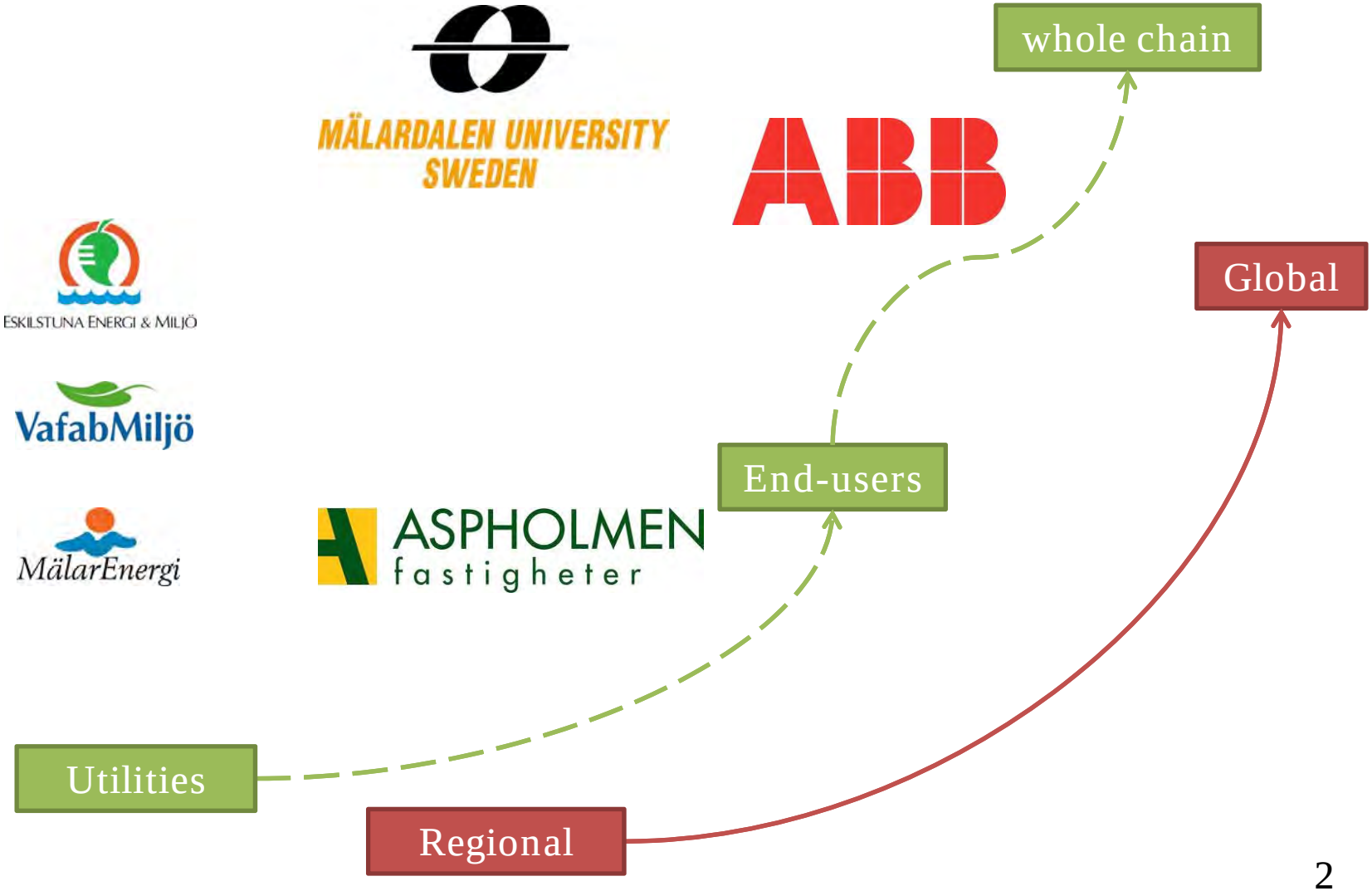
Future Energy

Brief introduction & implementation plan of the Future Energy Profile

Prof. Jinyue Yan

Director of Future Energy Profile

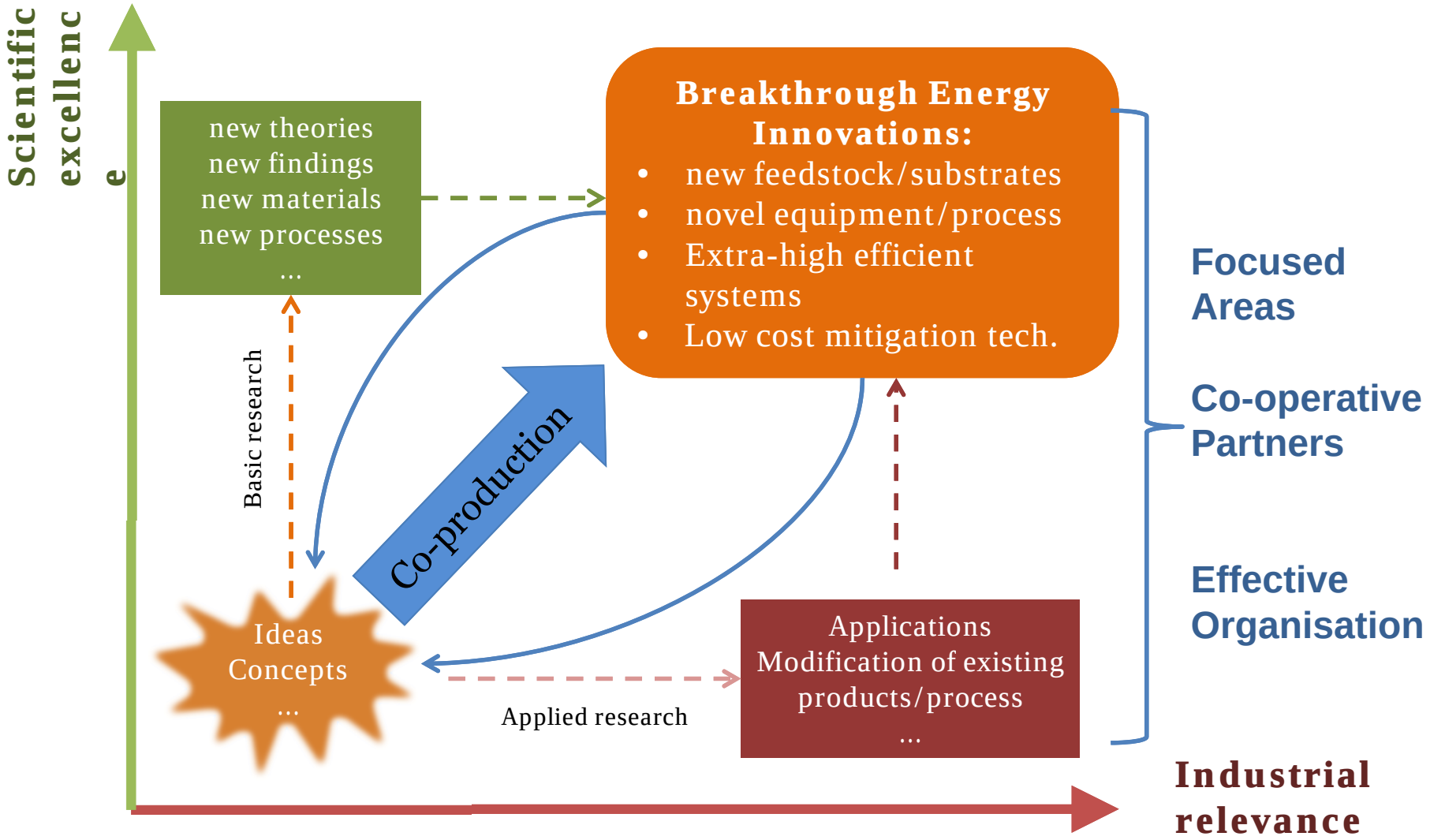
Co-production with industrial partners to strengthen region & global cooperation



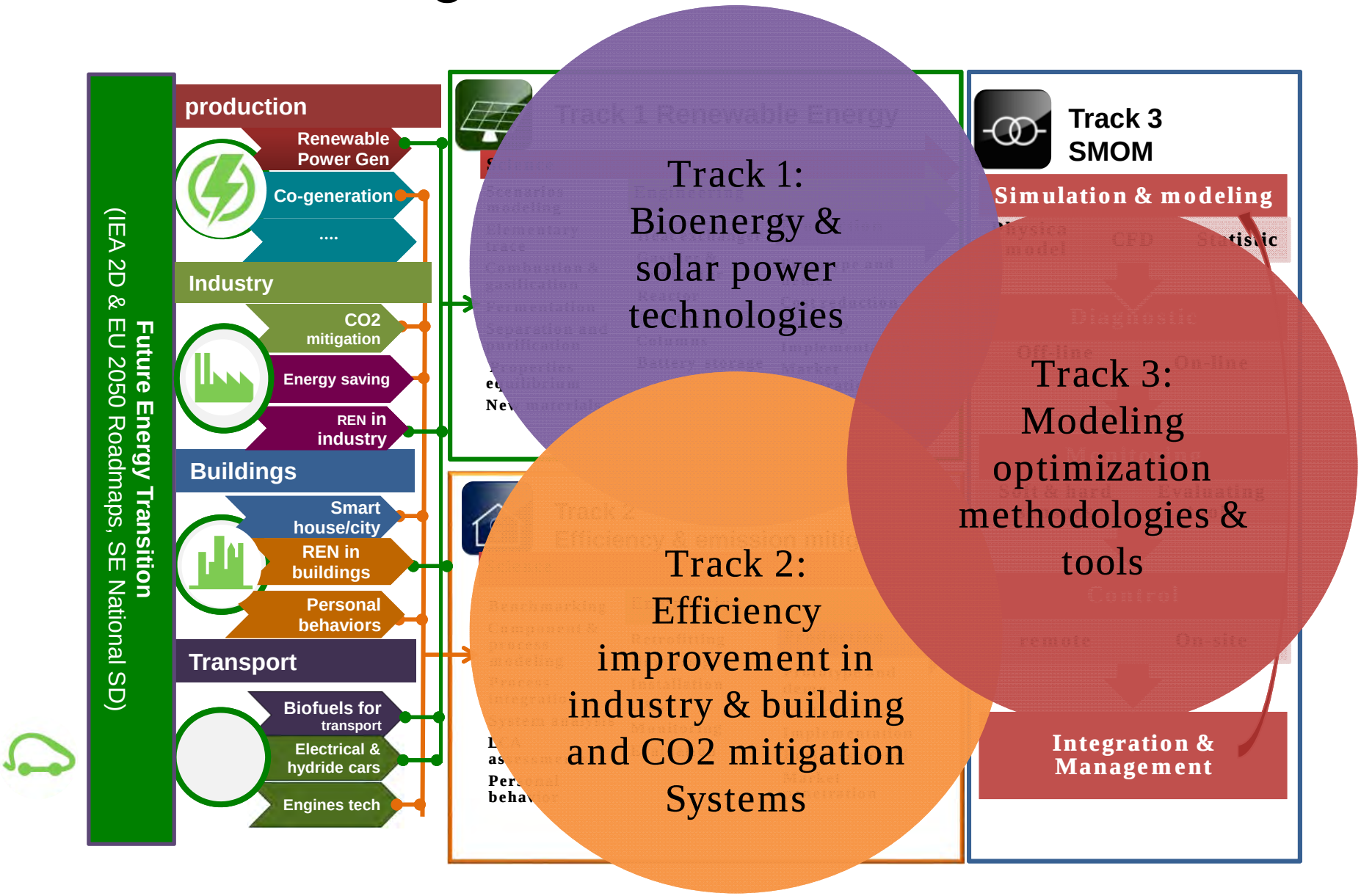
The objective of the Future Energy is to achieve scientific excellence by:

1. prioritising research areas at the international forefront of energy sciences based on future global, national and regional energy system transitions;
2. building up trusted partnerships with the industry and fully integrating with industrial expertise into the research environment; and
3. establishing an effective organisation populated by high quality team members by implementing strategic recruitments to ensure a sustainable competitive advantage.

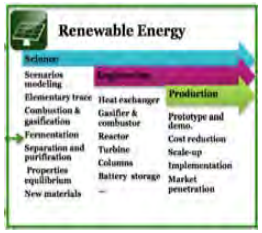
Methodology to achieve twin targets by co-production



Define 3 focused TRACKS with linkages to industrial sectors



Track 1 Renewable Energy with specific initial projects



P1: Integrated anaerobic digestion biogas production with element recovery & carbon capture

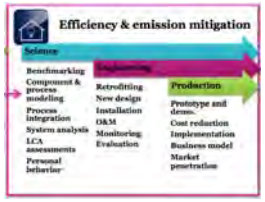
- Consortia description of micro algae and bacteria cultivated;
- Biogas process model, thermo-physical property models for CO_2 separation process;
- implementation of the property modelling in the process design,
- Characterization of element pathways to shifts in microbial growth, microbial activity and biogas production;
- new methods to minimising wastes and emissions,
- recycling of organic residues to farmland.

P2: Distributed renewable energy technologies

- Characterisation of bioenergy and solar resources to identify the technical and economic potential;
- flexible solar distributed technologies and systems;
- understanding and matching the load and resources variations;
- total system optimisation

FUTURE ENERGY
MÄLARDALEN UNIVERSITY SWEDEN
ABB
MälarEnergi
KK-stiftelsen
Eskilstuna Energi & Miljö
VafabMiljö
ESPHOLMEN fastigheter

Track 2 Efficiency & emission mitigation with specific initial projects



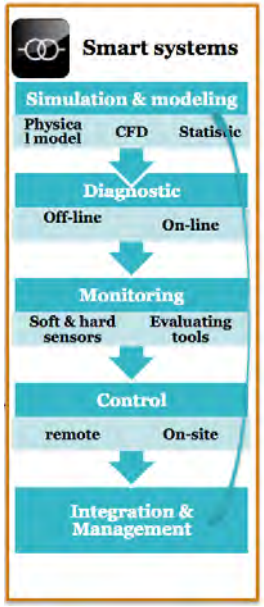
P3: BiPV with district heating and local CHP

- Quantitative and qualitative evaluation of PV cells;
- Tools and system to integrate PV with district heating system;
- Benefits assessment for local customer and the electric and district heat provider.

P4: Advanced electric & thermal energy storage systems

- Identification of the energy storage characteristics and needs for electric and/or thermal applications;
- Flow batteries for balancing electricity over seconds to day;
- mobilised thermal system (M-TES) for distributed heating users;
- Modules designs and pilot tests; & scale-up
- Domestic hot water storage for PV.

Track 3 Smarter modeling/optimization and management with specific initial projects



P5: Internet of Energy

- A new modelling framework for interaction between energy users and providers;
- Integration of existing data streams (e.g. Smart Meters);
- Systematic study on new technologies, business models and policy incentives

P6: Optimisation & control tools for industrial processes

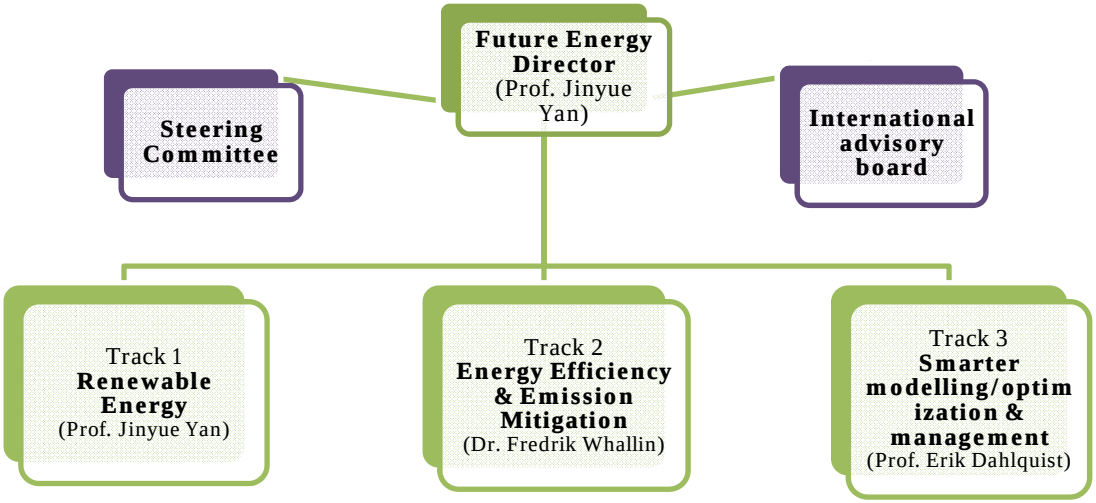
- Methodologies & tools for measurement, diagnostic, monitoring, and control;
- Demonstration on different applications in power plants, pulp and paper mills, steel process and activated sludge and biogas production processes;
- On-line control of processes

P7: Modelling and effective control of biogas production

- Test facility of the anaerobic digestion;
- identify key process parameters incl. influence on mixing;
- Analytical and CFD models for biogas production,
- Process simulation of biogas upgrading;
- Recommend control strategy

FUTURE ENERGY SWEDEN ABB MälarEnergi KK-stiftelsen Eskilstuna Energi & Miljö VafabMiljö SPHOLMEN fastigheter

FE Management & sustainable recruitment plan



Career track	2013	2014	2015	2016	2017	2018	2019
Professor							
Associate Professor							
Assistant Professor							
Post-docs (4 new)							
PhD students (4 new)							
Guest Professors		X	X	X	X	X	X
Visiting scholars	X	X	X	X	X	X	X

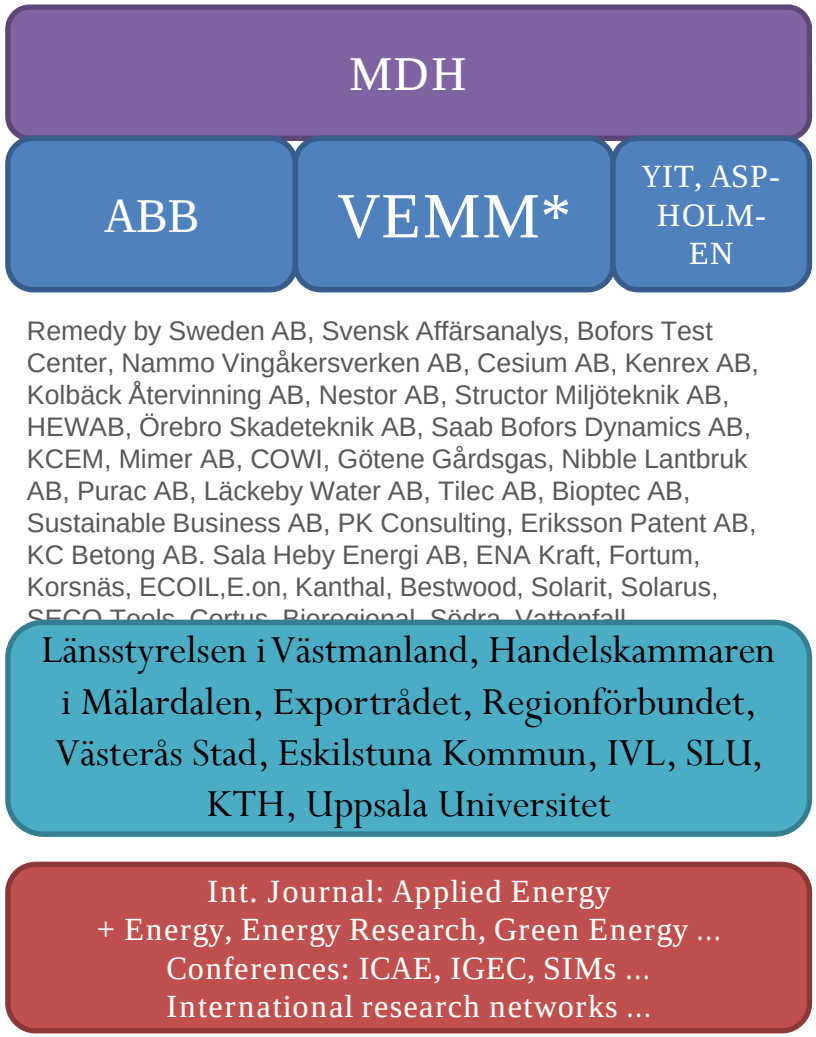
MDH
Professor Jinyue Yan
Professor Erik Dahlquist
Professor Björn Karlsson
Professor Bert Alard
Associate professor Eva Thorin
Associate professor Monica Odlare
Dr. Emma Nehrenheim
Dr. Fredrik Wallin
Dr. Hailong Li
Professor Sergei Silvestrov
Dr. Patrik Klimberg
Senior researcher
New Post docs
Doctoral students

ABB
Professor Rebei Bel Fdhila
Tomas Lagerberg
Dr. Bengt Stridh
Lars Krantz
Dr. Carl-Fredrik Lindberg
Dr. Birger Drugge

VEMM
Dr. Carina Färm (EEM)
Laboratory staff (EEM)
Anders Ericsson (ME)
Niklas Gunnar (ME)
Laboratory staff (ME)
Per-Erik Persson (VM)

YIT & AH
Daniel Åkervall (YIT),
Joakim Riström (AH),

Co-production in Future Energy



Future Energy, KKS

Dissemination and co-production to SME and other organisations

International market & network of Swedish companies incl. CleanTech export

*VEMM: (Vafab Miljö, Eskilstuna Energi och Miljö, Mälarenergi)

AppliedEnergy

UNi-LAB

UNL

UNi-LAB

Applied Energy - Celebrating 40 years of innovation in energy research

1975 - 2015

www.applied-energy.org

ELSEVIER

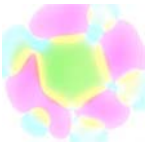
UNi-LAB

Applied Energy: Collective Intelligence

Applied Energy Journal – ICAE (Annual Conf.) – AEii (Innovation Platform) – Topic based Symposium (e.g. CUE) – UNi-LAB

Innovation

cue
Low-carbon Cities & Urban Energy



30K World-wide

Experts in Energy

Journal

Conferences

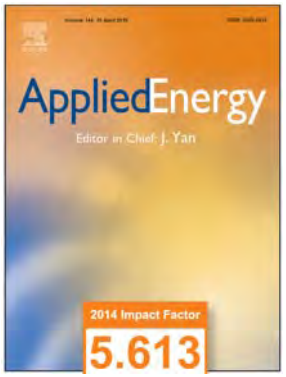
- ICAE
- CUE …

- AEii
- Uni-LAB

UNi-LAB

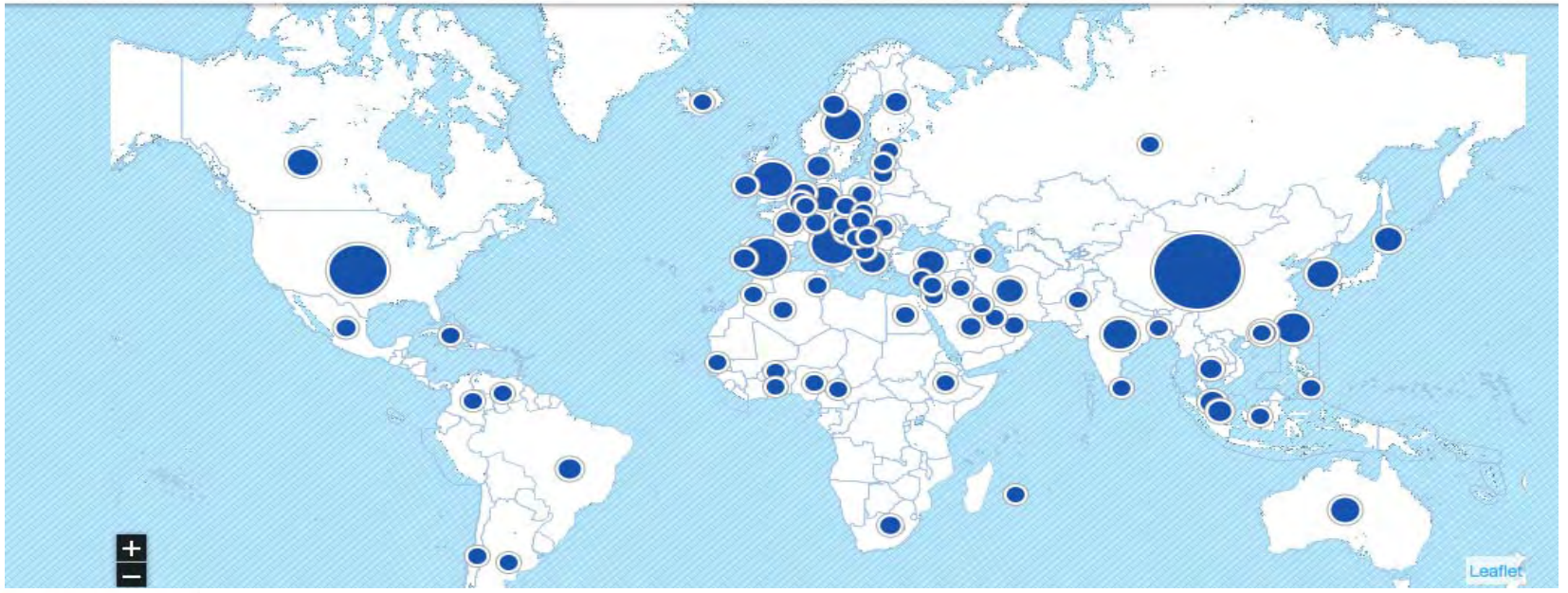
Applied Energy

over 30 K engineers and scientists, 2.5 million downloads per year. Experts from over 100+ countries



Overview of Authors

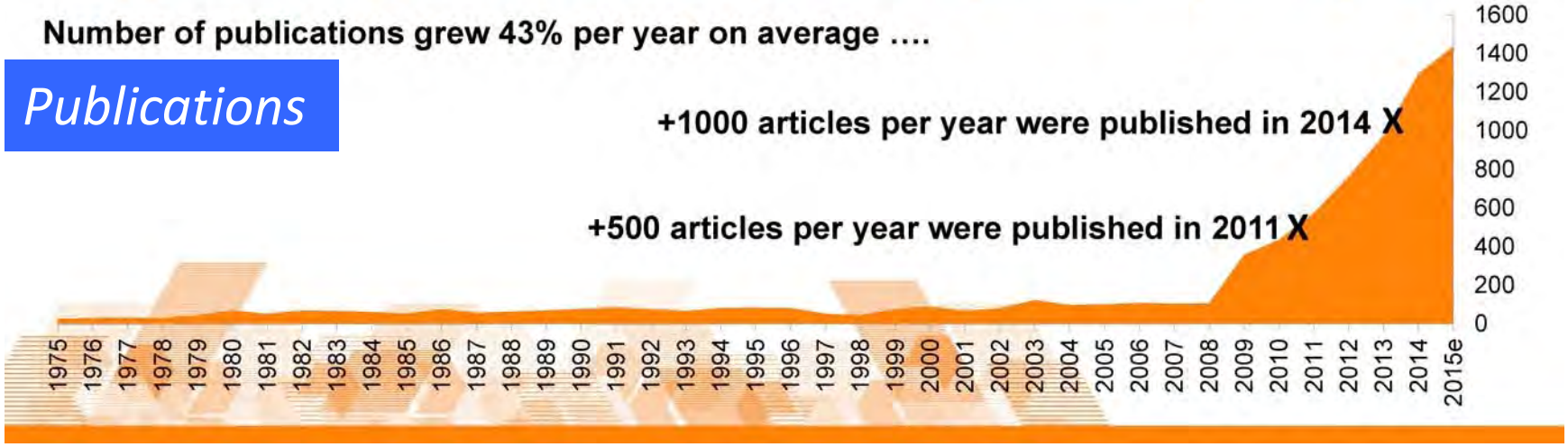
Indication of origin of the corresponding authors



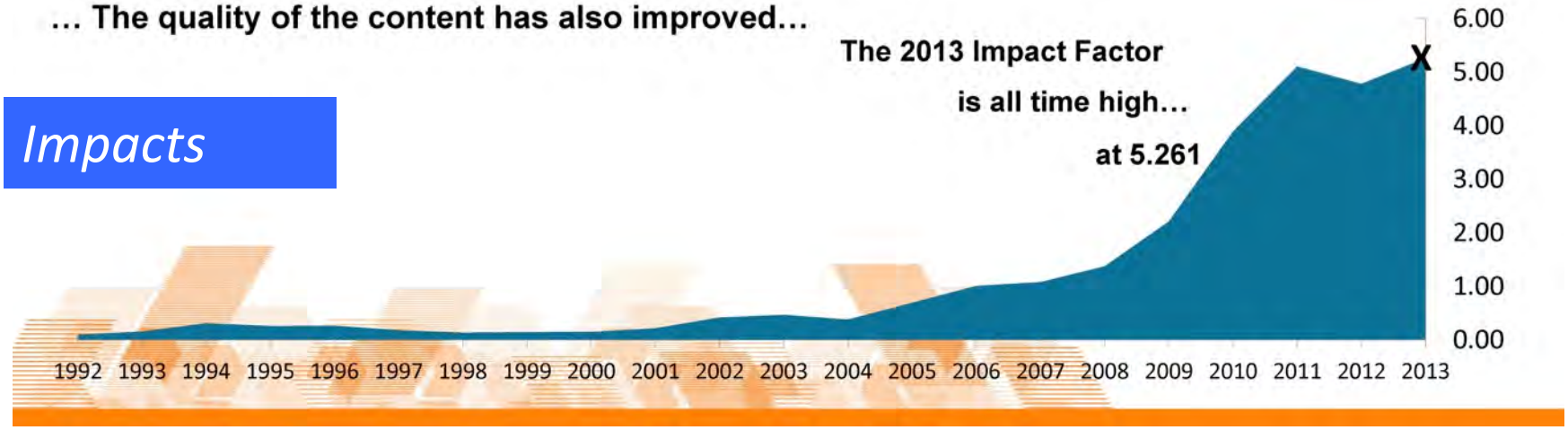
UNi-LAB

Applied Energy has flourish exponentially over the past 7 years

Publications



Impacts



UNi-LAB

Applied Energy has flourish exponentially over the past 7 years

Usage: 2.2 Million article downloads in 2014 via ScienceDirect

Market value of Applied Energy = 2,250,000 X 42 USD = 94 500 000 USD

UNi-LAB

International Conference on Applied Energy

Call for Papers:

ICAE2016:

The 8th International Conference on Applied Energy

Beijing

Oct 8-11, 2016

www.applied-energy.org

UNi-LAB

Why UNi-LAB?

Ideas need to not only *meet* and but also *mate*:

To make ideas have sex - mating minds ➔ Innovation.

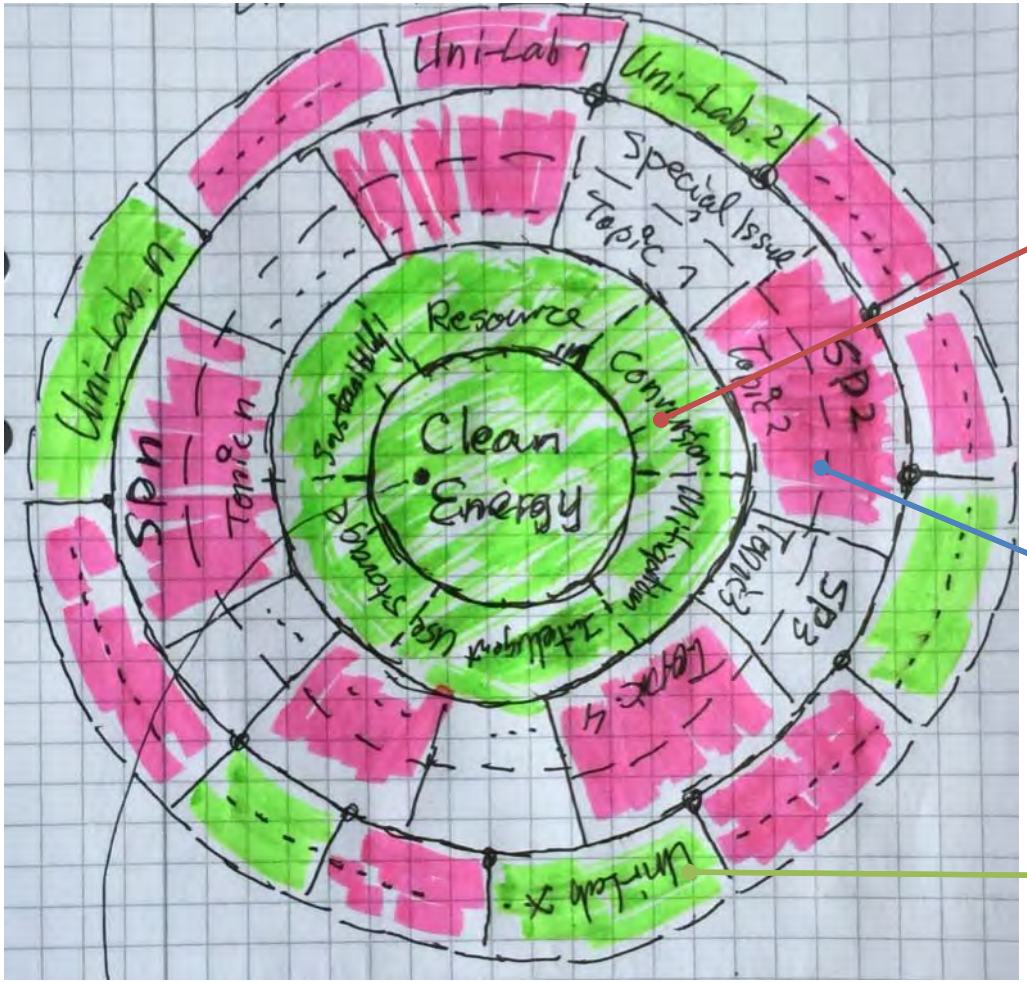
Evolution can happen without sex; but it is far, far slow.

A tool by one person

A tool by hundreds of persons

UNi-LAB

Applied Energy: UNi-LAB (to UNi-HUB)



A1: Renewable
A2: Conversion Tech
A3: Mitigation Tech
A4: Intelligent Energy Uses
A5: Energy Storage
A6: Sustainability

Topics ➔
- Special Issues
- Symposium
- Consortium/Committee

UNi-LAB

Research & Innovation without Borders

UNi-LAB

Objectives/Missions

- Unlock the world's creativity to remove the traditional barriers to research and innovation.
- Empower ever-growing Applied Energy's community of researchers and innovators to find success through the Uni-LAB platform.
- Maximize the win-win benefits through international cooperation in focused topics.

UNi-LAB

UNiLAB: Status

- 10+ in pipelines:
  - Synergy to integrate electricity, heat and fuels
  - RE microgrid
  - Interdependent behavior and stretegy of clean energy systems
  - Enhanced hear transfer of emerging energy technologies
  - Energy-water nexus
  - Interaction of electricity price and demand side management/responses
  - Hydride gas energy
  - Carbon capture, utilization and storage (CCUS)
  - Waste heat recovery
  - Clean coal technologies and emission mitigation
  - Energy efficiency and of chemical processes/industry
  - 10KM2: unban energy systems
- 10+ under discussion
- UNiLAB: Small wind turbine?

UNi-LAB

Welcome to Join

UNi-LAB

Thanks

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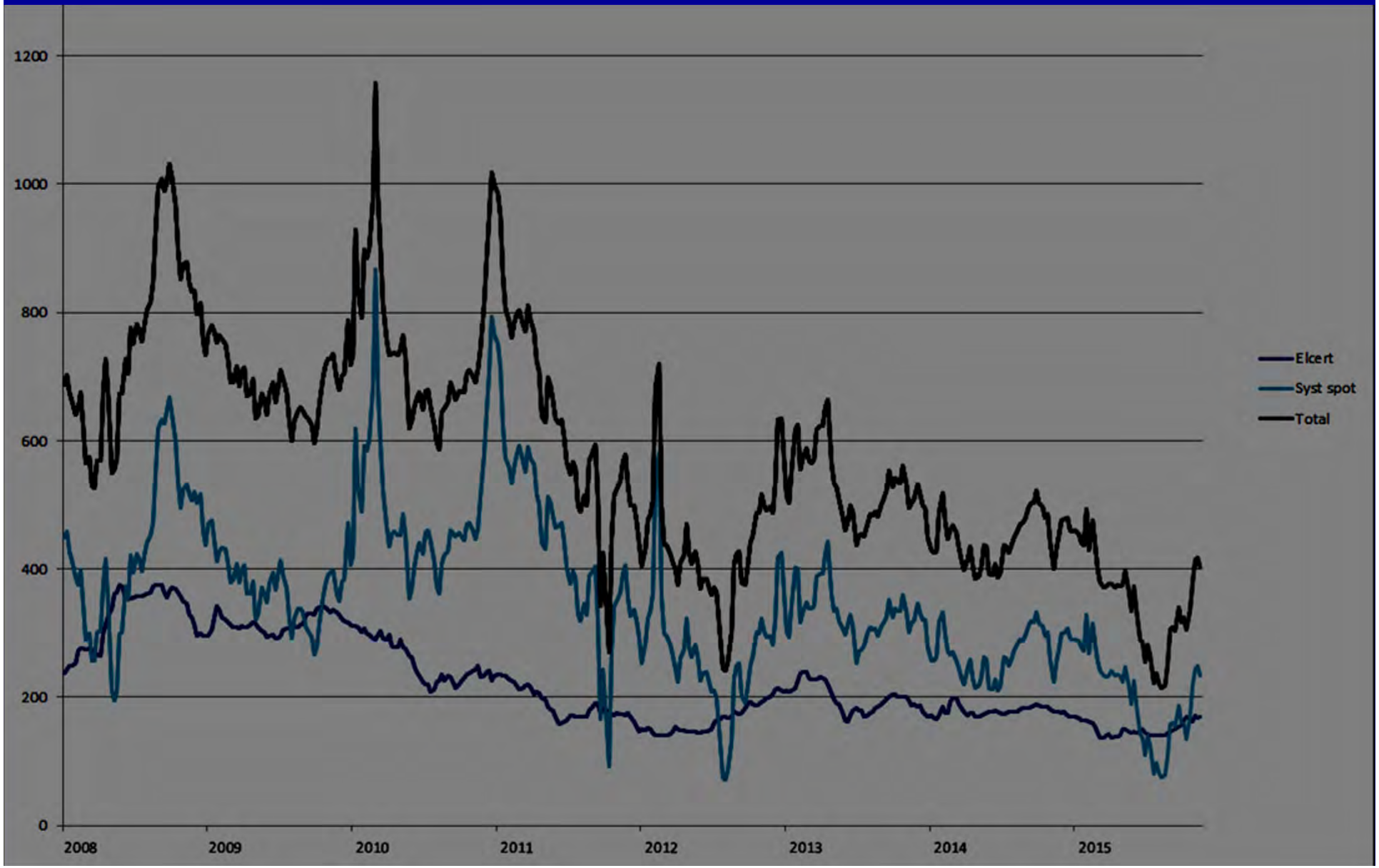
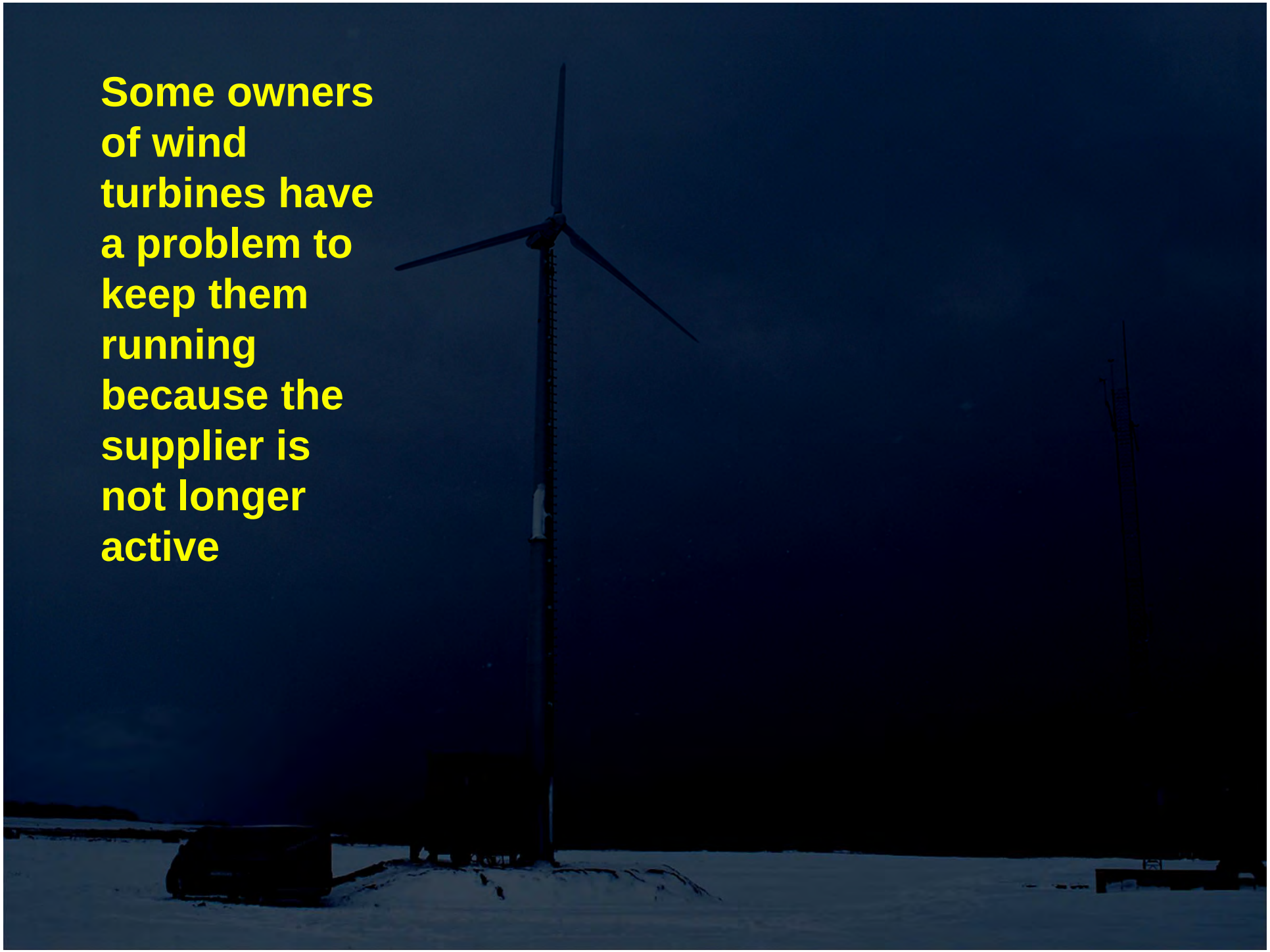
A SWEDISH PERSPECTIVE OF THE SMALL WIND TURBINE MARKET

Sven Ruin, TEROC AB and
Swedish Windpower Association

Electricity price development [SEK/MWh]




Some owners of wind turbines have a problem to keep them running because the supplier is not longer active

Attempt to find a solution

The Swedish Windpower Association has contacted the (former) owners of some Swedish manufacturers of small wind turbines, proposing that they release the design documentation as open source

Mats skrotar sitt vindkraftsprojekt

Uppdaterad 16 november 2015 16:45 · postad i Värme

Mats Jepsens satsning på ett eget vindkraftverk visade sig bli en dyrköpt affär. Kraftverket har helt slutat fungera och leverantören har gjort sig okontaktbar.

29 kommentarer

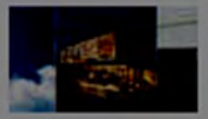
Mest läst på Värme


Inomhusluft och hälsa


Lufta elementen


Byta termostat och ventil på element


Vad kostar vattenburen golvvärme?


Allt om luft/vatten-värmepumpar

Passivhu
pulkabac

Idéer: Så
till huset

Open source

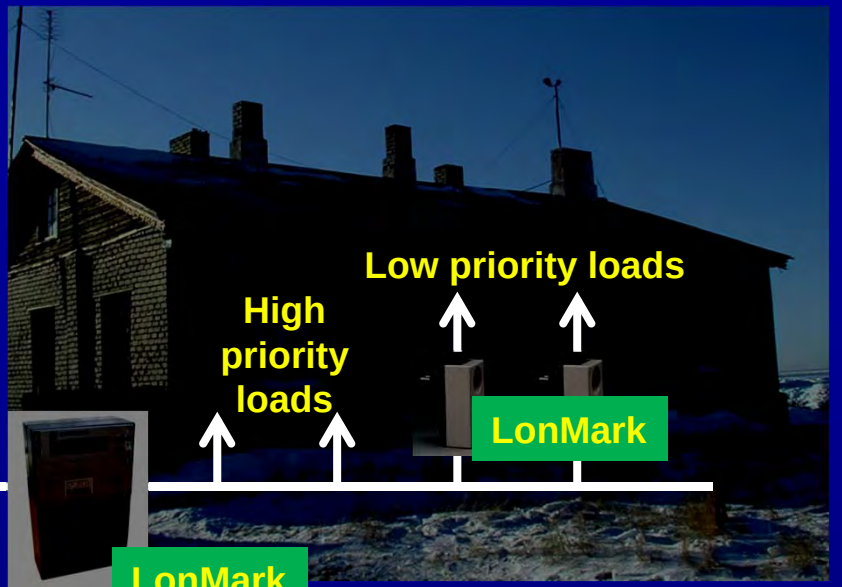
- A development model that promotes universal access via a free license to a product's design or blueprint, and universal redistribution of that design or blueprint, including subsequent improvements to it by anyone

- Not only for software – can also be used e.g. for open source hardware

- Can be important to build own knowledge, enabling spare parts to be manufactured, facilitating new ways of cooperation and creating volume. In short, a way to give some types of small wind turbines a new future!

JBA Vind, Sweden

TIP Control Modules



E.g. AC bus

Droop

LonMark

Droop

LonMark

Droop

LonMark

Droop

LonMark

LonMark

LonMark

Variable loads, e.g. pump, electric car

Logging, alarms, etc on site or remote

Examples of open source licenses

- **GNU GPL (General Public License) version 3, often used for software such as GNU/Linux**

- **CC-BY-SA (Creative Commons Attribution-ShareAlike) version 4.0, frequently used for other content such as drawings**

Example of use:

Thor Battery Monitor is free software. You can redistribute it and/or modify it under the terms of GNU General Public License as published by the Free Software Foundation, either version 3 of the License, or (at your option), any later version. It comes with ABSOLUTELY NO WARRANTY. See www.gnu.org/licenses

Thank you for your attention!

sven.ruin@teroc.se

Regulations on installing small wind turbines in Sweden

Småskaliga vindkraftverk (miniverk) – krävs det bygglov?

Patrycja Olivius
Construction engineer
Building inspector
Västerås stad

•Det krävs inte bygglov enligt plan- och bygglagen med tillhörande förordning för att bygga ett sådant vindkraftverk om inte verket ska monteras på en byggnad eller kommer uppföras på ett närmare avstånd från gränsen än verkets höjd.

Building permit is not required unless the wind turbine is placed on a building or when the distance between the site boundery and the wind turbine is shorter than the wind turbine´s heigh. (the Planning and Building Law)

•Om två eller fler vindkraftverk ska stå tillsammans omfattas verksamheten av anmälningsplikt enligt miljöbalken.

For två or more wind turbines reporting is required according to the Swedish Environmental Code.

•Även om inte bygglov behövs för miniverk krävs det anmälan enligt 6 kap. 5 § pkt 7 plan- och byggförordningen. Anmälan ska ske vid nybyggnad eller väsentlig ändring av ett miniverk. Anmälan ska innehålla underlag för att kommunen ska kunna granska om vindkraftverken uppfyller de tekniska egenskapskraven som anges i 8 kap. plan- och bygglagen. Det behövs en kontrollplan!

•The application to the municipality should fulfill all the technical requirements based on the Planning and Building Law (purpose, dimensions, noise emissions, situation plan, form, technical report).
•The application is required when constructing the wind turbine or with substantial modification of the wind turbine.

•Uppförande av vindkraftverk får inte påbörjas innan byggnadsnämnden har gett ett startbesked. Innan vindkraftverket får tas i bruk ska ett slutbesked erhållas.

The Building Department gives starting clearance in order to start building and end clearance before the wind turbine is in use.

Kommunens översiktsplan

- Översiktsplanen kan innehålla policy och principer som även berör miniverk.

The municipality has the layout plan that can show the policy for building the wind turbines as well as windconditions.

Detaljplan
Detailed development plan

Anger hur ett begränsat område i en kommun skall bebyggas och hur mark- och vattenområden får användas.
Vindkraftsbyggande ska inte stridas mot detaljplanen för området.

Detailed development plan describes how a smaller area within a municipality should be used. The wind turbines construction cannot be in conflict with it. Sometimes it can be a matter of judgement.

Andra infrastrukturintressen

Vindkraftverk kan påverka den tekniska infrastrukturen på olika sätt:

- Väderradar
- I och intill skärgård, farleder och hamnar krävs sådant avstånd från farlederna att sjöfartens framkomlighet och säkerhet inte störs
- Säkerhetsavstånd krävs till vägar, järnvägar och kraftledningar

he wind turbines can have impact on weather radar, waterways, ports, roads, ailways and power lines.

Natur, kultur & landskap

Hänsyn till lokala natur-, kultur- och landskapsvärden ska alltid tas. Berörs områden och värden som är skyddade med stöd av lagstiftning gäller särskilda regler och hänsyn.

The applicants should take into account the local natural, cultural and landscape values.

Hälsa & säkerhet
Health and safety

- ljud, skuggor, reflexer och ljus, nedisning samt säkerhet och riskavstånd.

sound, shadows, reflections and light icing as well as safety and risk distance.

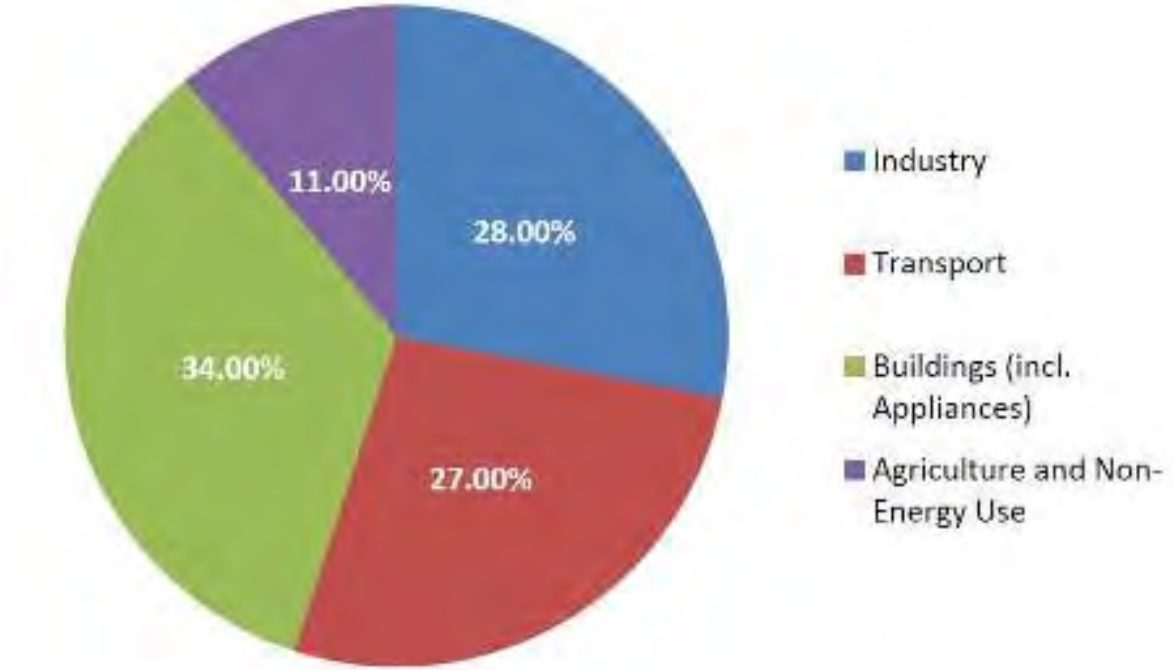
Frågor?
Questions?

patrycja.olivius@vasteras.se
tel: 021 – 39 12 98

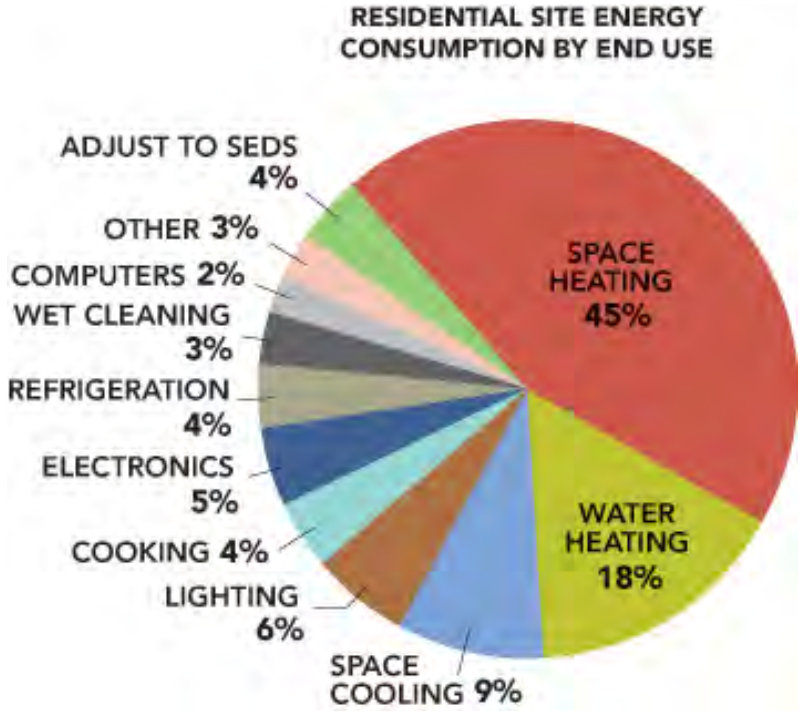
Developing a heat pump system driven by wind power

Hailong Li, Pietro Campana, Sara Berretta, Isabelle Hagström
EST, Mälardalens University
2016-01-15

Energy consumption in building sector



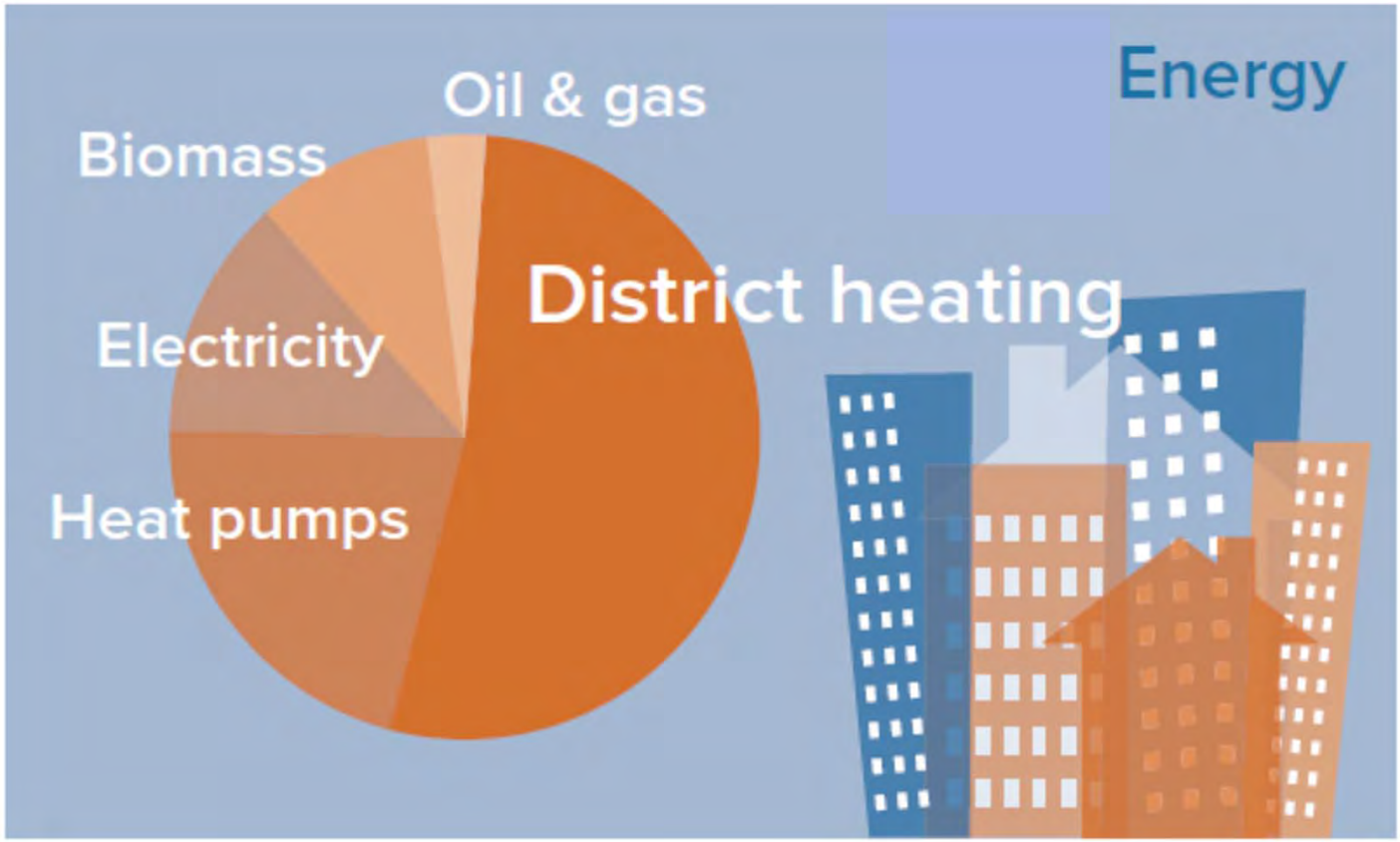
IEA 2012



http://buildingsdatabook.eren.doe.gov/ChapterIntro2.aspx

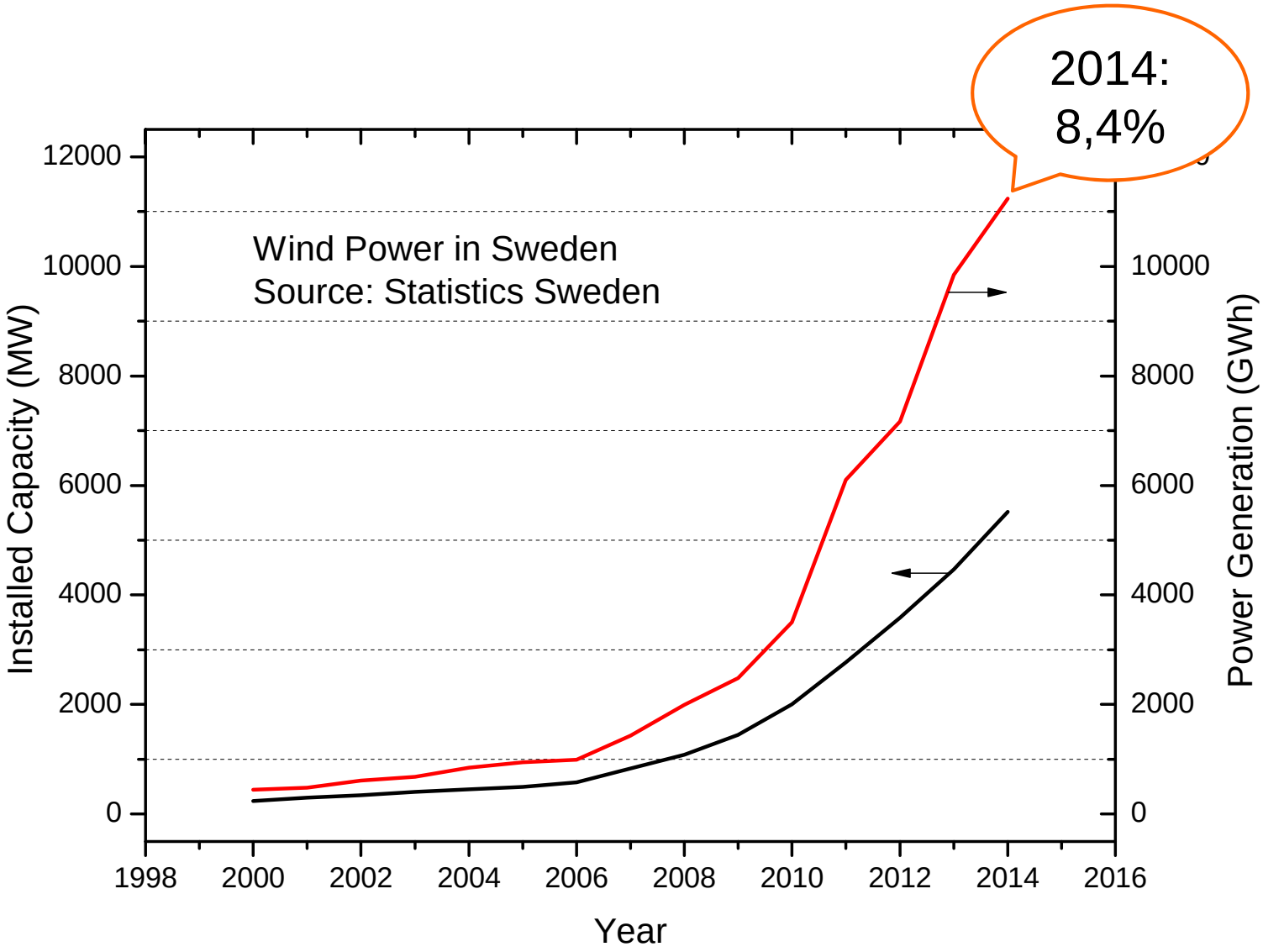
- In Sweden, energy for space heating and DHW production reached 100TWh in 2014
- To reduce the consumption of energy in buildings by 20% up to 2020 and by 50% up to the 2050, in comparison with the levels in 1995.

Space heating

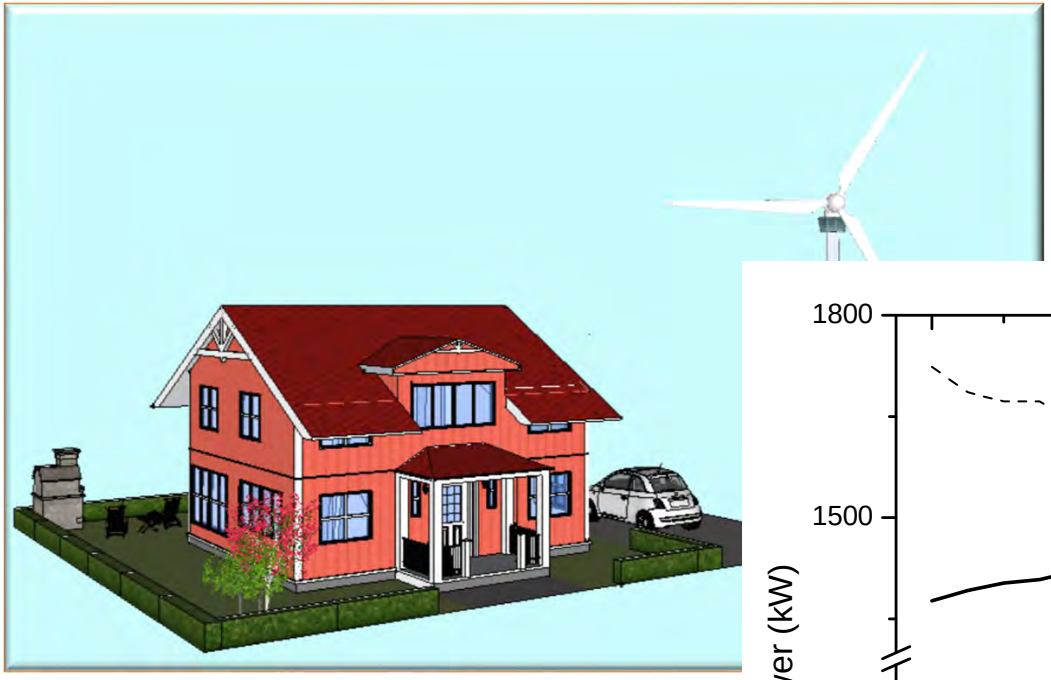


Source: Värmemarknad Sverige, The heating market in Sweden

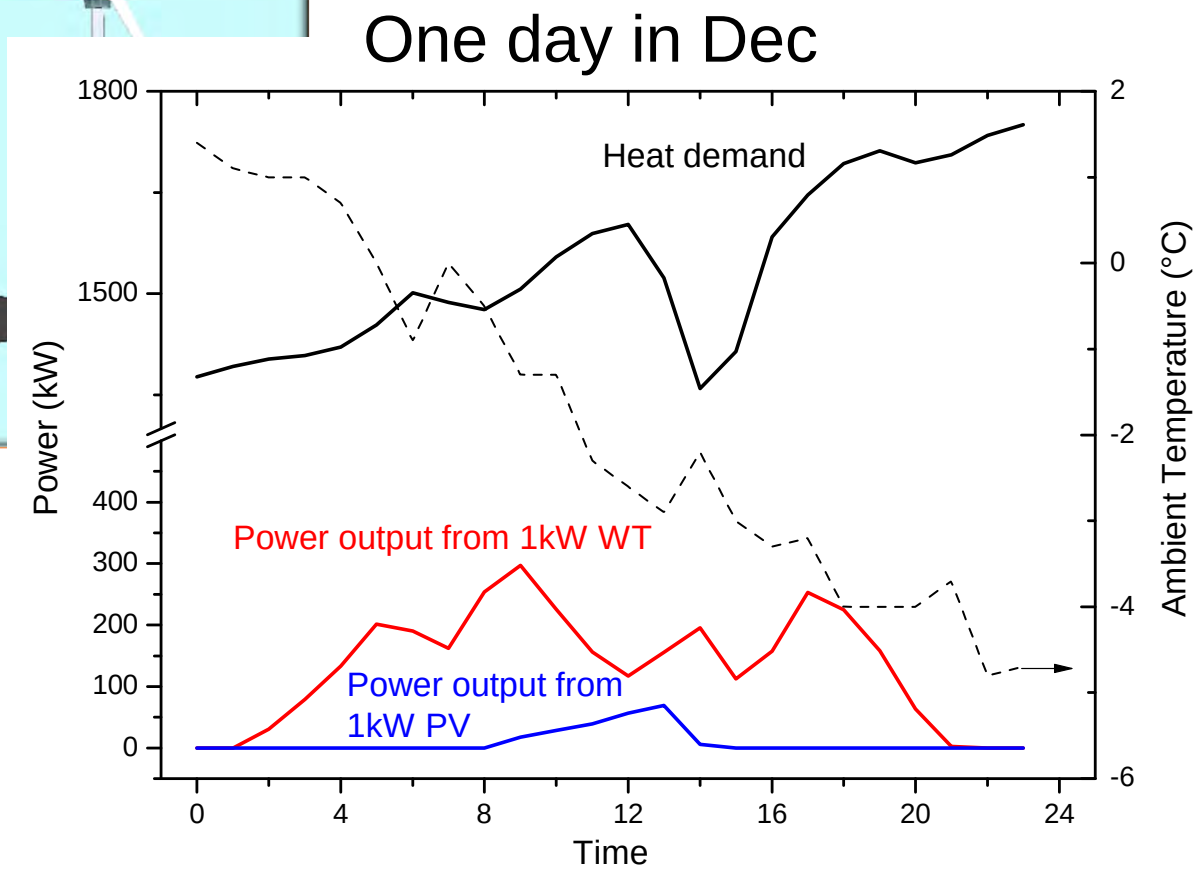
Wind power in Sweden



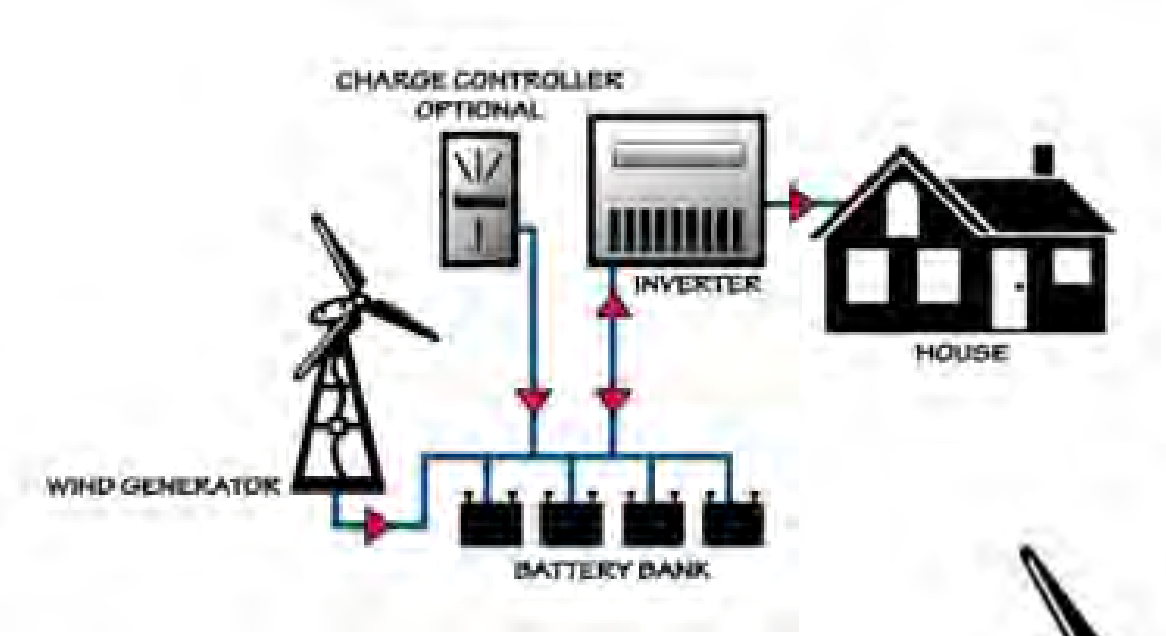
Heat supply for detached houses

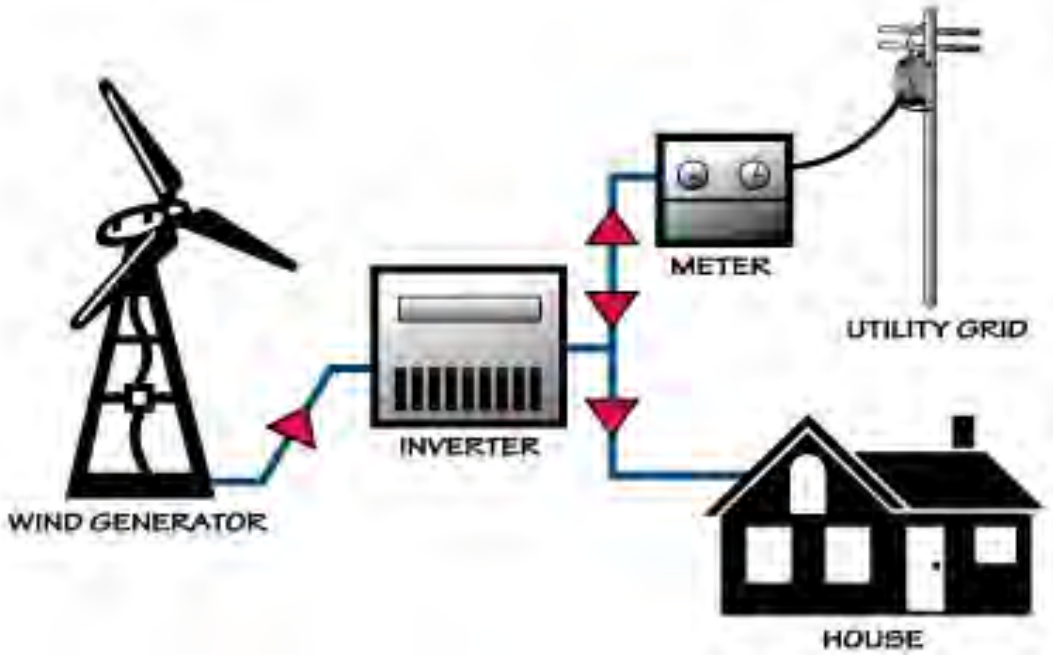


- South-Facing
- 2 Floors
- Total floor area 153m2
- Total heated volume 374.8 m3

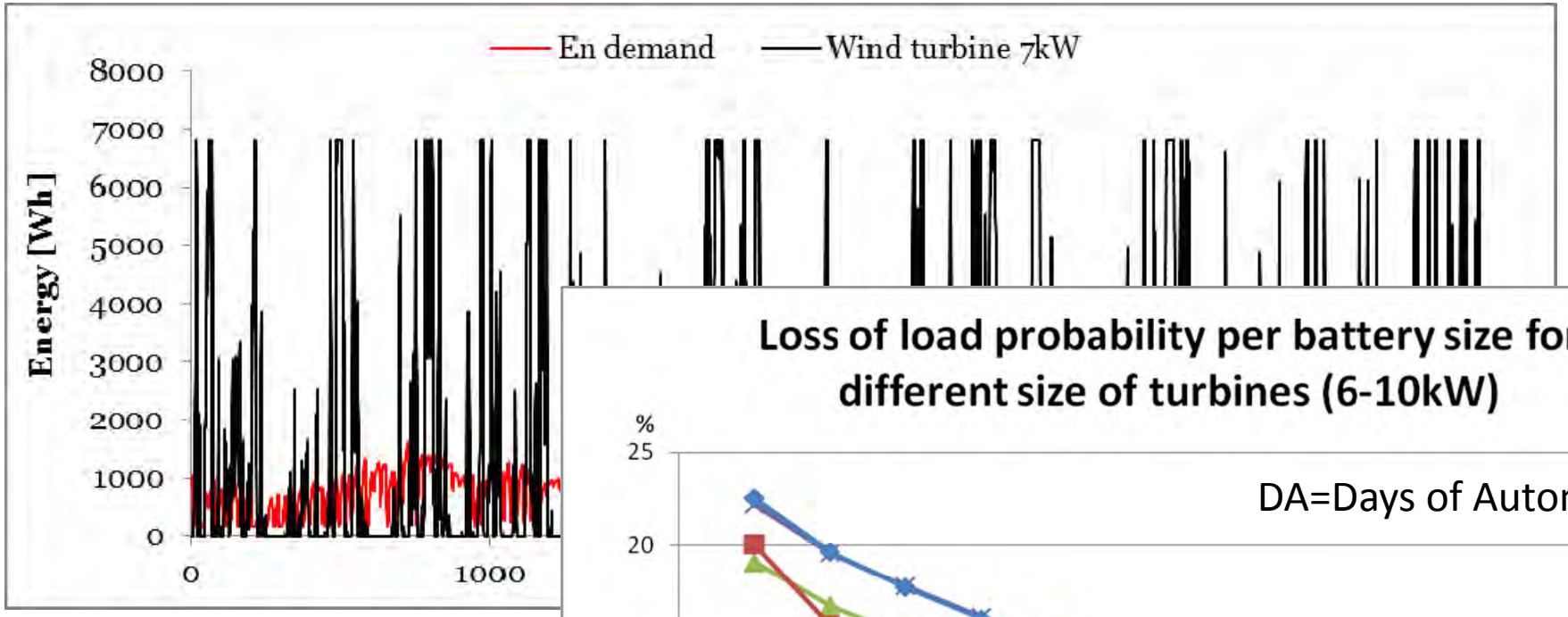


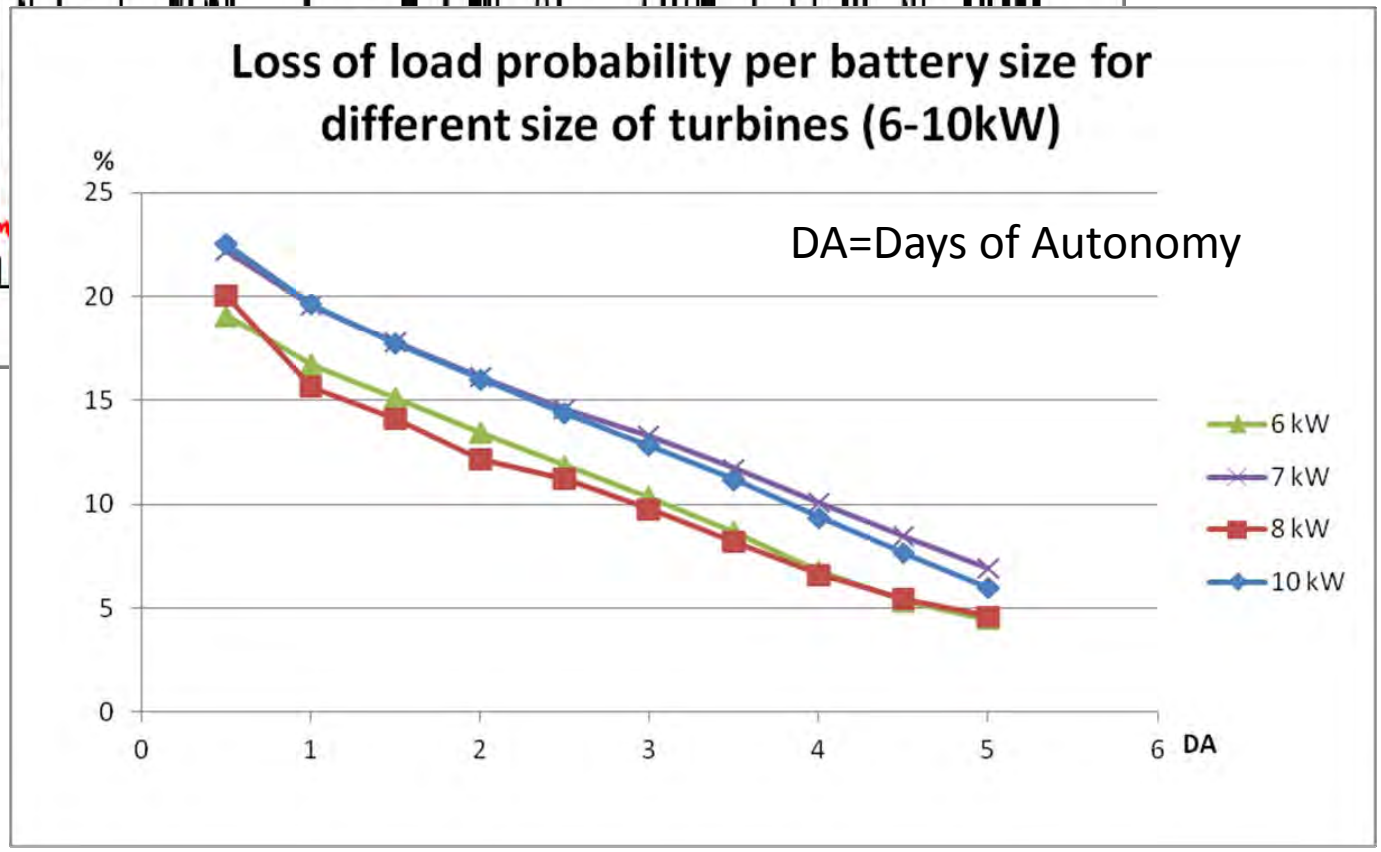
Wind Power driven Heat Pump configuration



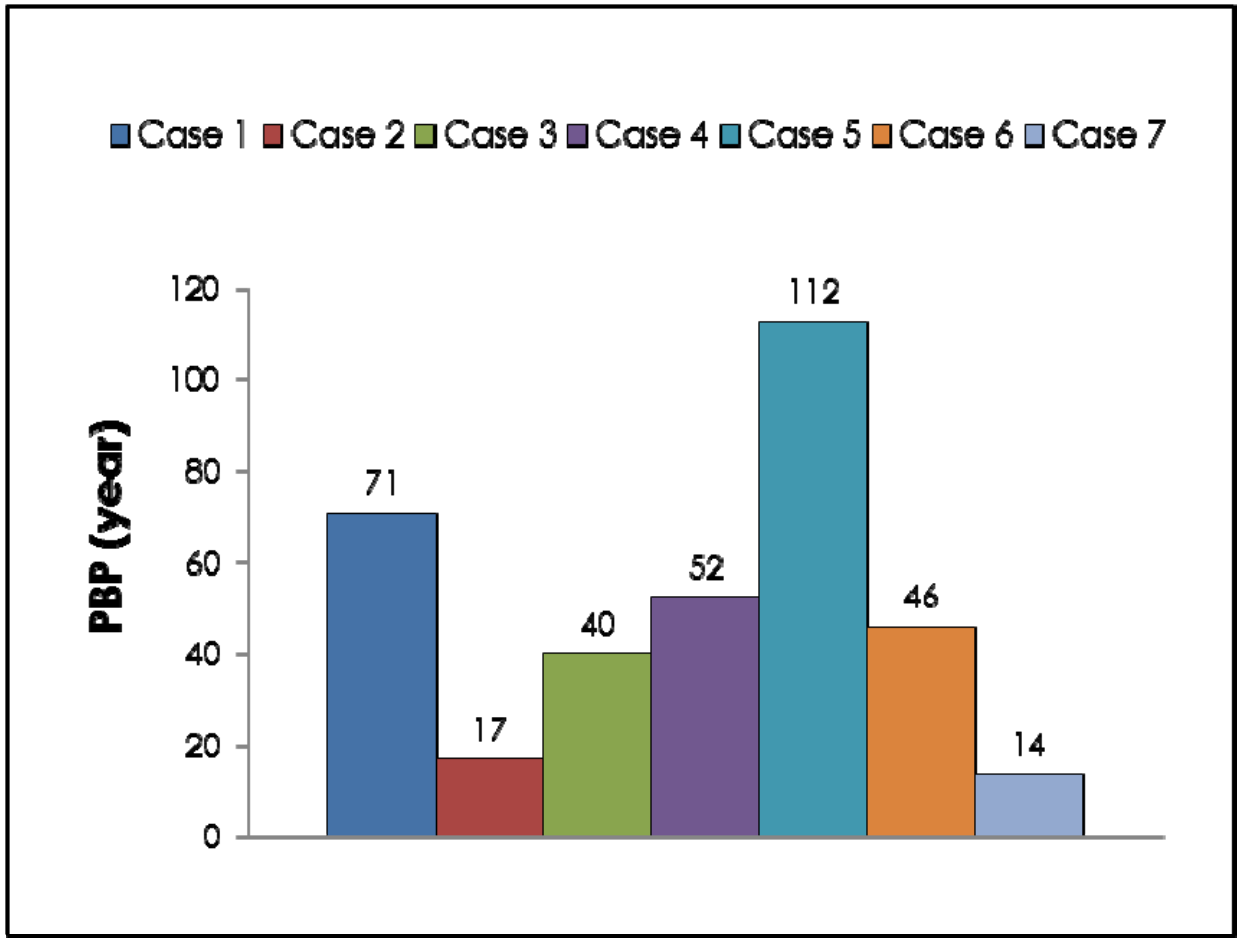


Technical feasibility of WP-HP





Economic feasibility



Case1: system without battery
Case 2: system without battery with the possibility to sell electricity (0,06983 €/kWh)
Case 3,4,5: system with battery (DA= 0,5;1;2)
Case 6: same as system 1, but with 24m pole
Case 7: same as system 1, but with 24m pole

Assumptions: WT: 989,6 €/kW, Pole cost of 88,4 €/m, Inverter 149,9 €/kW, Foundation: 587 € for 4 m2, electricity price = 0,2063 €/kWh, battery price: 108 €/kWh, Engineering and installation: 20% of the capital cost

Suggestions

- *Thermal energy storage instead of battery*
- *Integration of cooling demand*
- *Good business model/policy*

Acknowledgments

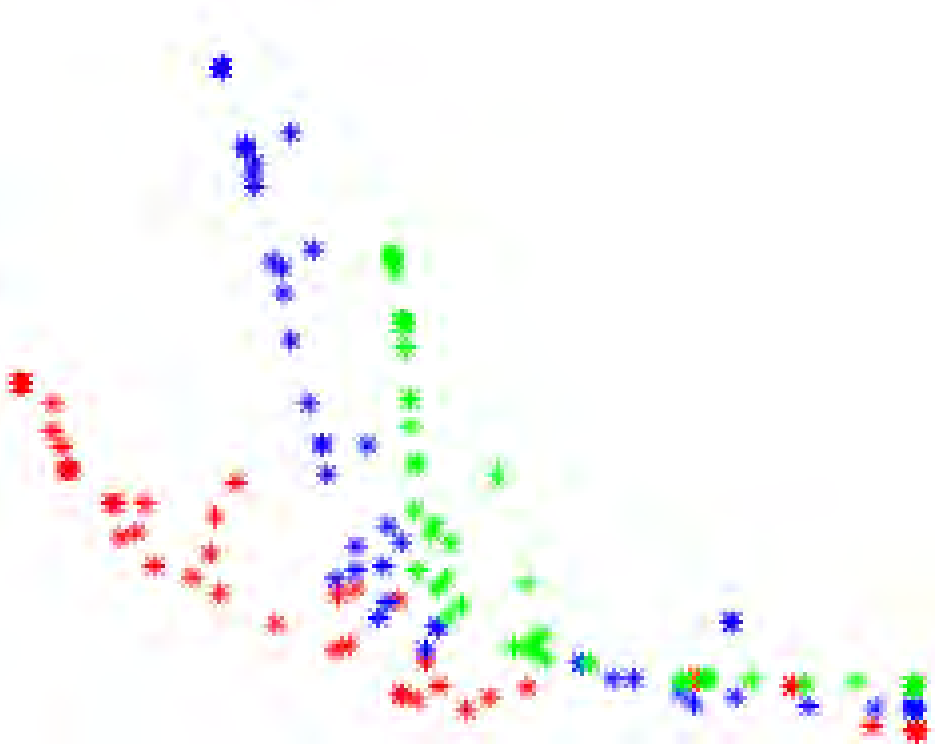
SWECO

TEROC

Thank you!

Optimization of hybrid power systems

P.E. Campana



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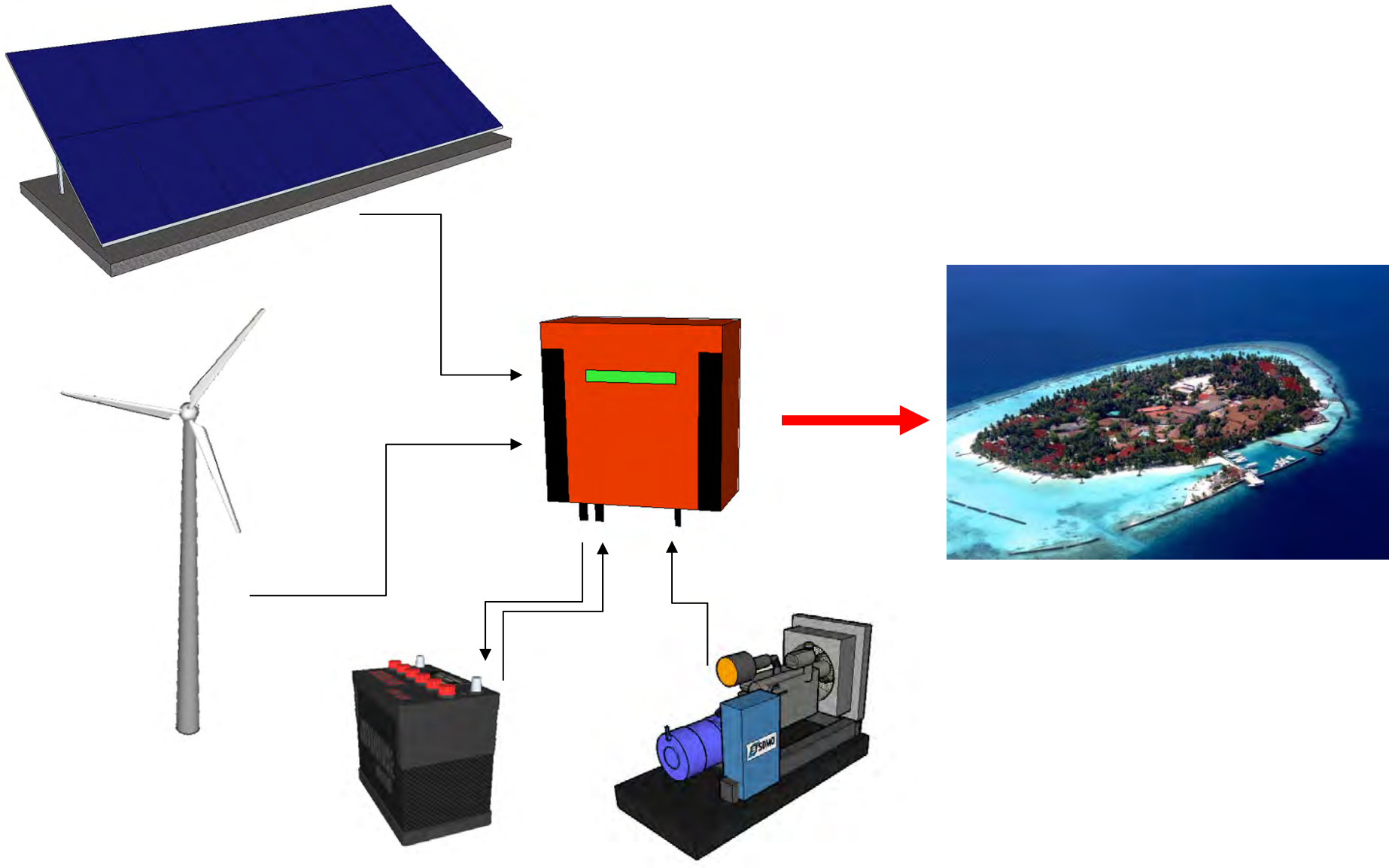
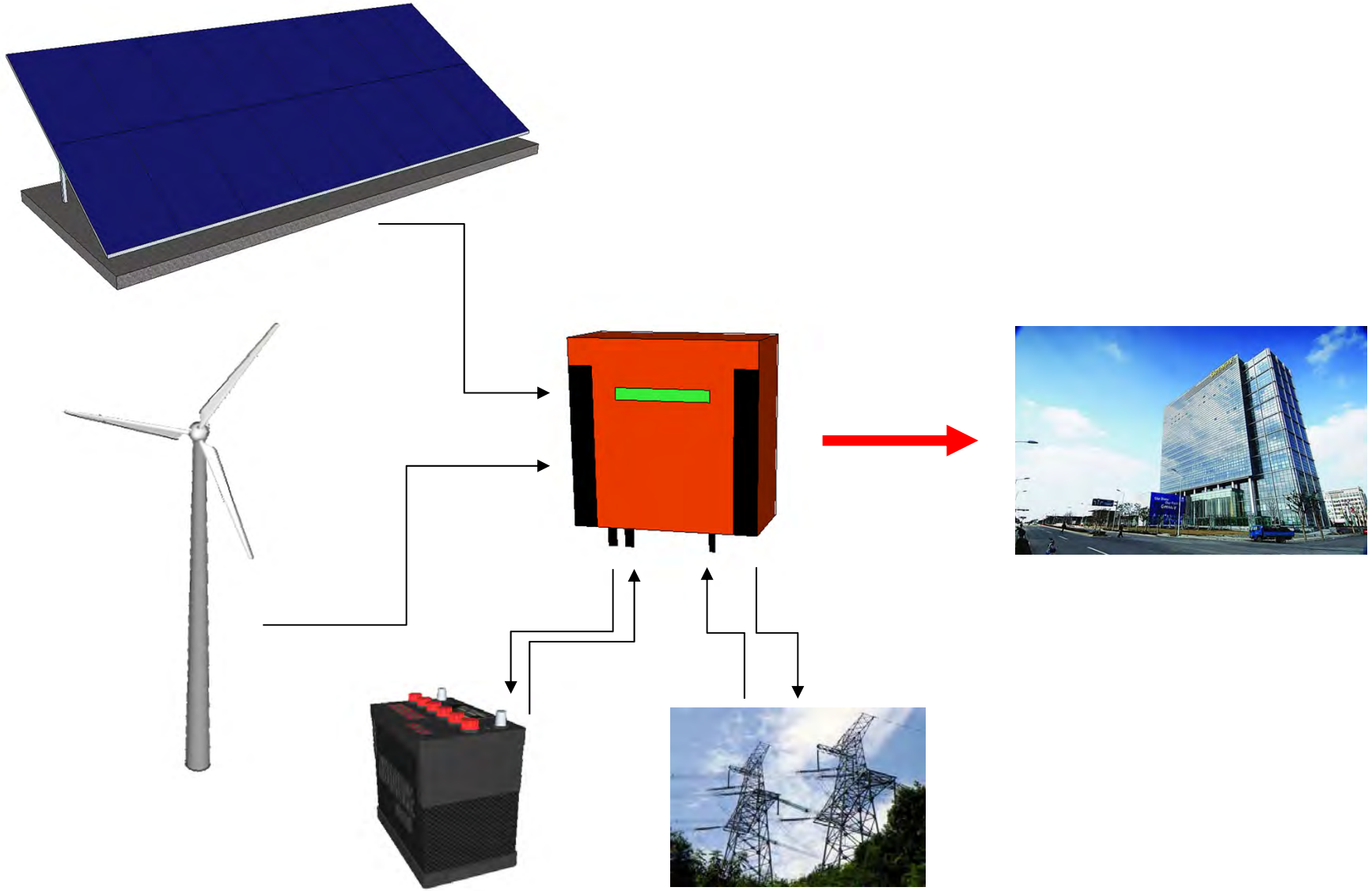
Hybrid power generation systems (1)



Hybrid power generation systems (2)



Model and model development

- Photovoltaic model

$$P_{PV} = \eta_{PV} A_{PV} G_{g,t}$$

$$\eta_{PV} = \eta_{PV,STC}\left[1 + \frac{\mu}{\eta_{PV,STC}}(T_a - T_{STC}) + \frac{\mu}{\eta_{PV,STC}}\frac{(NOCT - 20)}{800}(1 - \eta_{PV,STC})G_{g,t}\right]$$

$$\mu \approx \eta_{PV,STC}\frac{\mu_{V_{oc}}}{V_{mp}}$$

→ I-V curve

- Wind turbine model

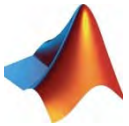
$$P_{WT} = \begin{cases} P_r \dfrac{v^k - v_c^k}{v_r^k - v_c^k} & (v_v \le v \le v_r) \\ P_r & (v_r \le v \le v_f) \\ 0 & (v < v_c \text{ and } v > v_r) \end{cases}$$

- Battery model

$$SOC(t) = SOC(t-1)(1-\sigma) + \left[E_{pro}(t) - \frac{E_{load}(t)}{\eta_{inv}}\right](charging)$$

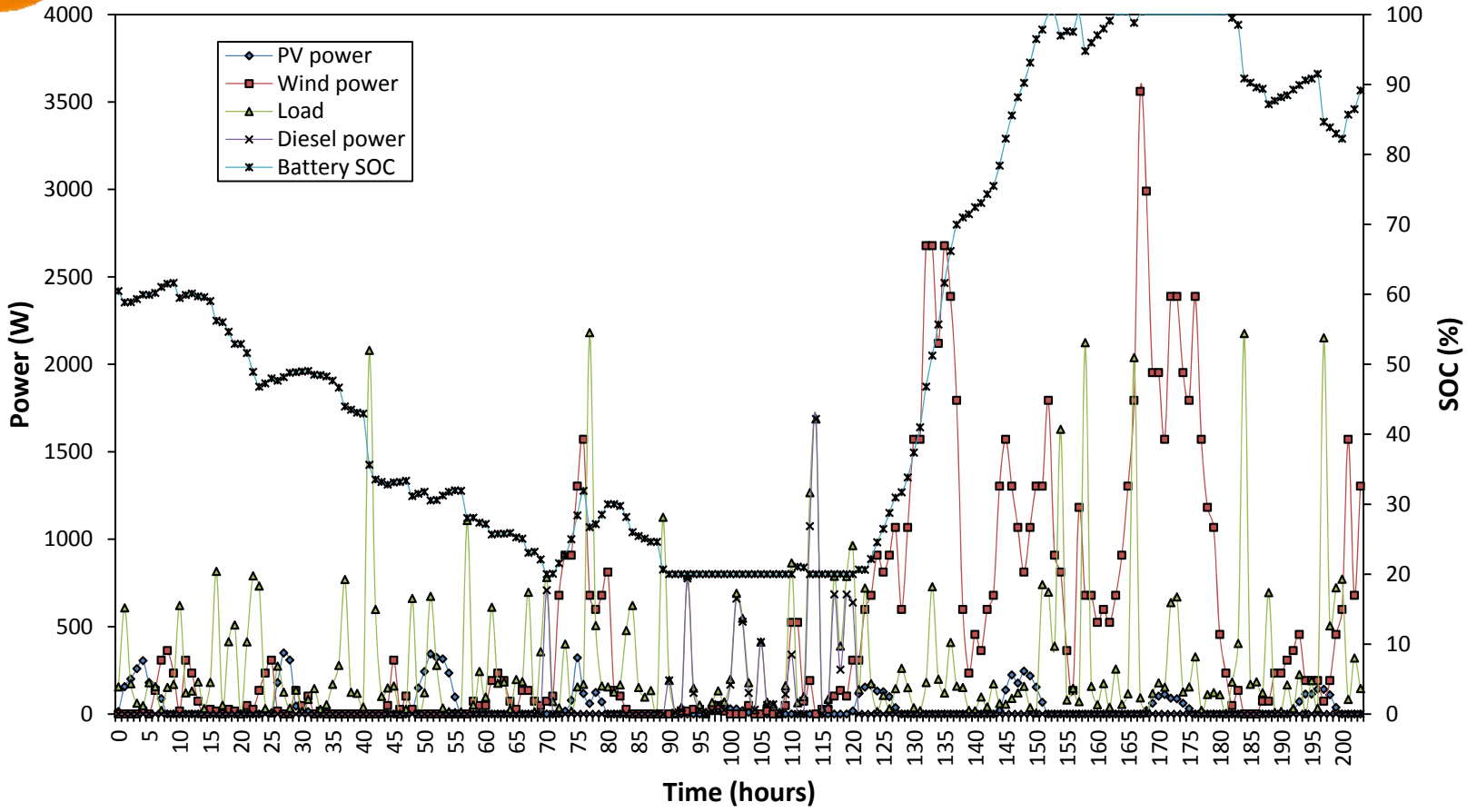
$$SOC(t) = SOC(t-1)(1-\sigma) + \left[\frac{E_{load}(t)}{\eta_{inv}} - E_{pro}(t)\right](discharging)$$

→ NREL model

→ 

J.A. Duffie, W.A. Beckman, “Solar engineering of thermal processes”, 3rd ed. Wiley; 2006.
T. Ma, H. Yang, L. Lu, J. Peng, “Technical feasibility study on a standalone hybrid solar-wind system with pumped hydro storage for a remote island in Hong Kong”, Renewable Energy 69 (2014) 7e15
A. Kaabeche, M. Belhamel, R. Ibtiouen, “Techno-economic valuation and optimization of integrated photovoltaic/wind energy conversion system”, Solar Energy 85 (2011) 2407–2420

How does it work?



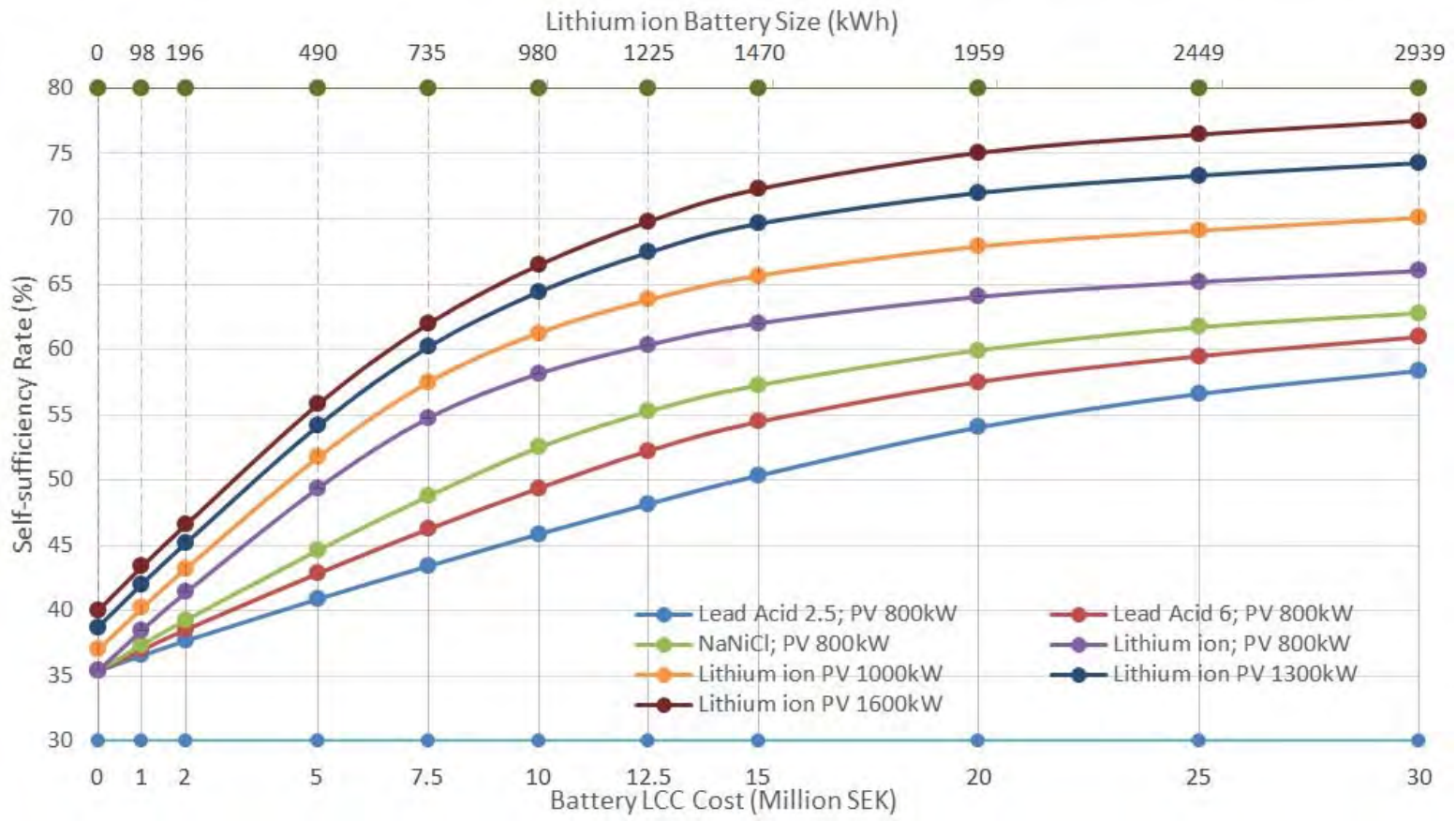
DECISIONAL VARIABLES

- PV PEAK CAPACITY
- TILT AND AZIMUTH ANGLES
- WIND TURBINE CAPACITY
- WIND TOWER HEIGHT
- BATTERY CAPACITY

OPTIMAL SYSTEM CONFIGURATION

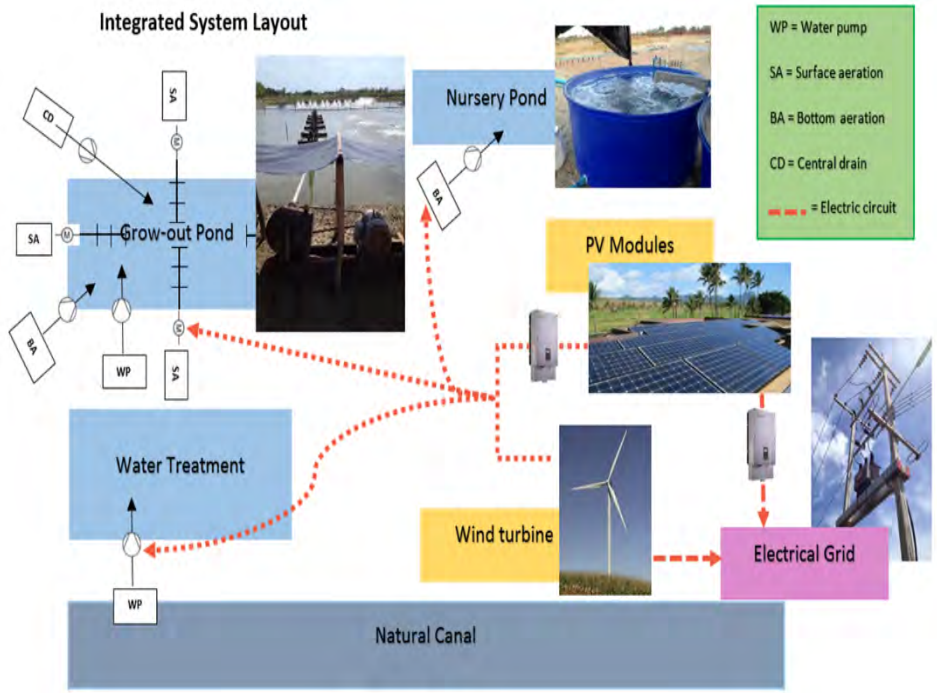
- LCC (min)
- RENEWABLES RELIABILITY (max)
- CO_2 EMISSIONS (min)

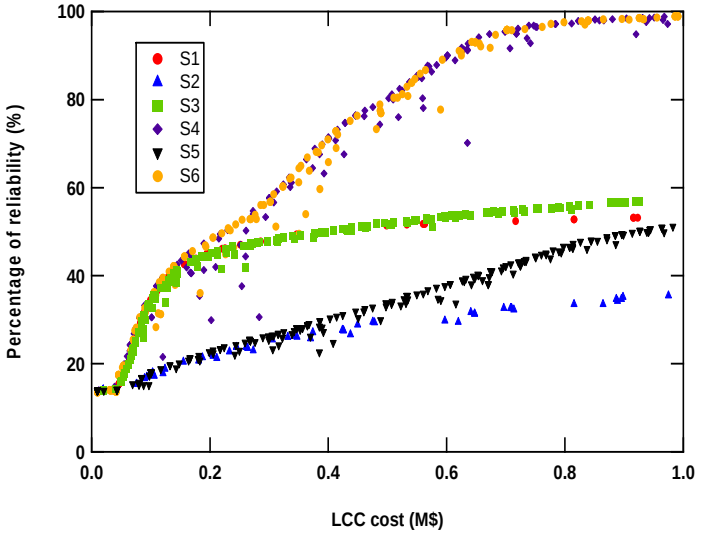
Case study: Battery storage analysis



Y. Zhang, A. Lundblad, P.E. Campana, J. Yan, "Study on employing battery storages to increase photovoltaic self-sufficiency in a residential building of Sweden", Low-carbon Cities and Urban Energy systems CUE2015, Nov 15-17, 2015, Fuzhou, China

Case study: Thai shrimp farm

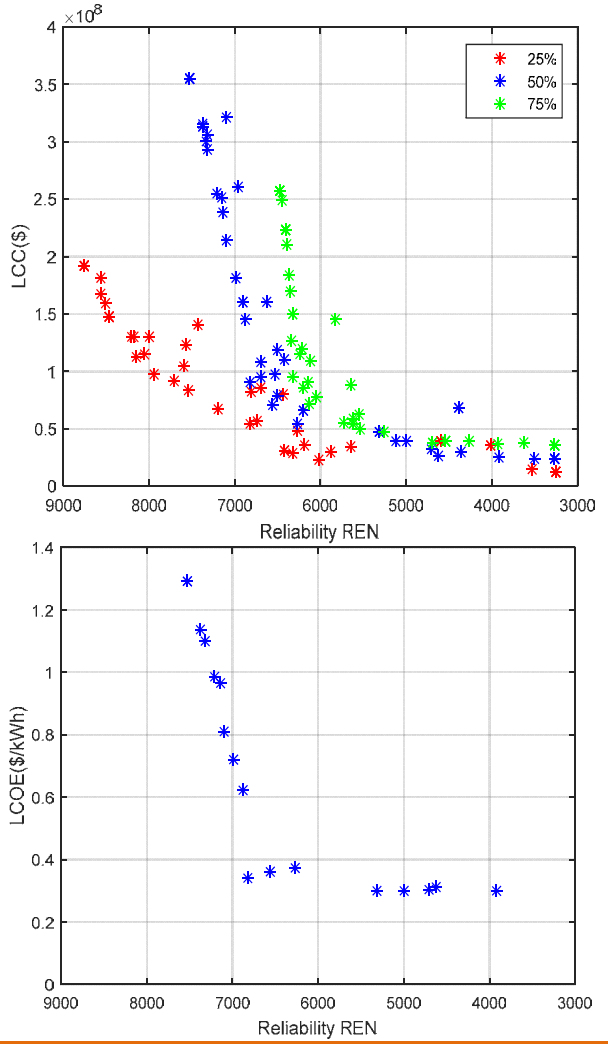




Evaluated Option	Scenario					
	S1	S2	S3	S4	S5	S6
Solar PV	√		√	√	-	√
Wind turbine	-	√	√	-	√	√
Battery	-	-	-	√	√	√

W. Nookuea, P.E. Campana, J. Yan, "Evaluation of solar PV and wind alternatives for self-renewable energy supply: case study of shrimp cultivation", Low-carbon Cities and Urban Energy systems CUE2015, Nov 15-17, 2015, Fuzhou, China

Case study: Gothenburg residential district



P.E. Campana, S.J. Quan, F.I. Robbio, A. Lundblad, Y. Zhang, T. Ma, J. Yan, “Spatial optimization of residential urban district - Energy and water perspectives”, Low-carbon Cities and Urban Energy systems CUE2015, Nov 15-17, 2015, Fuzhou, China

Acknowledgments

FUTURE ENERGY

MÄLARDALEN UNIVERSITY SWEDEN

ABB

MälarEnergi

KK-stiftelsen

VafabMiljö

ASPHOLMEN Fastigheter

SVENSK vindkraft FÖRENING

TEROC

Svensk Marinteknik AB

Thank you very much for your attention!!!

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SWEDEN

(ELECTRICAL) ENERGY STORAGE SYSTEMS: AN OVERVIEW

Anders Lundblad

Outline

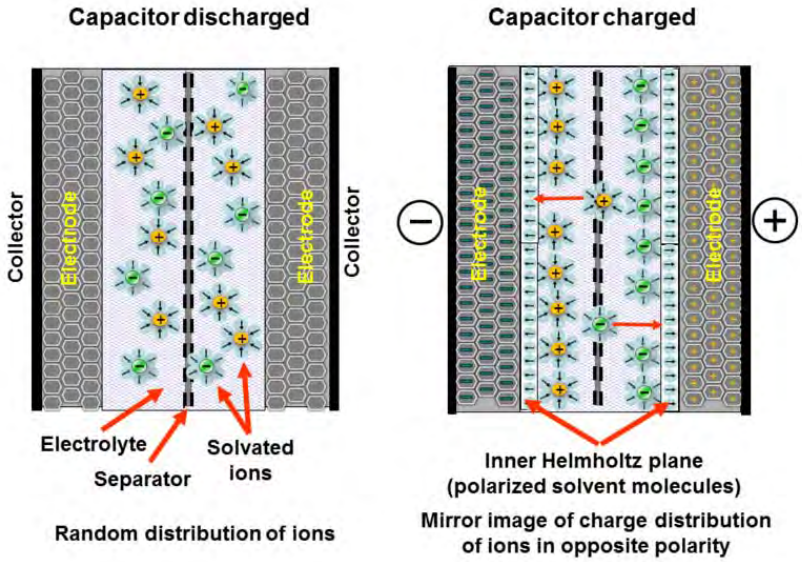
- Energy storage and time scales
- Short term energy storage – Supercaps
- Medium term energy storage – Batteries
- Long term energy storage – Hydrogen and fuel cells

Energy storage and time scales

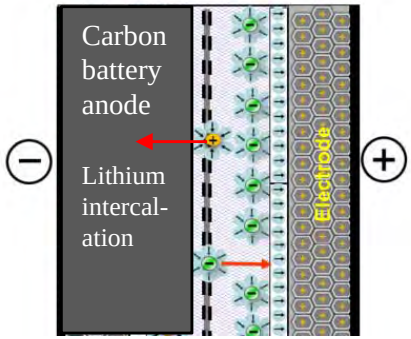
Short term (second to minutes)	Medium term (hours to days)	Long term (weeks to months)
High cyclability	High reliability and life	Feasibility?
Energy efficiency	Low cost	Cost efficiency
Which ...	leads...	to...
Supercapacitors (Efficiency > 95%)	Batteries (Efficiency = 80-90%)	H_2 and fuel cells (Efficiency = 30-40%)

Supercapacitors

- 1.6 – 3.2 V/cell
- Spec. energy: up to 4 Wh/kg
- Spec. power: up to 14 000 W/kg
- Max deep cycles: 100 000 cycles
- Hybrid Capacitor (LiC): 15 Wh/kg
- Used as memory backup battery
- Used for high power industrial applications



Li-ion capacitor



ENVILINE™ energy recovery and storage system

ABB Incorporates Maxwell Technologies Ultracapacitors for Braking Energy Recuperation in Philadelphia Area Electric Rail Lines.

1 Megawatt during 20 seconds!

Up to 30 percent energy savings.

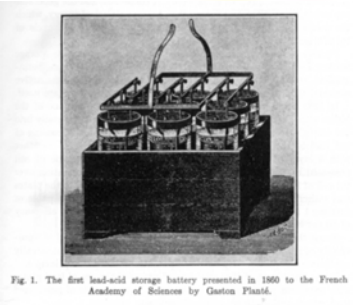
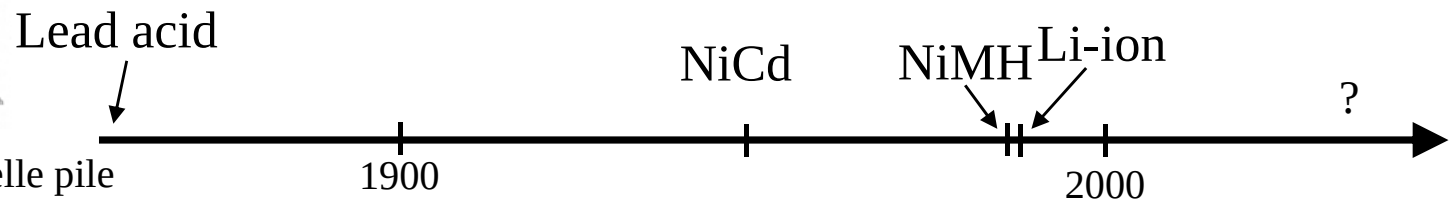


Fig. 1. The first lead-acid storage battery presented in 1860 to the French Academy of Sciences by Gaston Planté.

Rechargeable Batteries



G. Planté, ”Nouvelle pile secondaire d’une grande puissance”, *Compt. Rend.*,*50*, *640*, (1860).

Type	Sp.energy (Wh/kg)	Sp. Power (W/kg)	Number of deep cycles
Lead acid	42	180	300
NiMH	100	1000	2000
Lithium ion	260	350	1200
(Supercapacitor)	5-15	10 000	100 000

Lithium-ion batteries

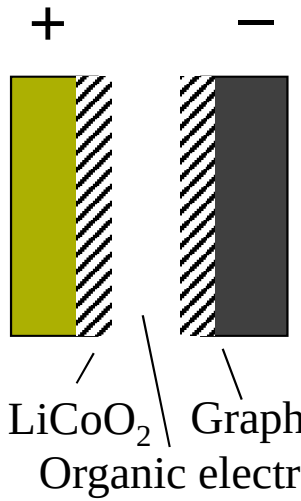
- 3.7- 4 V/cell
- Spec. energy: up to 265 Wh/kg
- Spec. power: up to 350 W/kg
- Max deep cycles: up to 1200 cycles (9000 LTO)
- Many different types (LCO, LFP, NMC, LTO)
- Used for computers, mobile phones, etc since 1991
- Also used for electric vehicles

Positive (LCO):

$Li_{1-x}CoO_2(s) + xLi^+ + xe^- \rightarrow LiCoO_2(s)$

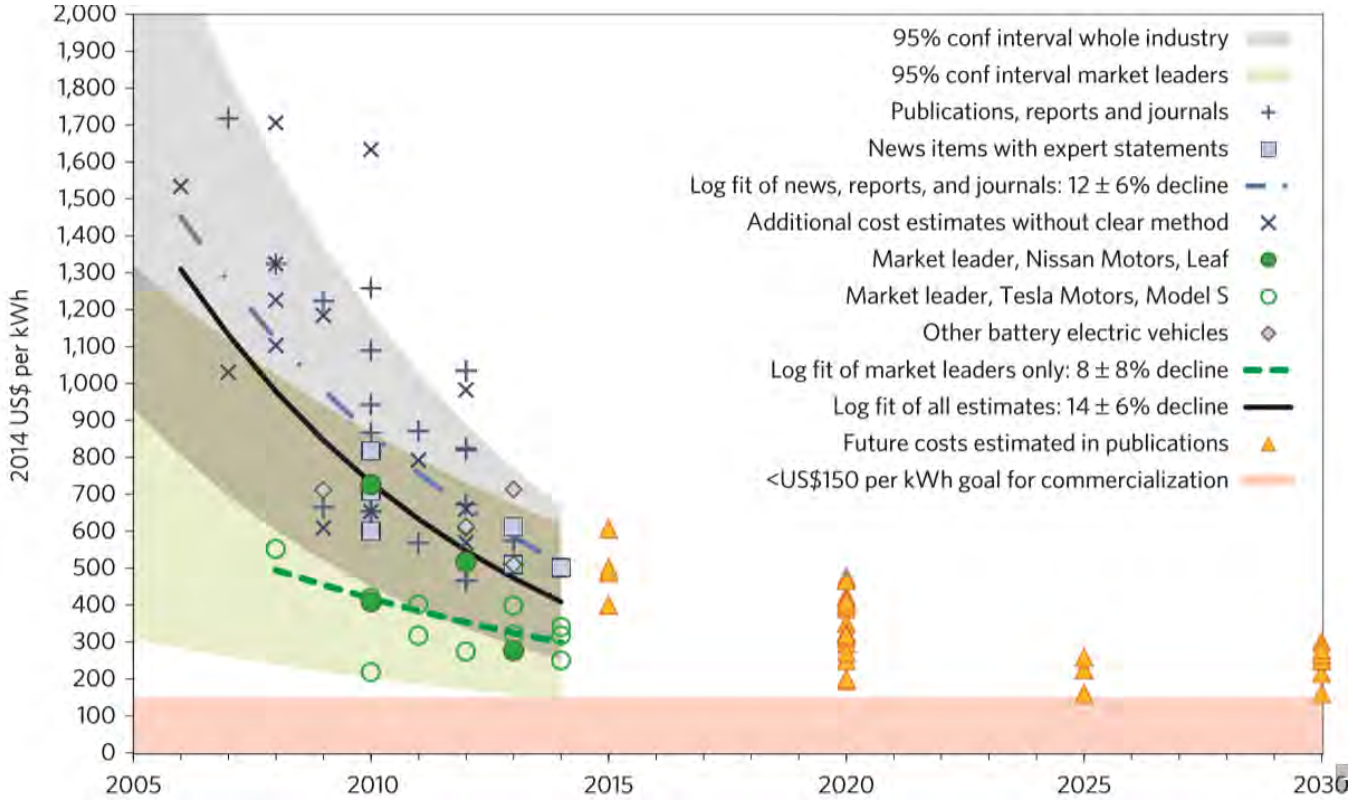
Negative:

$xLiC_6 \rightarrow xLi^+ + xe^- + xC_6$



Lithium-ion batteries – rapidly falling cost

(Cost of Li-battery packs in BEV)



(Nykvist B, Nilsson M. ,Nature Clim Change 2015; 5(4): 329-332.)

Lithium-ion batteries – for PV systems

Samsung – PV all in one solution (3.6 -8 kWh).

Tesla Powerwall
(7- 10 kWh, 3000-3500 USD)

LG Chem
(3.2-6.4 kWh)

Bosch BPT-S5Hybrid
(4.4-13.2 kWh)

Second life for vehicle batteries

- Vehicle batteries are exchanged after 5-10 years.
- Can still work several years in low power applications

Batteries in electrical buses from Volvo
are re-used in a residential building.

- ElectriCity R&D project
- 19 battery packs of 350 kg
- In total more than 300 kWh

Box of Energy (Sweden)
(10-40 kWh)

”Swedish government to support energy storage”

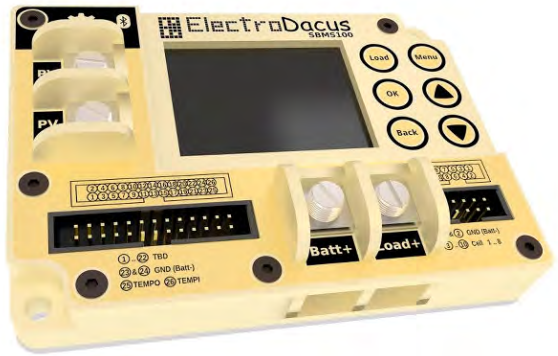
- Specific support for energy storage
- 175 MSEK during 4 years
- 25 MSEK during 2016
- 50 MSEK 2017, 2018, 2019

(Ny Teknik 150917)

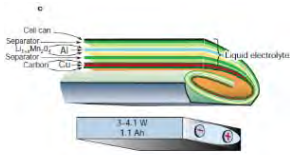
Batteries in the open source context

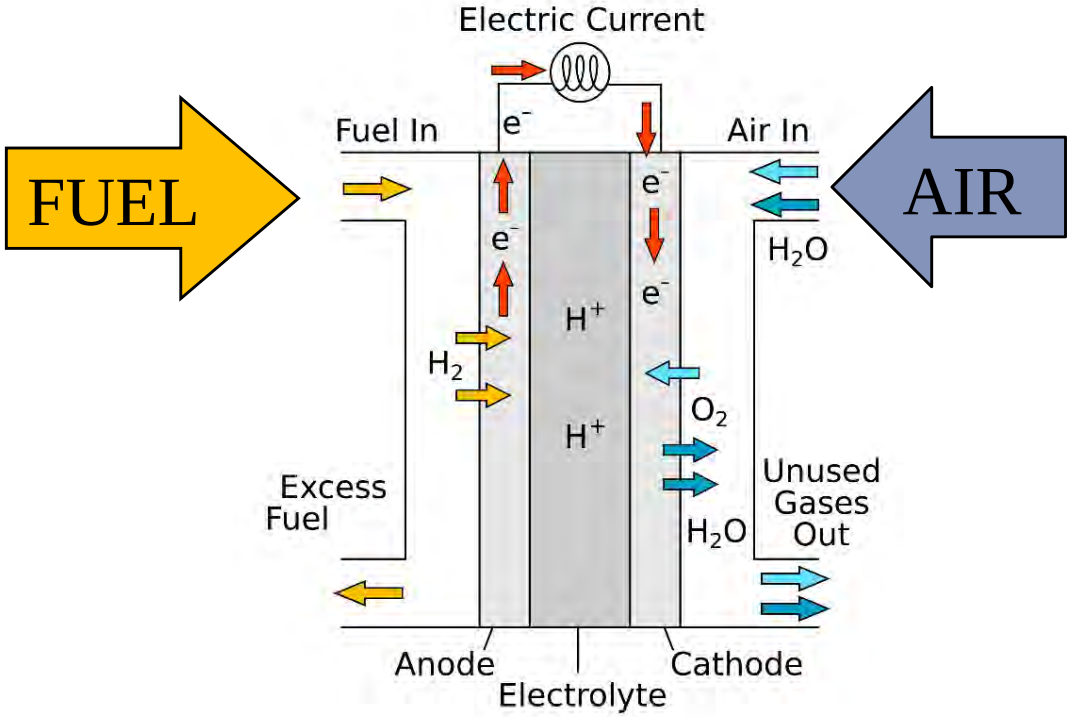
Open source battery management systems:

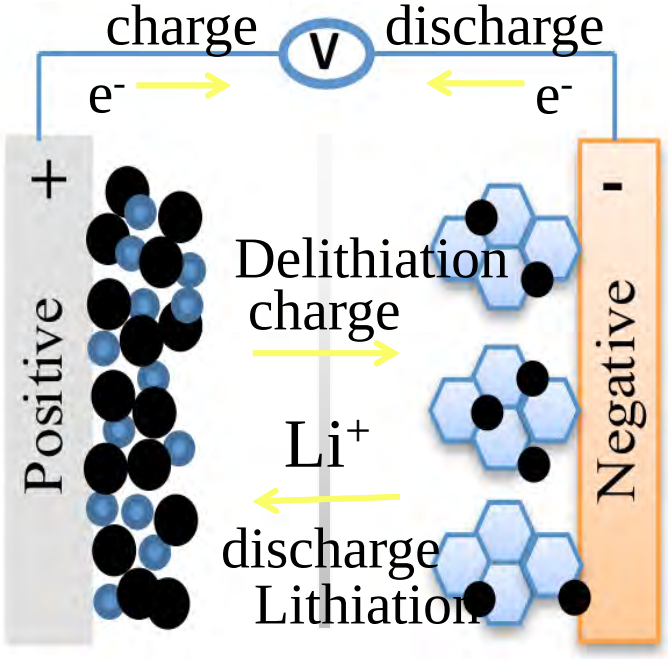
- Teslafly: https://github.com/Teslafly/OpenBMS
- BMsafe: https://code.google.com/p/bmsafe/
- Electrodacus: http://electrodacus.com/
-



Fuel Cells and Batteries – similar but different

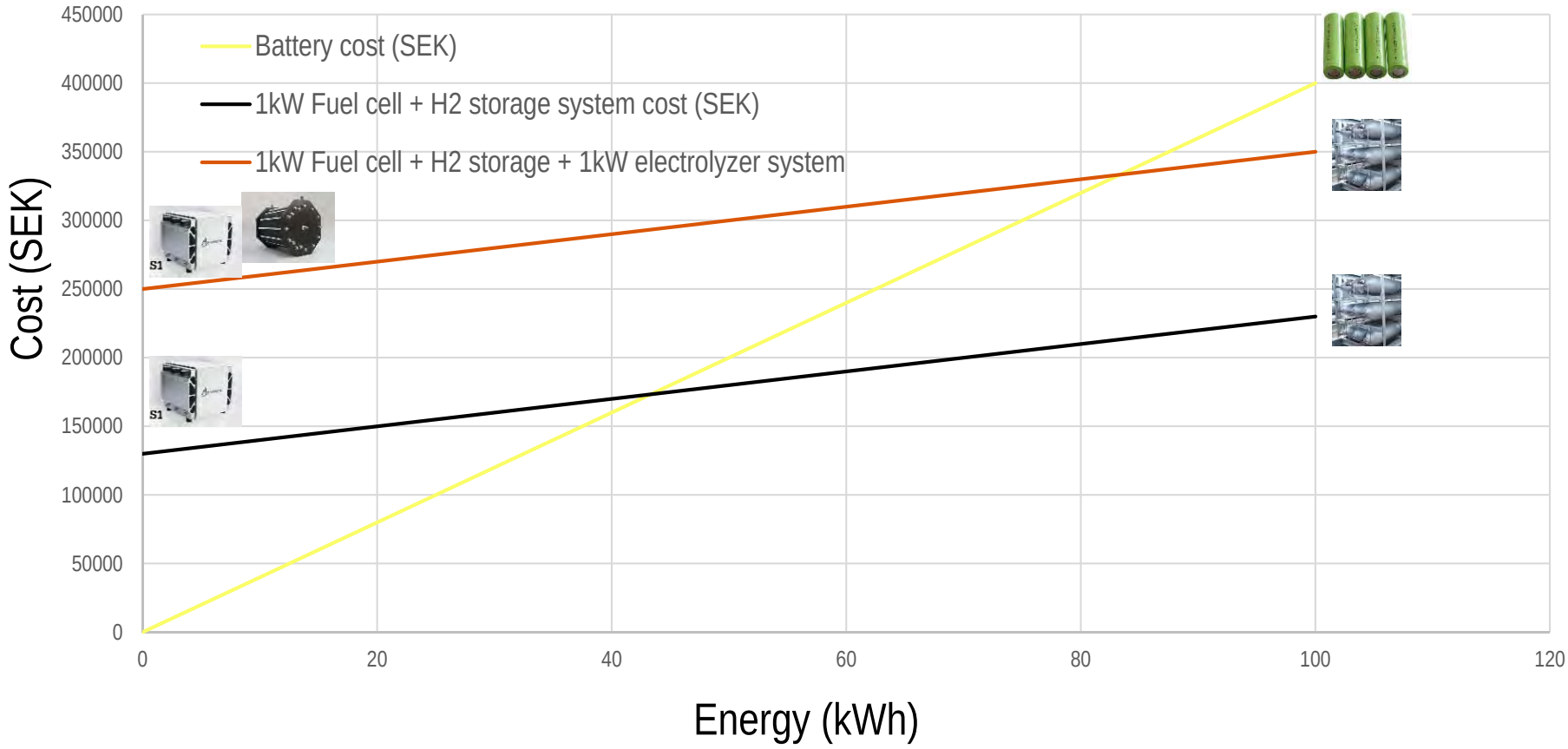






Schematics of the electrochemical process in PEM fuel cell and a Li-ion cell.

Batteries versus Fuel cell Systems



Energy storage – power to gas

Toyota's vision of a sustainable society, April 2015.

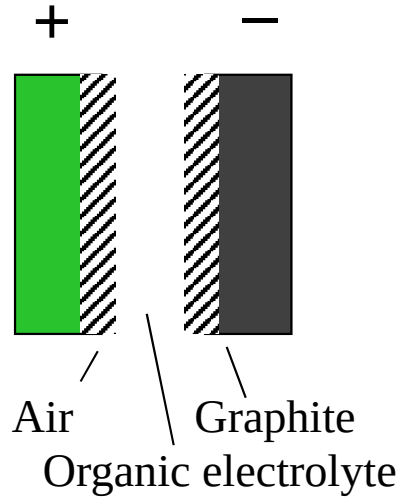
German project: Energie Park Mainz

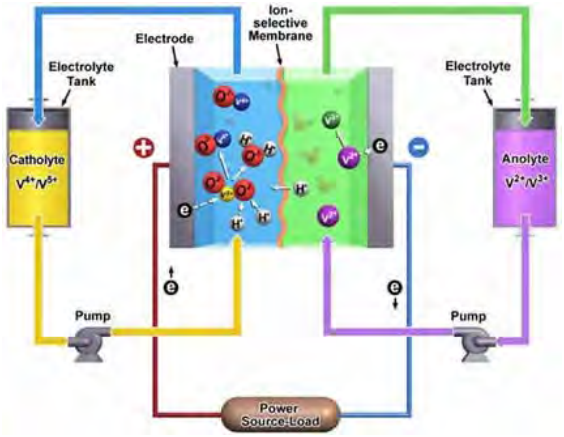
Energy storage – hydrogen for houses

Ny Teknik 151117: “Nu startar han sin egen bränslecell”
Hans-Olof Nilsson, en av vinnarna i ”Sveriges smartaste hem”

Future battery technologies

- Sodium batteries (exchange Li with Na)
- Lithium-air (> 1000 Wh/kg?)
- Redox flow batteries
- SR-Klotet: Energilagring – förutsättning för sol och vind…(http://sverigesradio.se/)





Thank you!

InnoVentum

Mälardalen Högskola
Svensk Vindkraftförening
15/01/2016 Västerås

Marcus Ulmefors
marcus@innoventum.se

Wooden towers

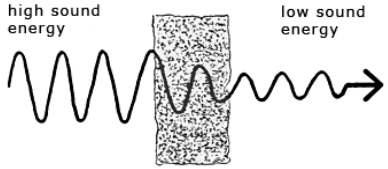
Advantages using wood

Transport easily

Wood is a light material compared to steel and the structure is modular.

Absorb vibration and noise

The flexibility of the wooden construction dampens vibrations and consequently reduces noise levels and risk of resonance.



Eliminate concrete

By using wooden towers in combination with screw foundations it is possible to avoid concrete and thereby greatly reduce CO_2 footprint.

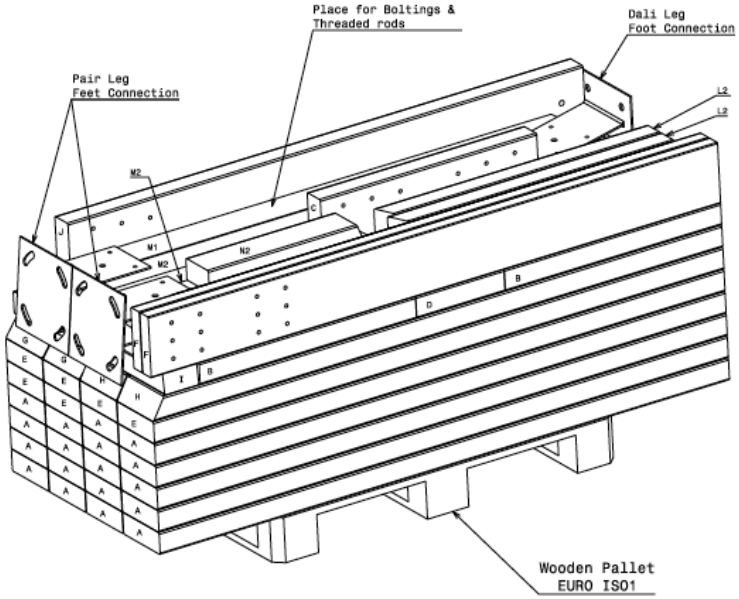
InnoVentum
power to the people

Modularity

Volume of wood: 1.5 m^3

Modules no longer than 2 m

The "tower kit" is stackable and can be transported on a trailer and stored easily



Do it yourself*

*some IKEA experience recommended


nd winches
rope and winches
rope and winches
No crane required

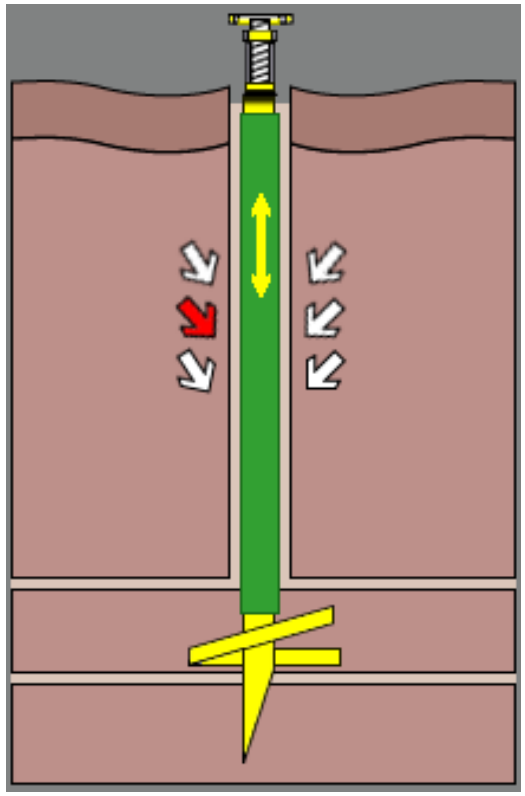
Foundation brought to new level

The screw foundation revolutionizes the installation process by being:

FAST: installed in hours instead of days or weeks for a standard concrete foundation.

GREEN: for the Dali XII, it causes 7 times less CO_2 emission than a concrete foundation and requires no soil movement.

It is the foundation of choice for both tower designs: Dali XII and Dalifant XX.



Screw foundation Dalifant

CO_2 balance

benchmarking conventional steel tower

Component	kg CO_2	EU kWh	Sweden kWh
Tower	-1 600	-3 200	-40 000
Foundation	-2 400	-4 800	-60 000
Total	-4 000	-8 000	-100 000

InnoVentum
power to the people

Dalifant Mandelmanns Trädgårdar

Dalifant Mandelmanns Trädgårdar

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Dali PowerTower – Philippines and Sweden

Giraffe 2.0 Västra Hamnen Malmö


Thank You

Open Source Web-Enabled Variable Monitoring

Javier Campillo, Doctoral Candidate

“Measurement is the first step that leads to control and eventually to improvement. If you can’t measure something, you can’t understand it. If you can’t understand it, you can’t control it. If you can’t control it, you can’t improve it.”

H. James Harrington

Agenda

Real World
(Analog)

Sensing
(e.g. Thermistor)

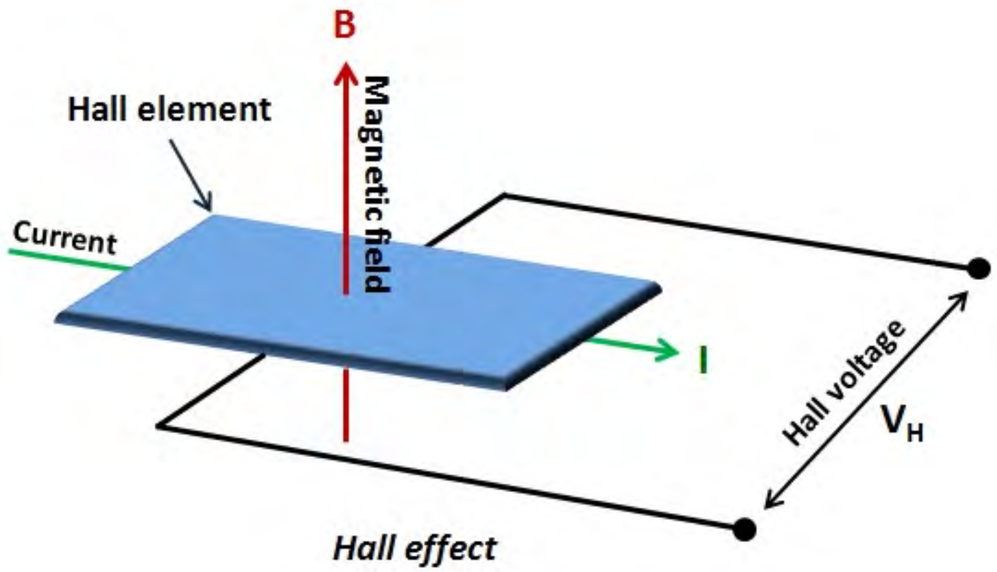
Signal Conditioning
(e.g. R —> V)

Digitisation

Visualisation

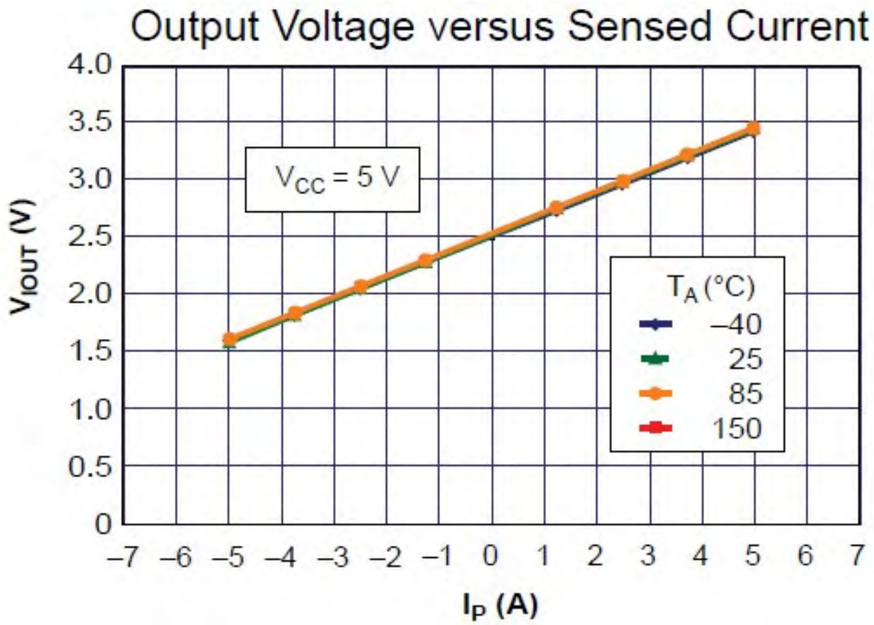
Sensing our world

A ***Sensor*** is a device that has a characteristic that changes in a predictable way when exposed to the stimulus it was designed to detect



Hall-effect current sensor

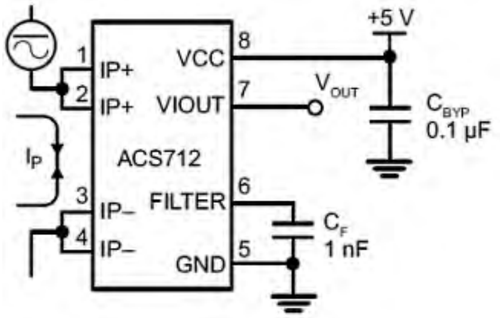
Image: embedded-lab.com

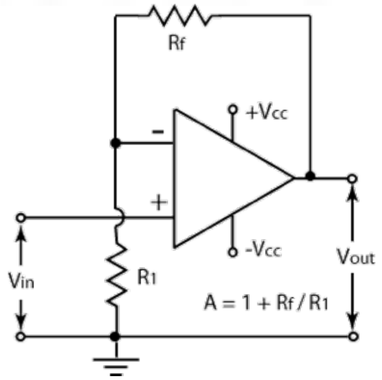


ACS712-5A response

Image: embedded-lab.com

Signal Conditioning

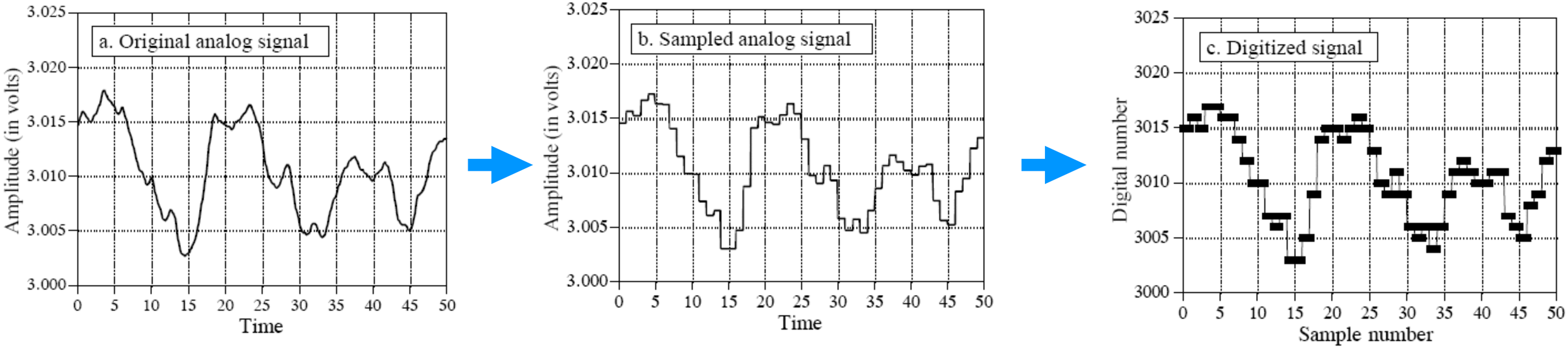




Sensor Output → Signal conditioning circuit → ADC

Digitisation

"There are 10 types of people in the world: those who understand binary, and those who don't."

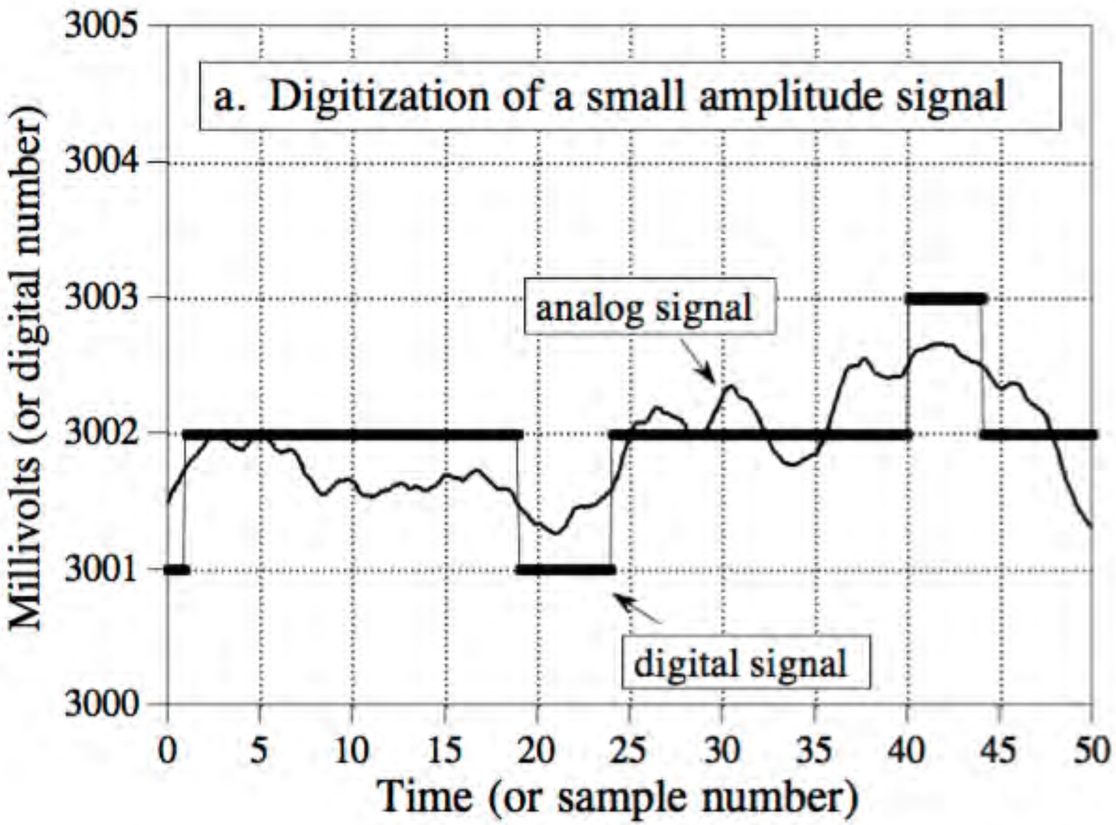


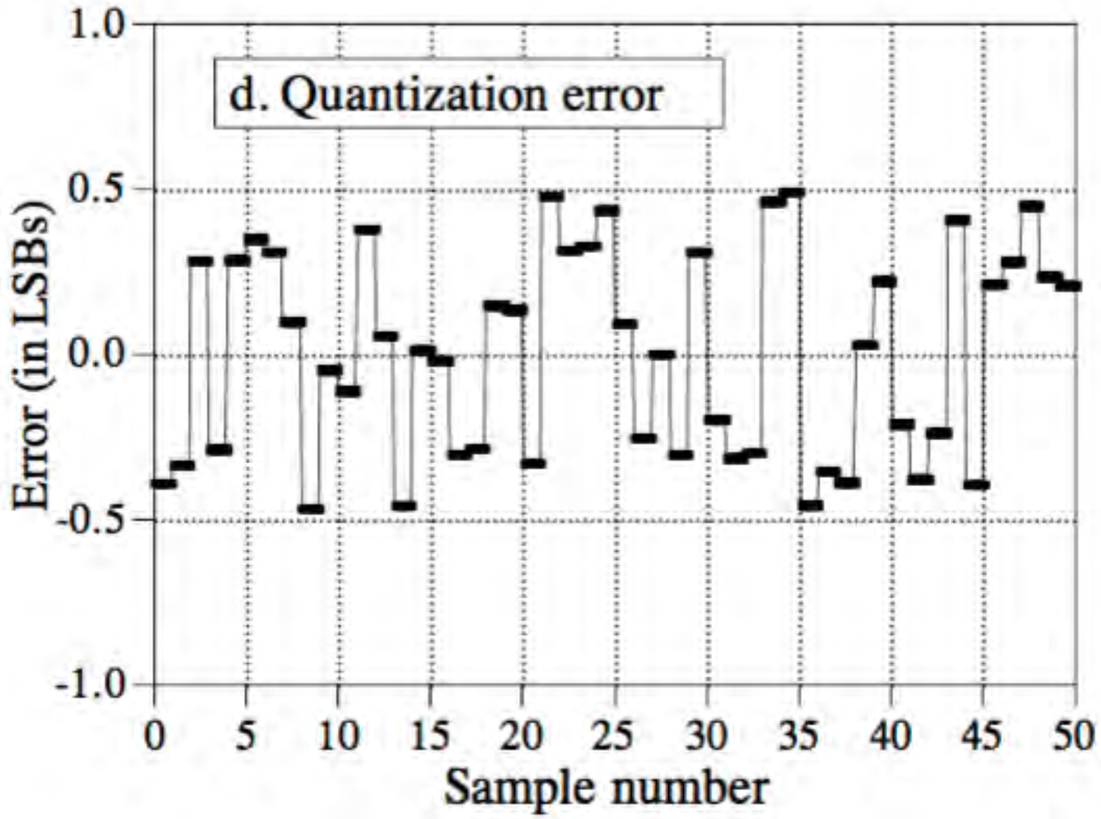
Analog Signal → S/H → ADC → Digital Value

Source: Steven W. Smith. The Scientist and Engineer's Guide to Digital Signal Processing. California Technical Publishing. 2011

Quantisation Error

Error = +/- 0.5 LSB

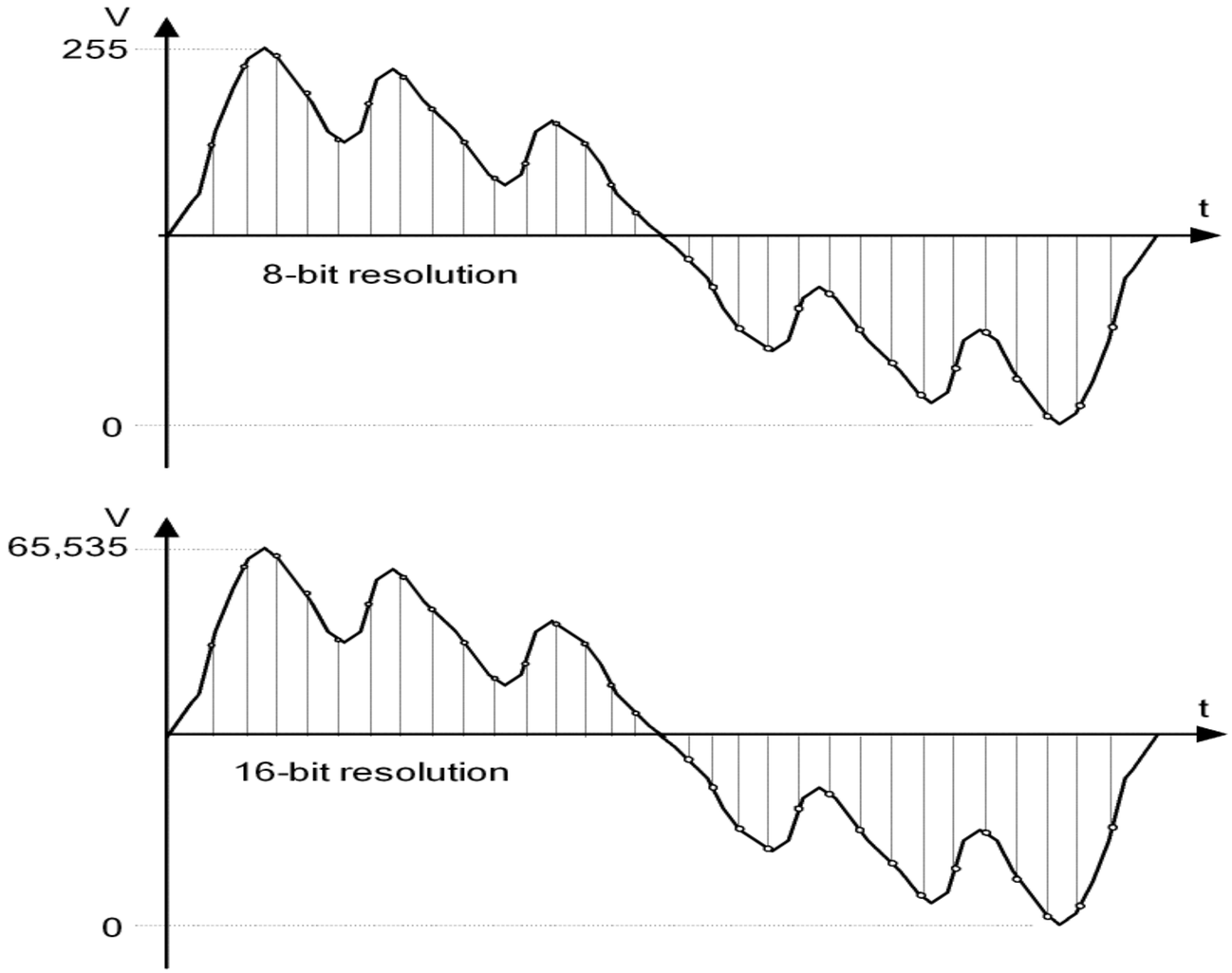


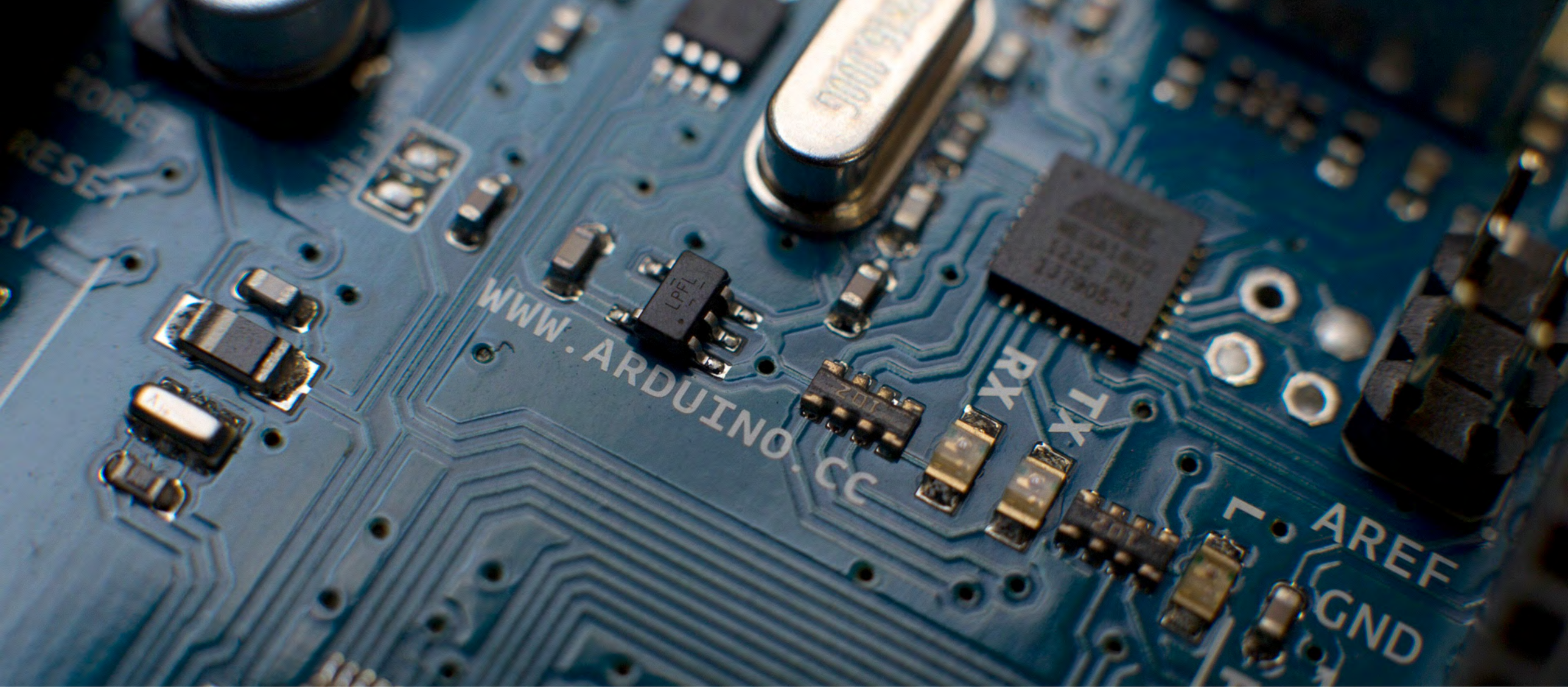


Source: Steven W. Smith. The Scientist and Engineer's Guide to Digital Signal Processing. California Technical Publishing. 2011

ADC Resolution, why does it matter?

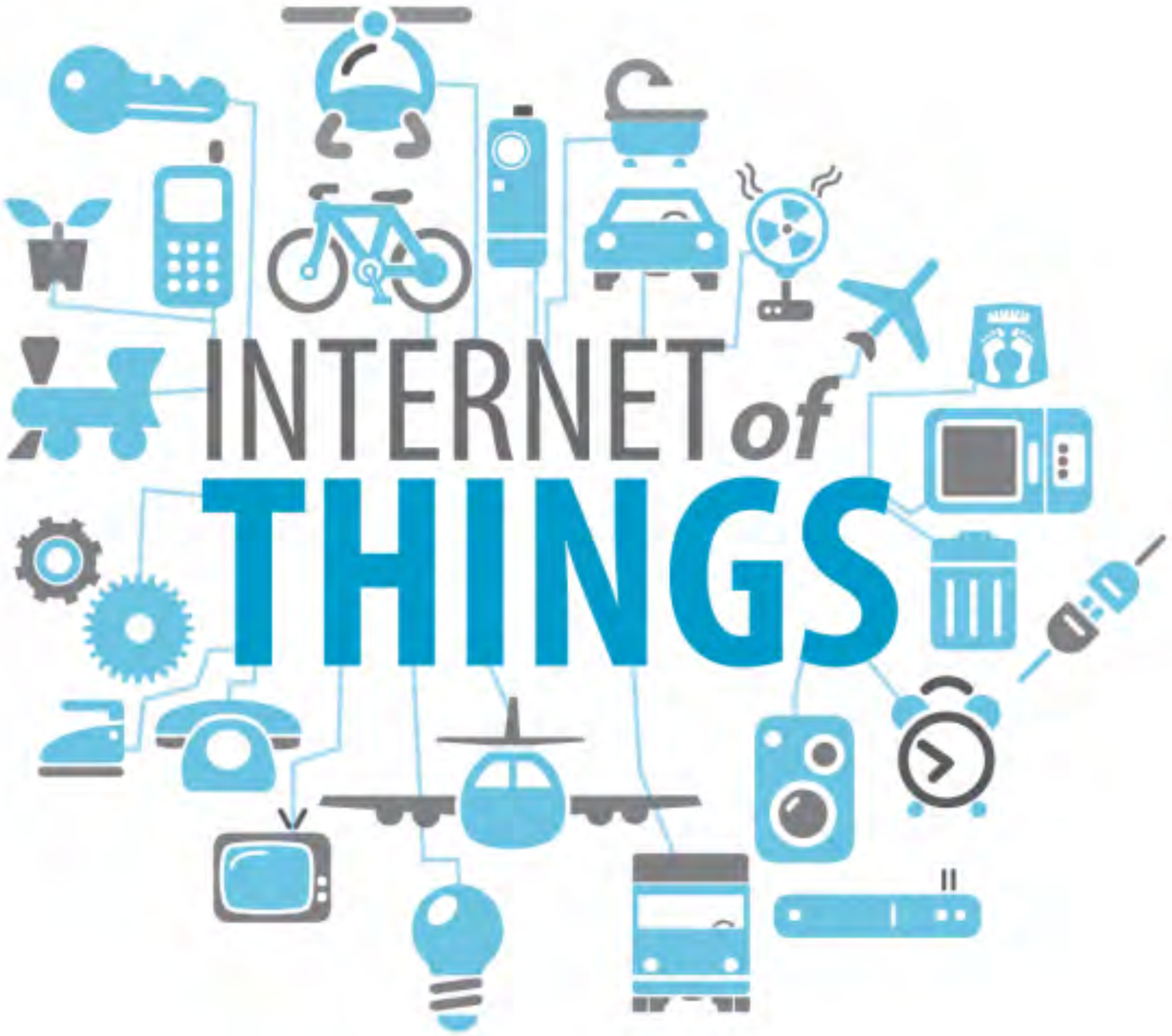
Resolution	No. Values	e.g 12V
8 bits	256	46.8 mV
10 bits	1024	11.7 mV
12 bits	4096	2.9 mV
16 bits	65536	0.18 mV





Metering Platforms

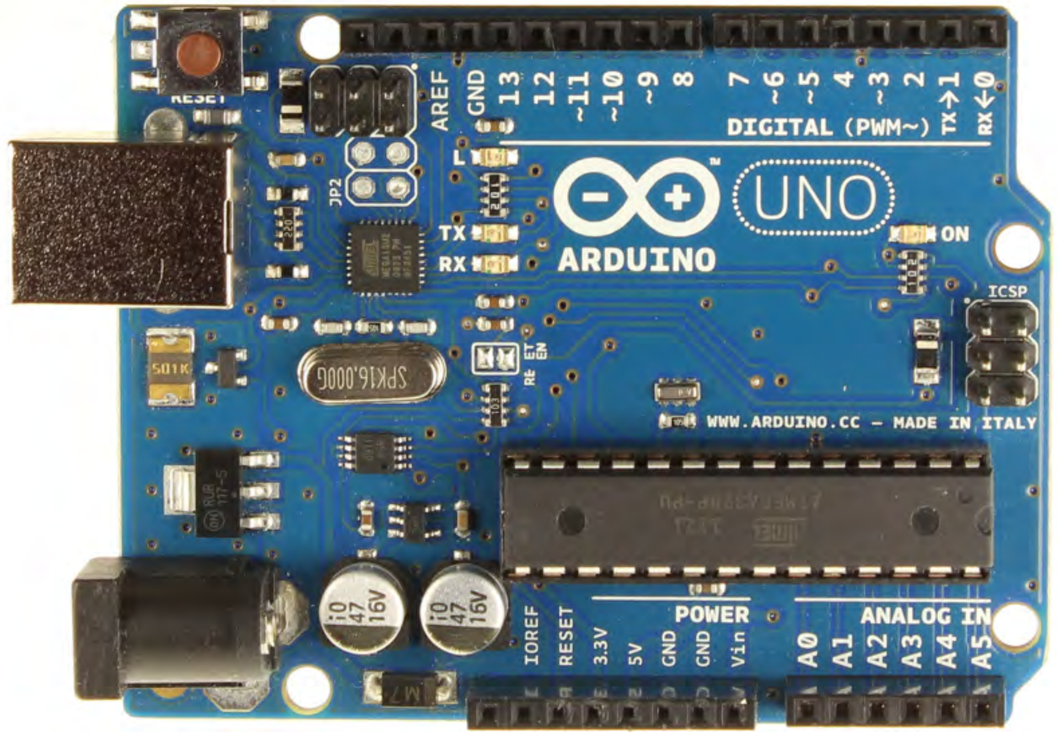
OpenSource Boards



"Trying to determine the market size for the Internet of Things is like trying to calculate the market for plastics in 1940. At that time, it was difficult to imagine that plastics would be in everything"

Michael Nelson
Georgetown University

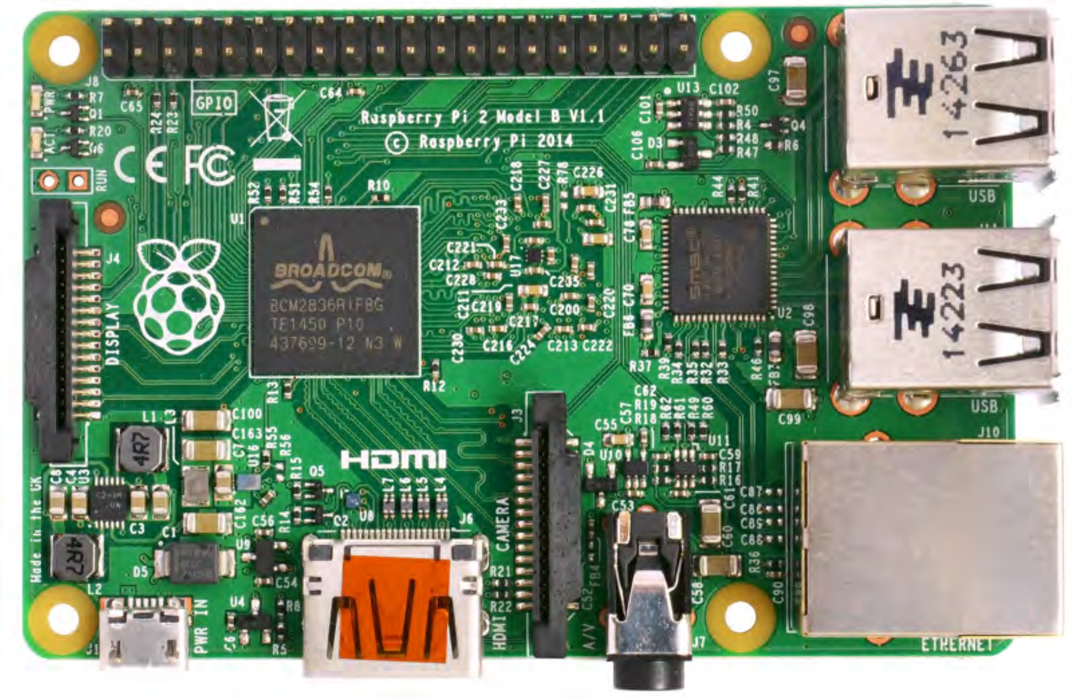
Development Boards - Arduino Based



Arduino Uno

- Microcontroller-based boards
- Suitable for low-power applications
- Real-time applications available (RTOs)
- Analog & Digital I/O
- Hardware-level programming
- Useful for directly connect multiple sensors
- Communication capabilities available through shields

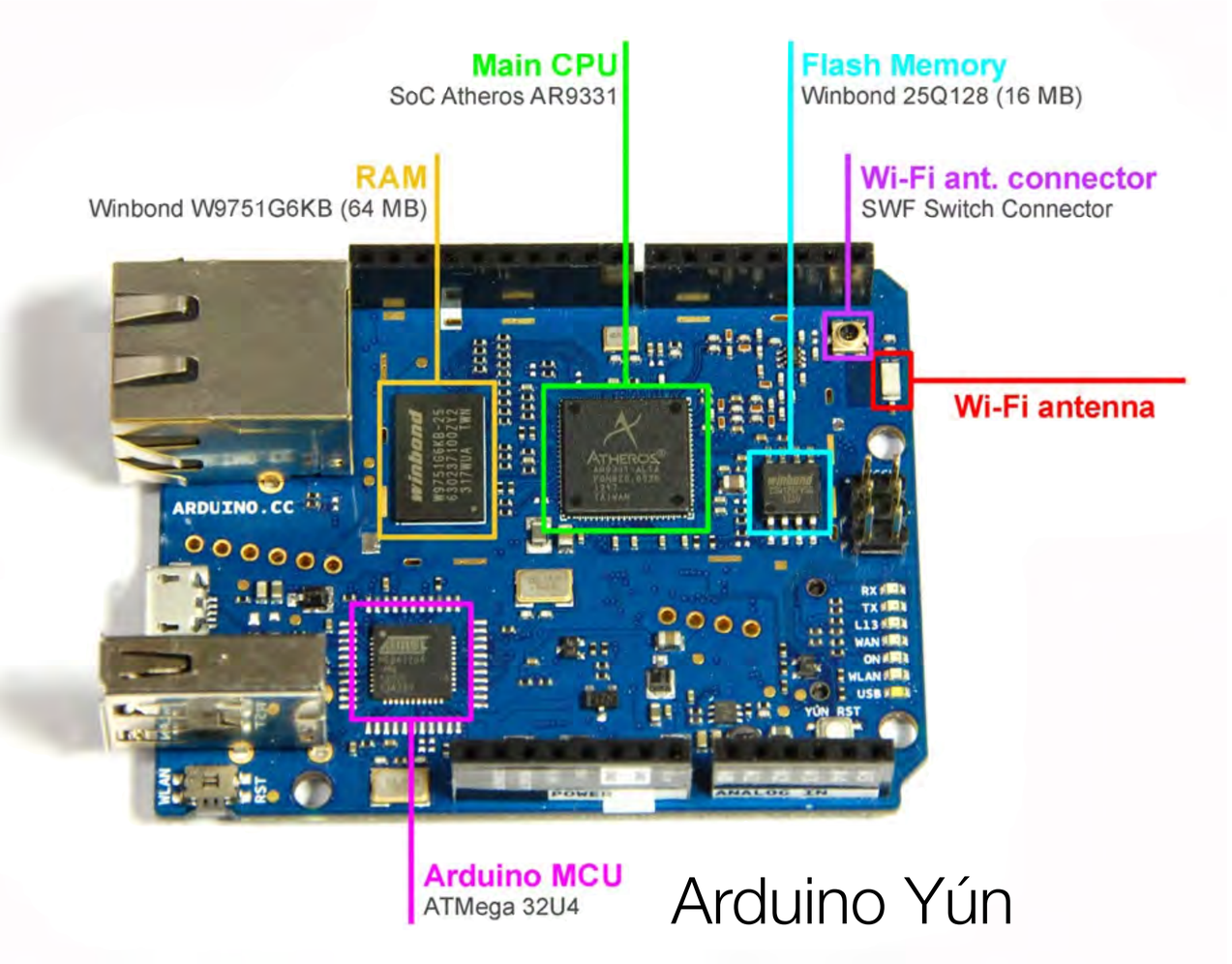
Development Boards - Linux Based



RaspberryPi

- Full-Spec microcomputer
- Linux operating system (for ARM)
- Hi-level programming (e.g. java, phyton)
- USB-peripherals
- HDMI Output
- Audio output
- Scalable storage (Via micro/SD card)
- Digital GPIOs

Linux & Arduino - Best of both worlds?

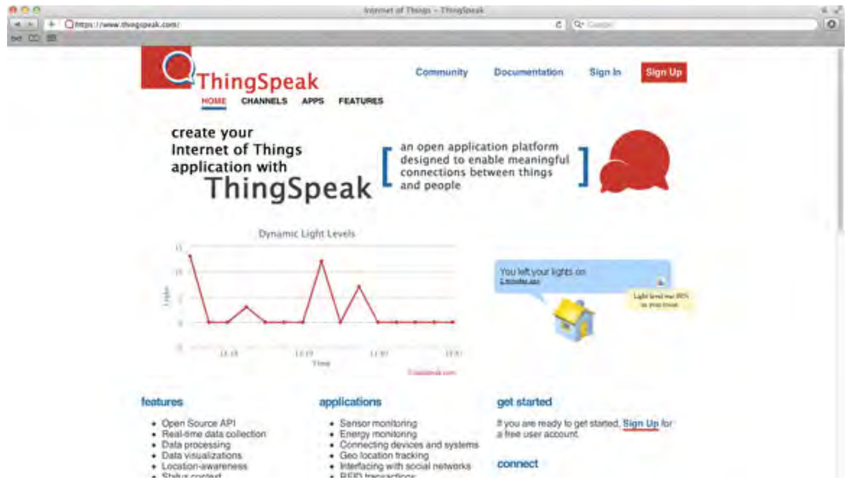


Arduino Yún

- ATmega32u4 Microcontroller (Arduino)
- Atheros AR9331 Microprocessor (Linux)
- Built-in USB
- Built-in WiFi
- micro-SD card
- 20 digital input/output pins
- 12 analog inputs
- Independent reset switches for Linux/ Arduino

Data Collection & Visualisation

freeboard.io



www.thingskpeak.com

Cloud-Based Services

Easy to deploy

Open-Access

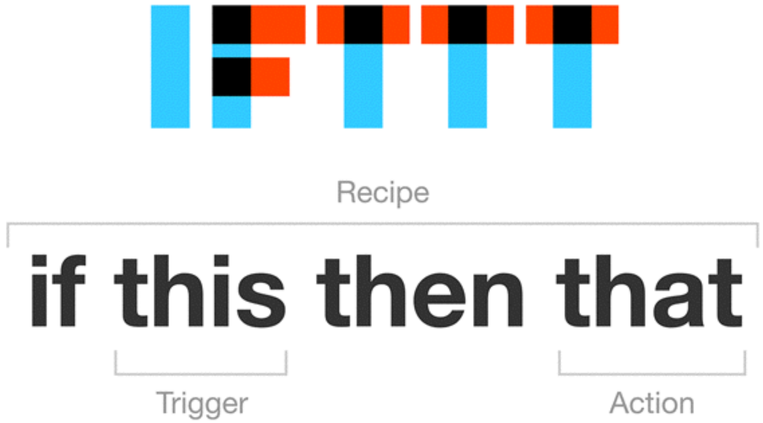
In-house Services

Private

Scalable

Automate & Interact

www.openhab.org

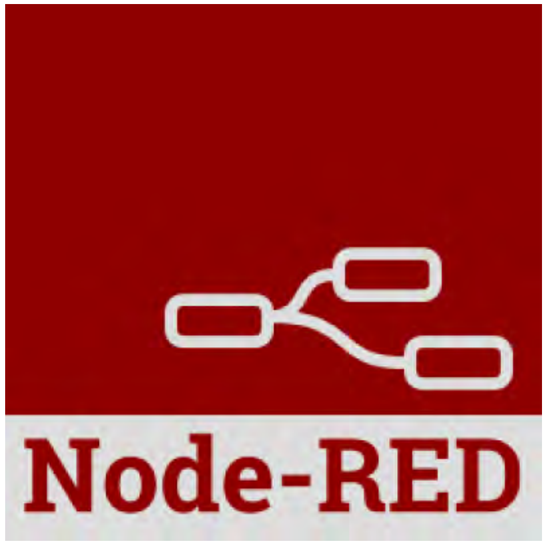


ifttt.com

www.openremote.org

Open Home Automation

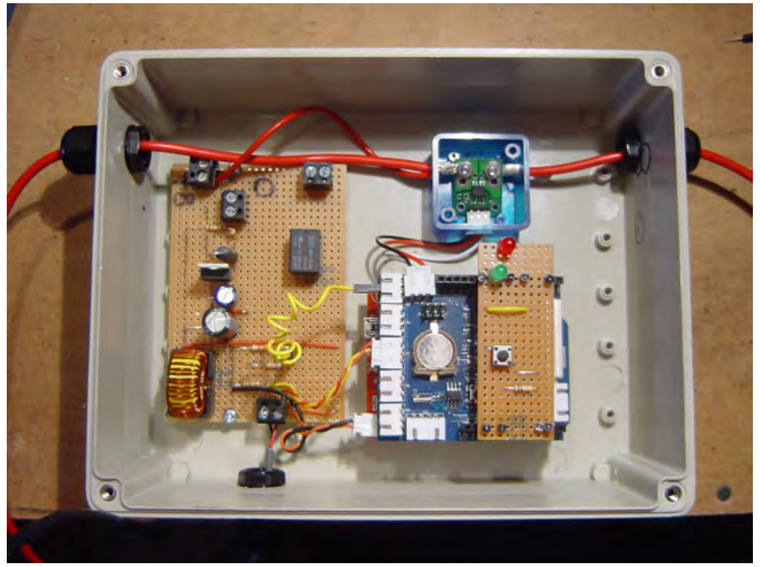
www.openhomeautomation.net



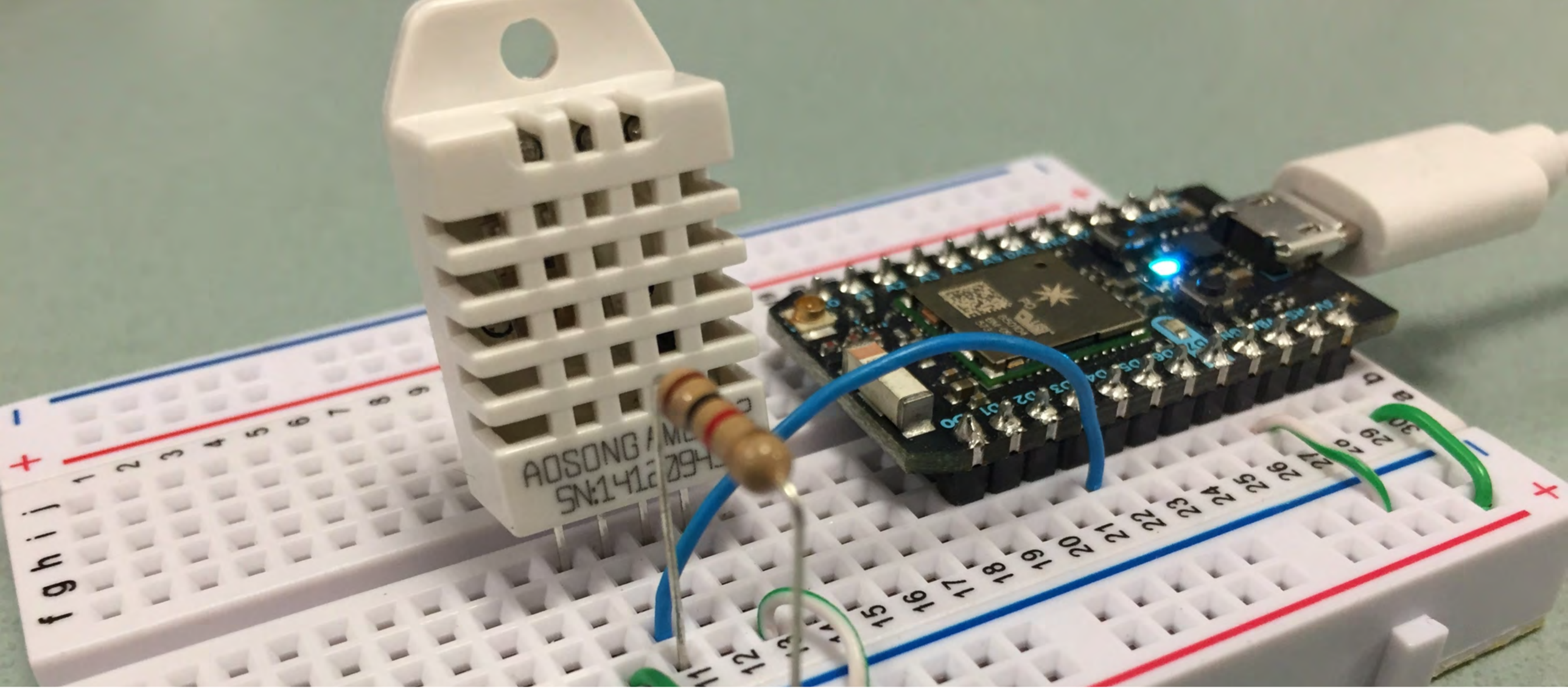
nodered.org

Example: Wind speed and DC energy data logger with OpenEnergy Monitor

- Monitor Hugh-Piggot design
- 48V DC
- 800W (3 metre diameter blades)
- 3 phase
- Arduino-based
- Uses Vortex anemometer
- Monitors 60V regulator
- OpenEnergy Monitor



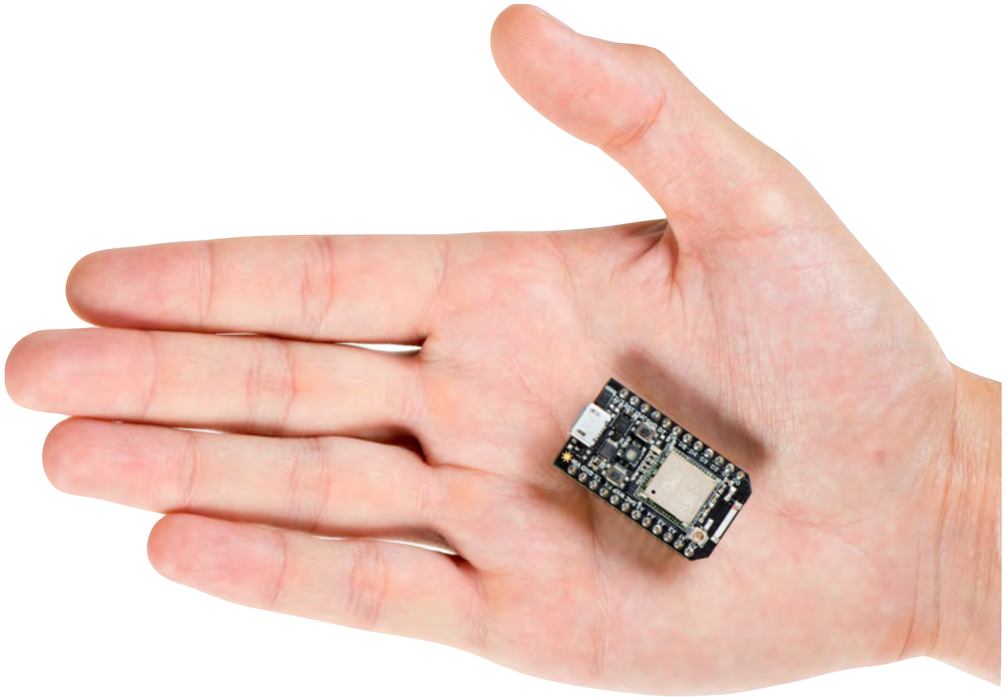
openenergymonitor.org



Demo

Arduino Digital & Analog Signals

Particle Photon



- Arduino-compatible
- 802.11b/g/n Wi-Fi
- STM32F205 120Mhz ARM Cortex M3
- 1MB flash, 128KB RAM
- 18 Mixed-signal GPIO and advanced peripherals
- Open source design
- Real-time operating system (FreeRTOS)
- Soft AP setup
- Over-the-air programming & updating
- FCC, CE and IC certified

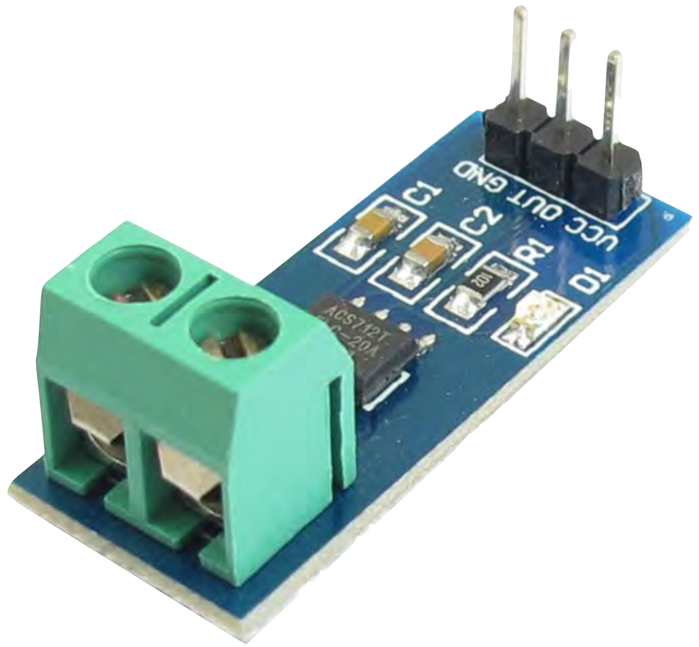
Source: particle.io

DHT22 Temperature & Humidity Sensor

Model	DHT22
Power supply	3.3-6V DC
Output signal	digital signal via single-bus
Sensing element	Polymer capacitor
Operating range	humidity 0-100%RH; temperature -40~80Celsius
Accuracy	humidity +-2%RH(Max +-5%RH); temperature <+-0.5Celsius
Resolution or sensitivity	humidity 0.1%RH; temperature 0.1Celsius
Repeatability	humidity +-1%RH; temperature +-0.2Celsius
Humidity hysteresis	+-0.3%RH
Long-term Stability	+-0.5%RH/year
Sensing period	Average: 2s
Interchangeability	fully interchangeable
Dimensions	small size 14*18*5.5mm; big size 22*28*5mm

Source: sparkfun.com

ACS712-5 Hall-effect Current Sensor



x05B PERFORMANCE CHARACTERISTICS[1] T_A = –40°C to 85°C, C_F = 1 nF, and V_{CC} = 5 V, unless otherwise specified

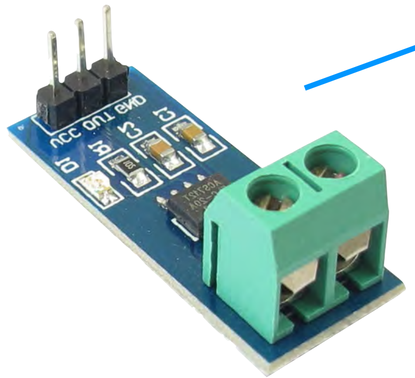
Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Optimized Accuracy Range	I_P		–5	–	5	A
Sensitivity	Sens	Over full range of I_P, T_A = 25°C	180	185	190	mV/A
Noise	$V_{NOISE(PP)}$	Peak-to-peak, T_A = 25°C, 185 mV/A programmed Sensitivity, C_F = 47 nF, C_{OUT} = open, 2 kHz bandwidth	–	21	–	mV
Zero Current Output Slope	$\Delta I_{OUT(Q)}$	T_A = –40°C to 25°C	–	–0.26	–	mV/°C
		T_A = 25°C to 150°C	–	–0.08	–	mV/°C
Sensitivity Slope	ΔSens	T_A = –40°C to 25°C	–	0.054	–	mV/A/°C
		T_A = 25°C to 150°C	–	–0.008	–	mV/A/°C
Total Output Error[2]	E_{TOT}	I_P =±5 A, T_A = 25°C	–	±1.5	–	%

[1]Device may be operated at higher primary current levels, I_P, and ambient temperatures, T_A, provided that the Maximum Junction Temperature, $T_{J(max)}$, is not exceeded.

[2]Percentage of I_P, with I_P = 5 A. Output filtered.

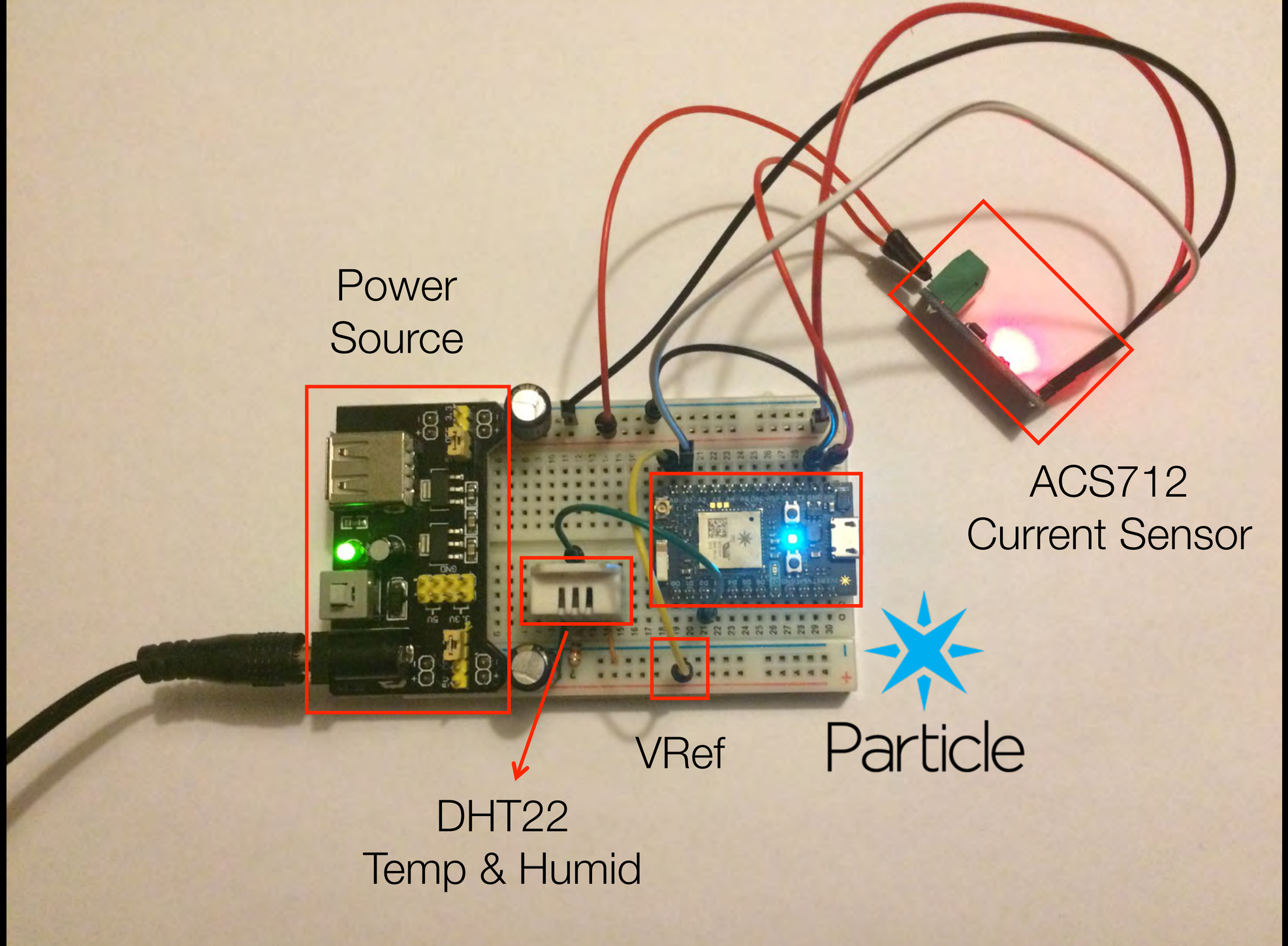
Source: Allegro Microelectronics

Demo Setup



ThingSpeak

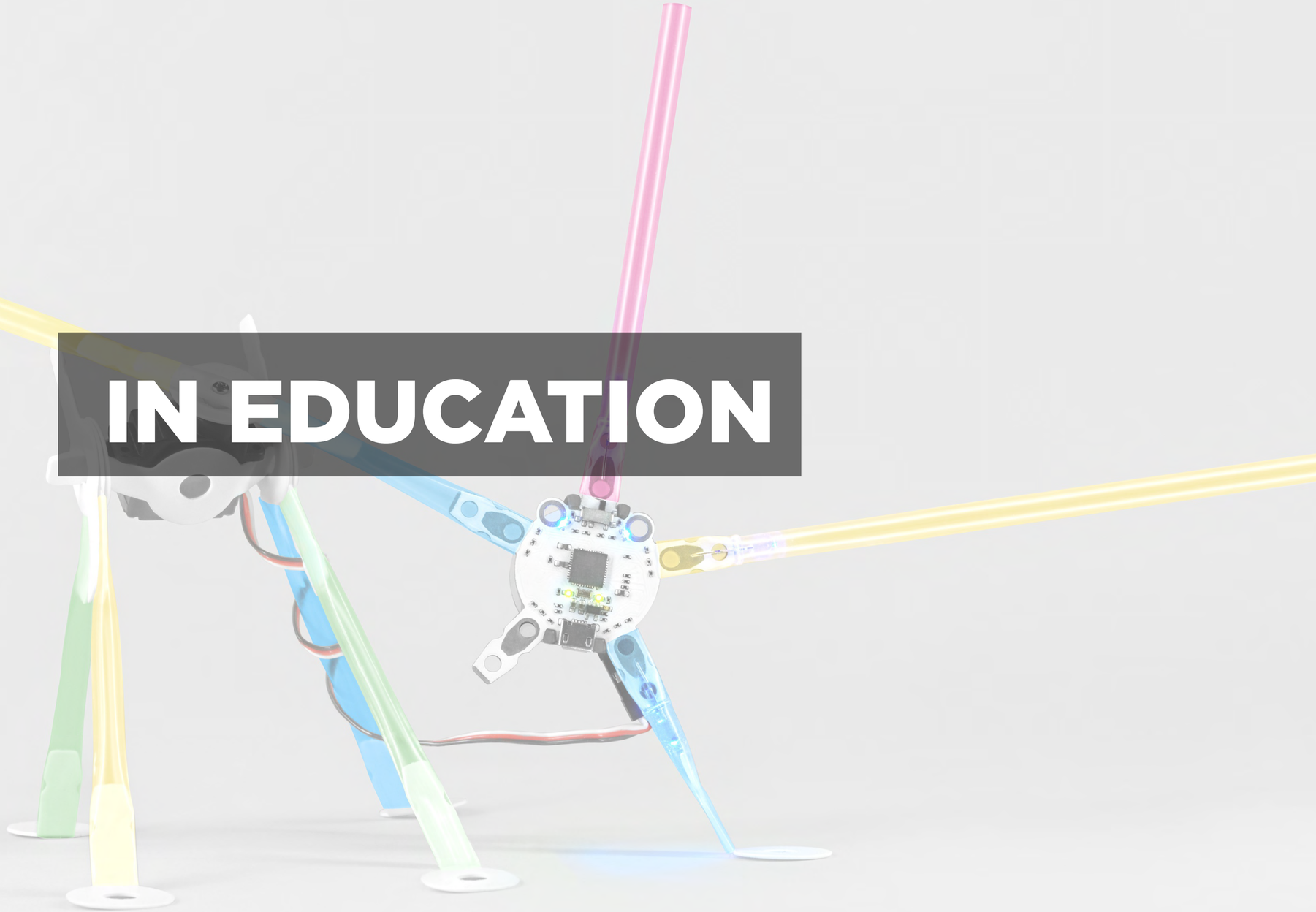
freeboard.io


Power
Source
ACS712
Current Sensor
VRef
Particle
DHT22
Temp & Humid

open source hardware

Logo by Open Source Hardware Association

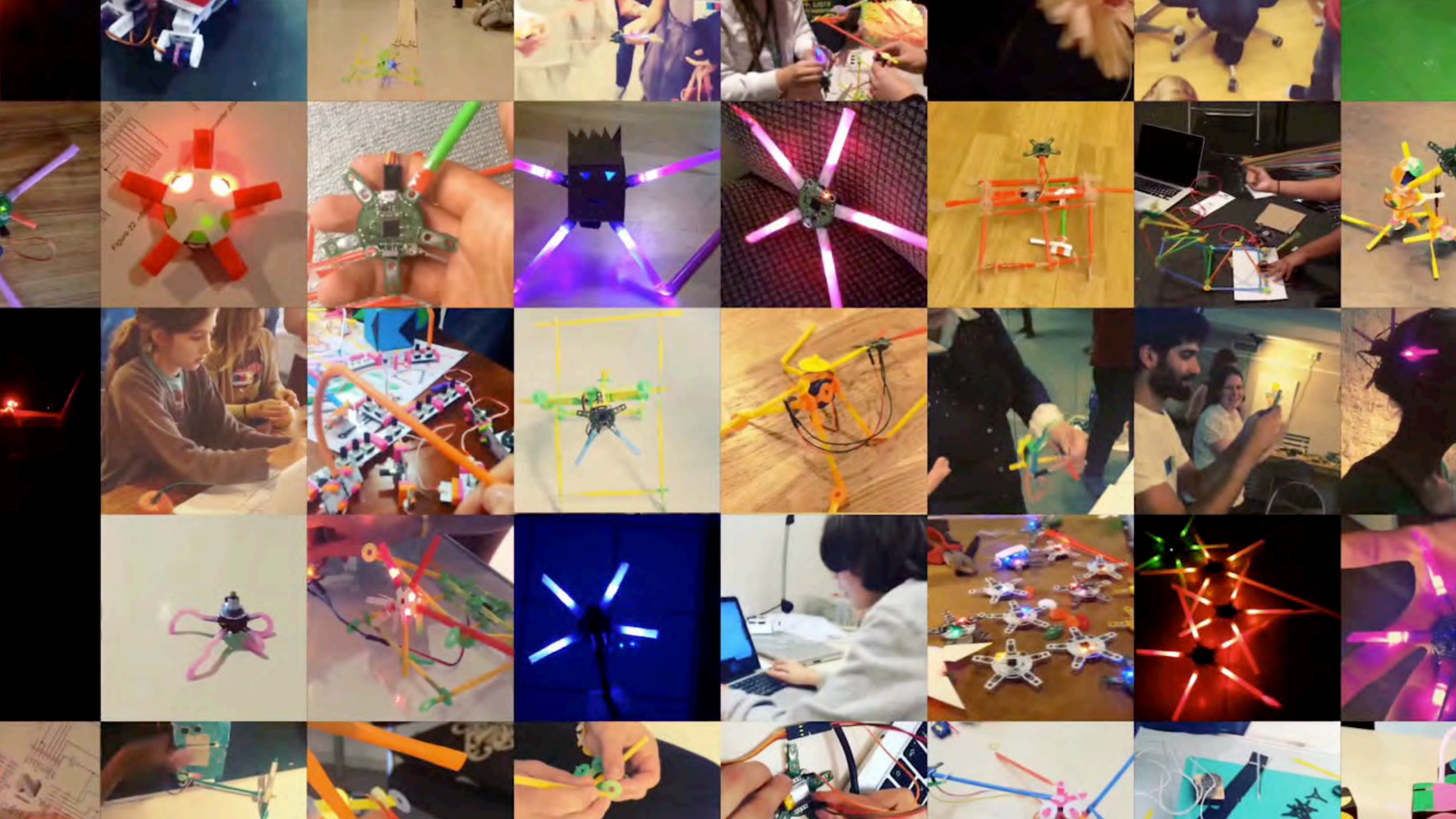
IN EDUCATION



QUIRKBOT, KIDS HACK DAY

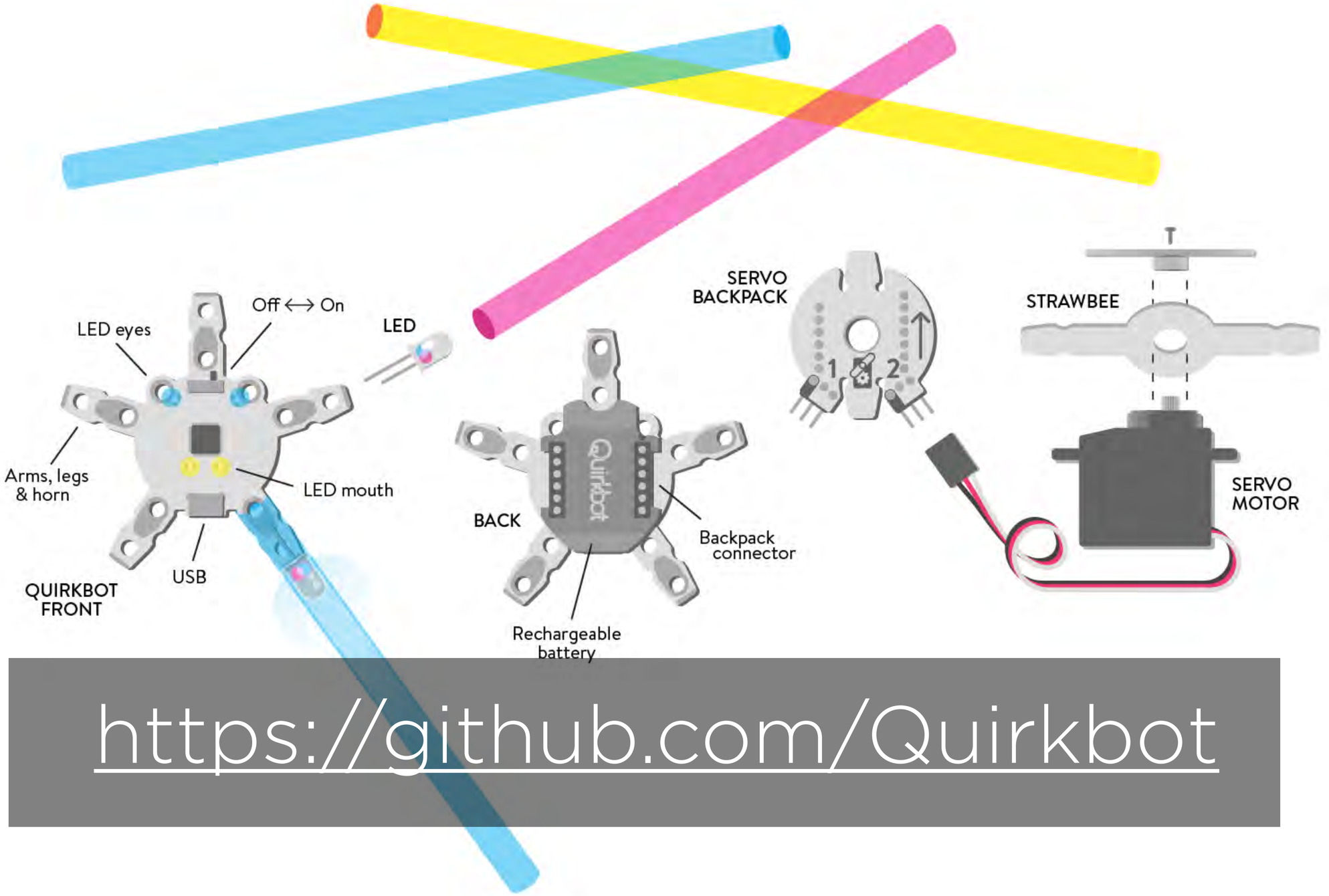
& OPEN SOURCE HARDWARE

Enabling a prototyping platform for kids

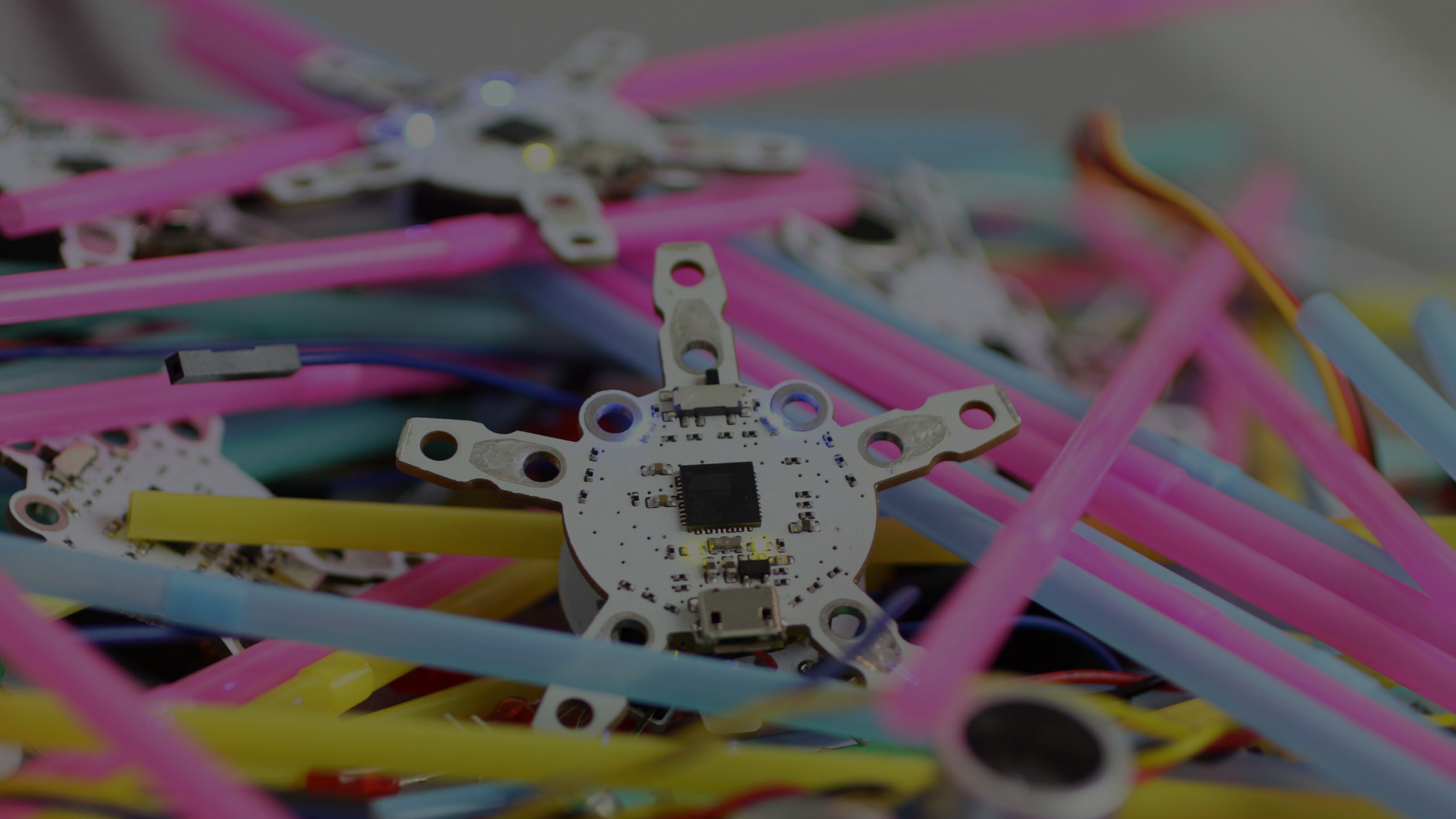


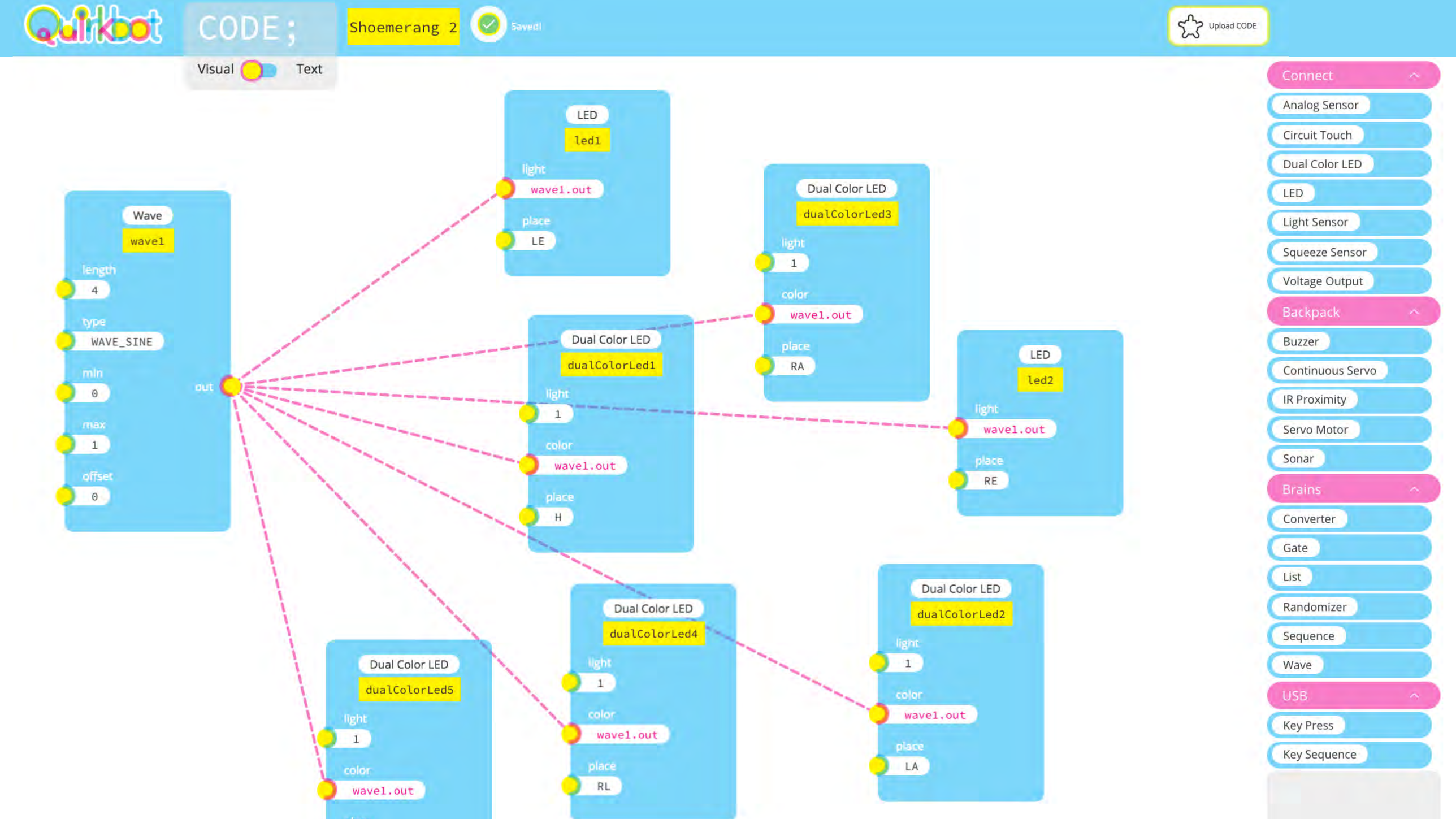
A TOY TO MAKE TOYS

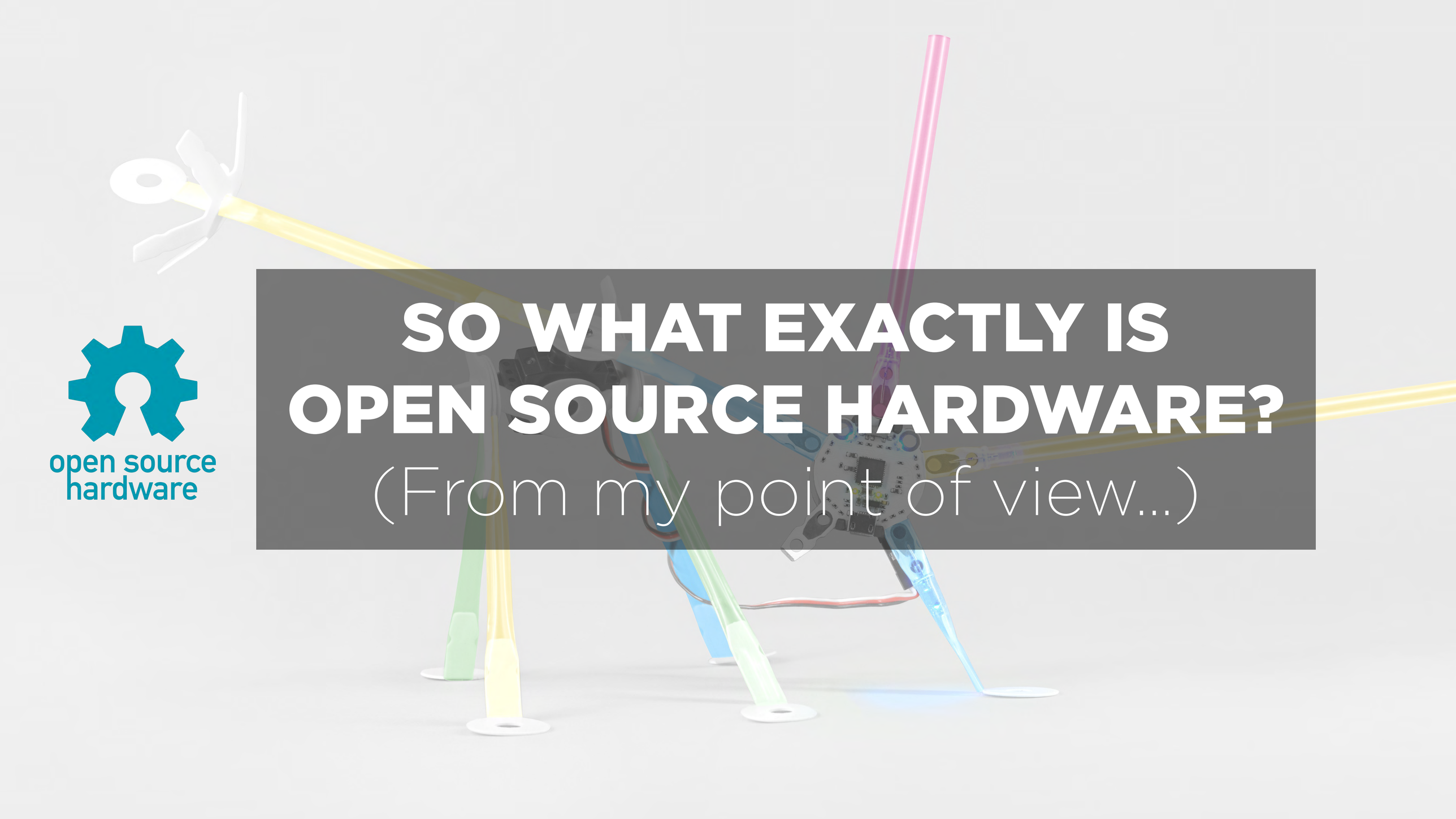
WHY OPEN?



https://github.com/Quirkbot




Quirkbot
CODE;
Visual
Text
Shoemerang 2
Saved!
Upload CODE
Connect
Analog Sensor
Circuit Touch
Dual Color LED
LED
Light Sensor
Squeeze Sensor
Voltage Output
Backpack
Buzzer
Continuous Servo
IR Proximity
Servo Motor
Sonar
Brains
Converter
Gate
List
Randomizer
Sequence
Wave
USB
Key Press
Key Sequence
Wave
wave1
length
4
type
WAVE_SINE
min
0
max
1
offset
0
out
LED
led1
light
wave1.out
place
LE
Dual Color LED
dualColorLed3
light
1
color
wave1.out
place
RA
Dual Color LED
dualColorLed1
light
1
color
wave1.out
place
H
LED
led2
light
wave1.out
place
RE
Dual Color LED
dualColorLed5
light
1
color
wave1.out
Dual Color LED
dualColorLed4
light
1
color
wave1.out
place
RL
Dual Color LED
dualColorLed2
light
1
color
wave1.out
place
LA

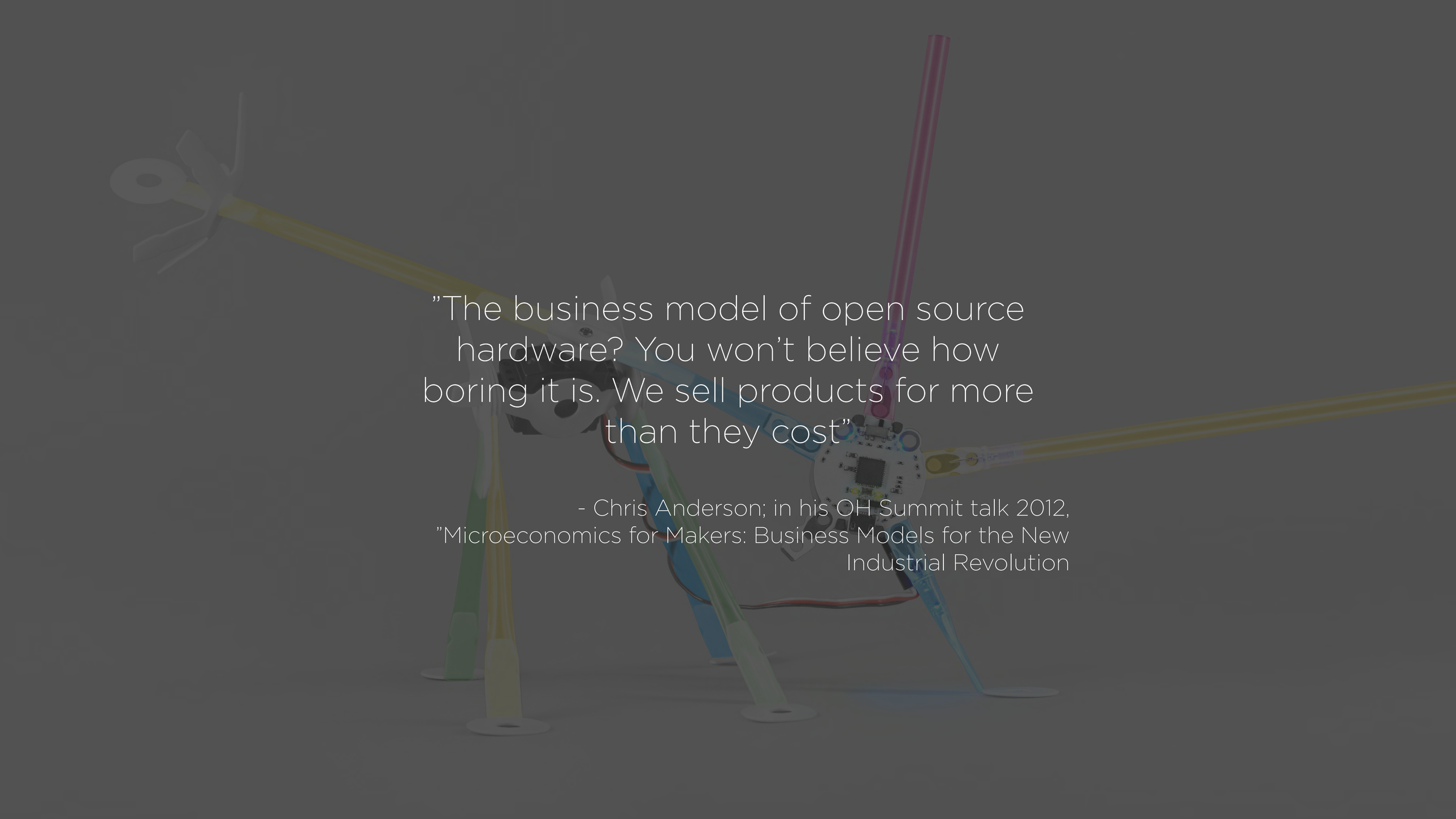


open source hardware

SO WHAT EXACTLY IS OPEN SOURCE HARDWARE?

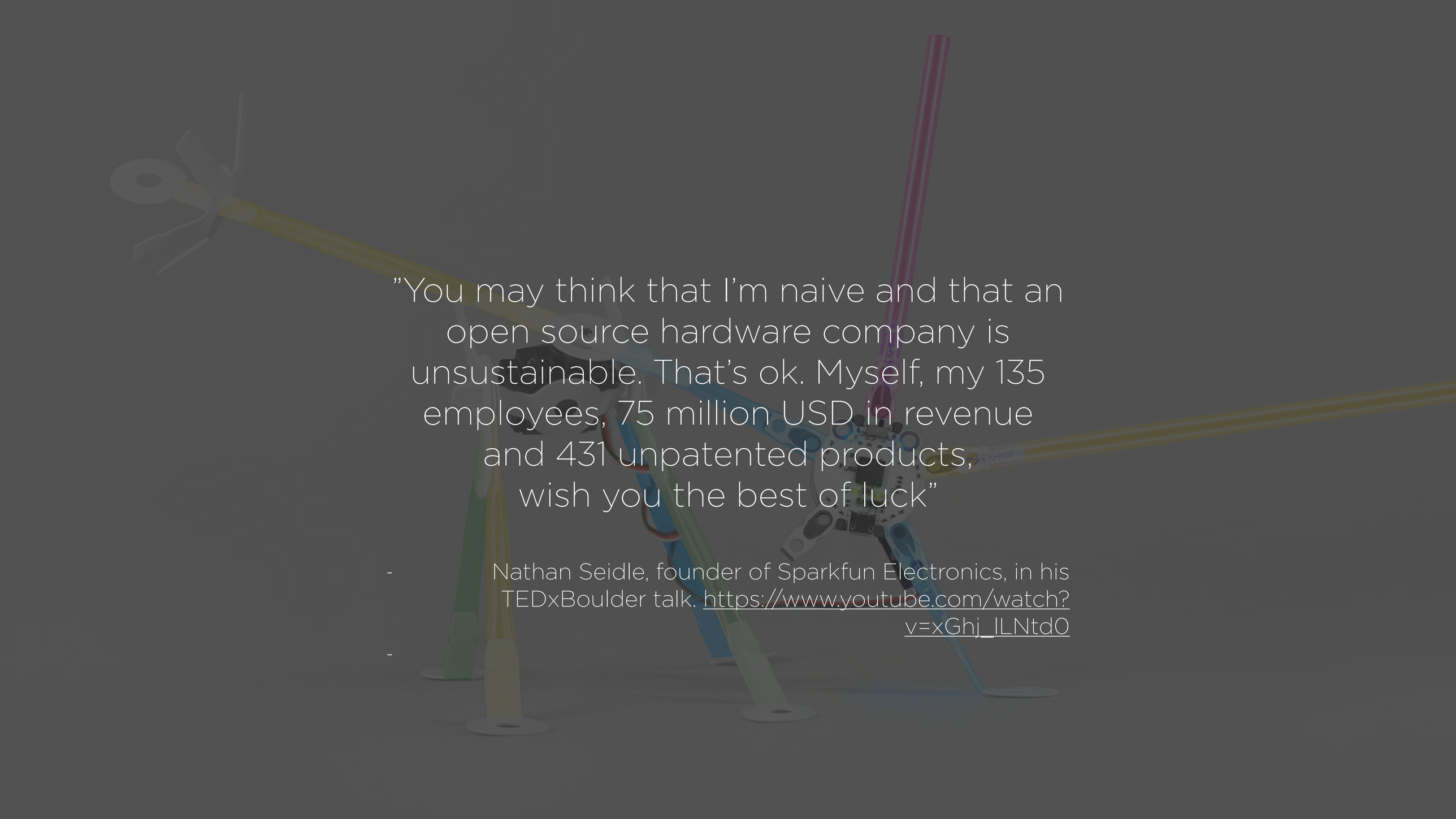
(From my point of view...)


IDEOLOGY
FOR EVERYONE
OPEN SOURCE SOFTWARE
LET'S START WITH WHAT IT'S NOT...
EASY WAY OUT
FREE
ONE-SIDED SINGLE LICENSE
MATURE
THE OPPOSITE OF PATENTS



”The business model of open source hardware? You won’t believe how boring it is. We sell products for more than they cost”

- Chris Anderson; in his OH Summit talk 2012, ”Microeconomics for Makers: Business Models for the New Industrial Revolution



”You may think that I’m naive and that an open source hardware company is unsustainable. That’s ok. Myself, my 135 employees, 75 million USD in revenue and 431 unpatented products, wish you the best of luck”

- Nathan Seidle, founder of Sparkfun Electronics, in his TEDxBoulder talk. https://www.youtube.com/watch?v=xGhj_ILNtd0
-

OK I GOT IT. BUT IS THIS OSHW THING REALLY SOMETHING FOR THE WIND POWER INDUSTRY?

LESS R&D COSTS → BETTER PRODUCTS

LESS LEGAL FEES → COLLABORATION & SYNERGIES

ETHICAL BONUS FOR THE BRAND → LESS COSTS FOR SUPPORT, ADs. PR etc

→ BETTER EMPLOYEES

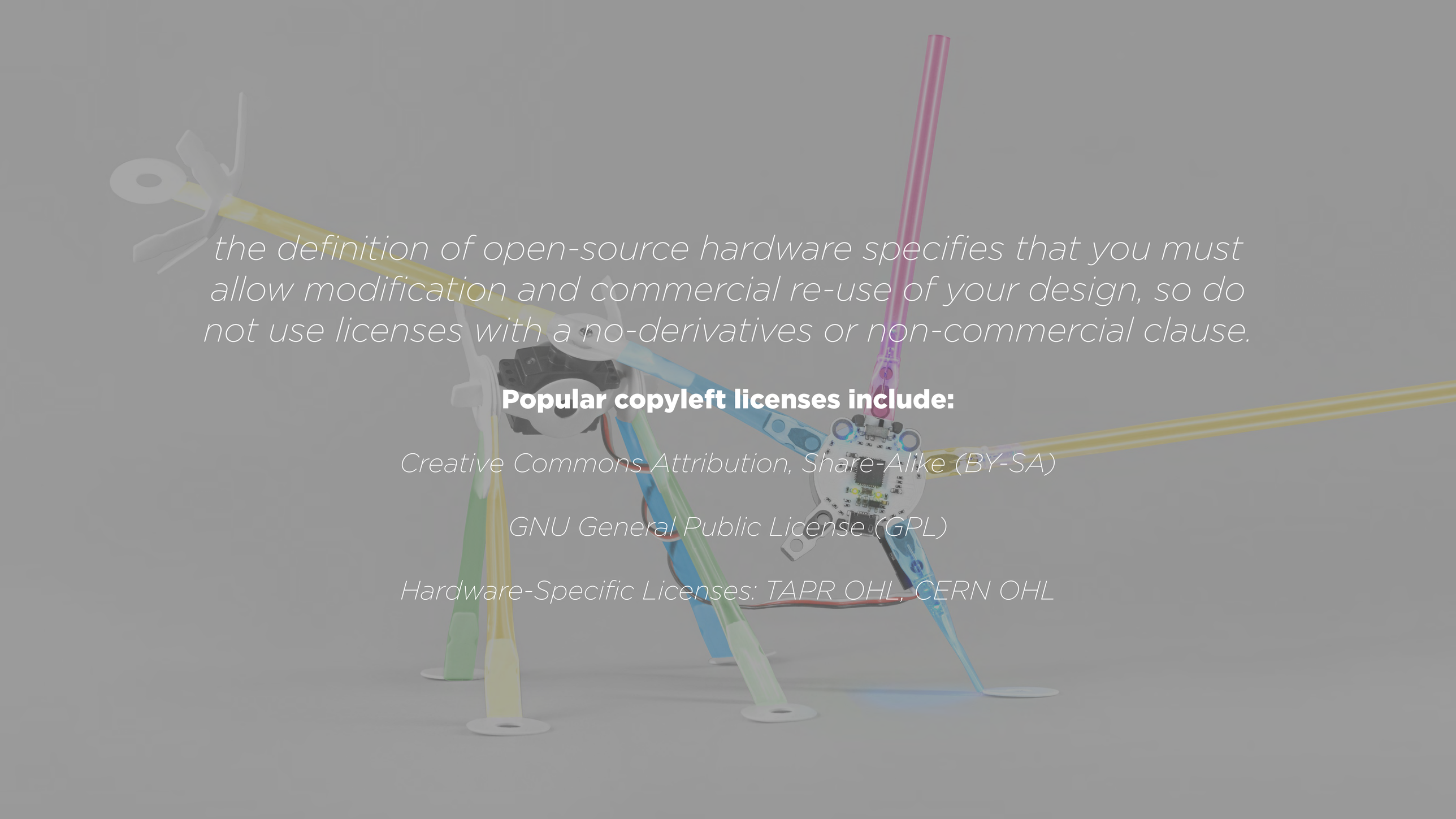
THE OSHW BUSINESS MODEL

PRODUCE &
SELL PRODUCTS

SELLING THE
SERVICE (ENERGY)

ON REQUEST
INDIVIDUAL
DEVELOPMENT

SUPPORT



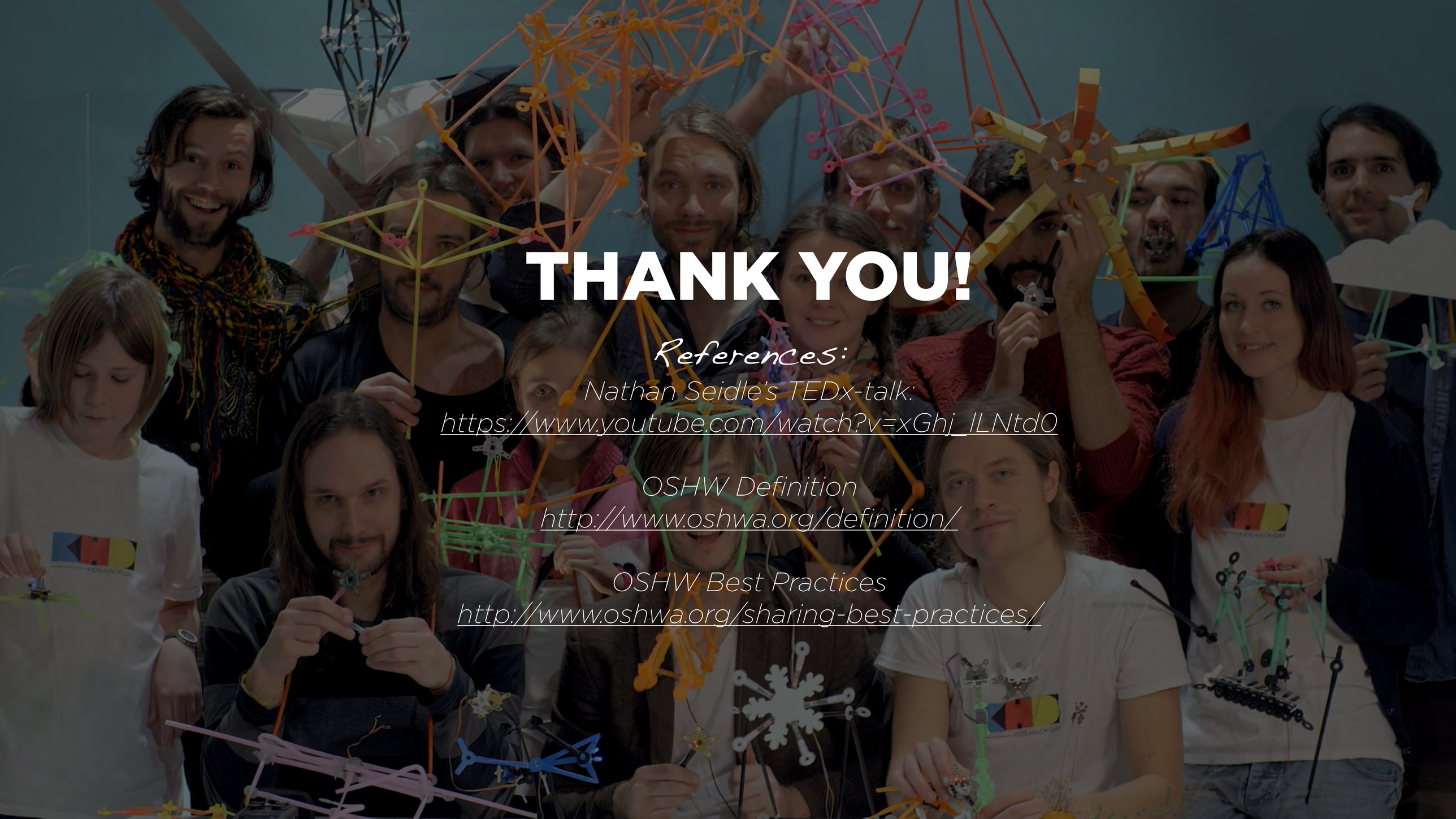
the definition of open-source hardware specifies that you must allow modification and commercial re-use of your design, so do not use licenses with a no-derivatives or non-commercial clause.

Popular copyleft licenses include:

Creative Commons Attribution, Share-Alike (BY-SA)

GNU General Public License (GPL)

Hardware-Specific Licenses: TAPR OHL, CERN OHL



THANK YOU!

References:

Nathan Seidle's TEDx-talk:
https://www.youtube.com/watch?v=xGhj_ILNtd0

OSHW Definition
http://www.oshwa.org/definition/

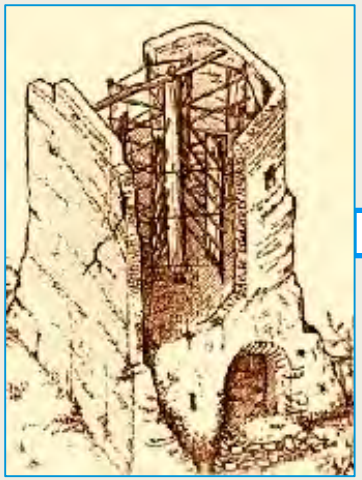
OSHW Best Practices
http://www.oshwa.org/sharing-best-practices/

Where does small wind go from here?

Jay Hudnall
jay@tieole.com

TI'ÉOLE
ÉNERGIES ÉOLIENNES

Over 2000 years of wind energy



-200 BC

1200s

1880s

1920s

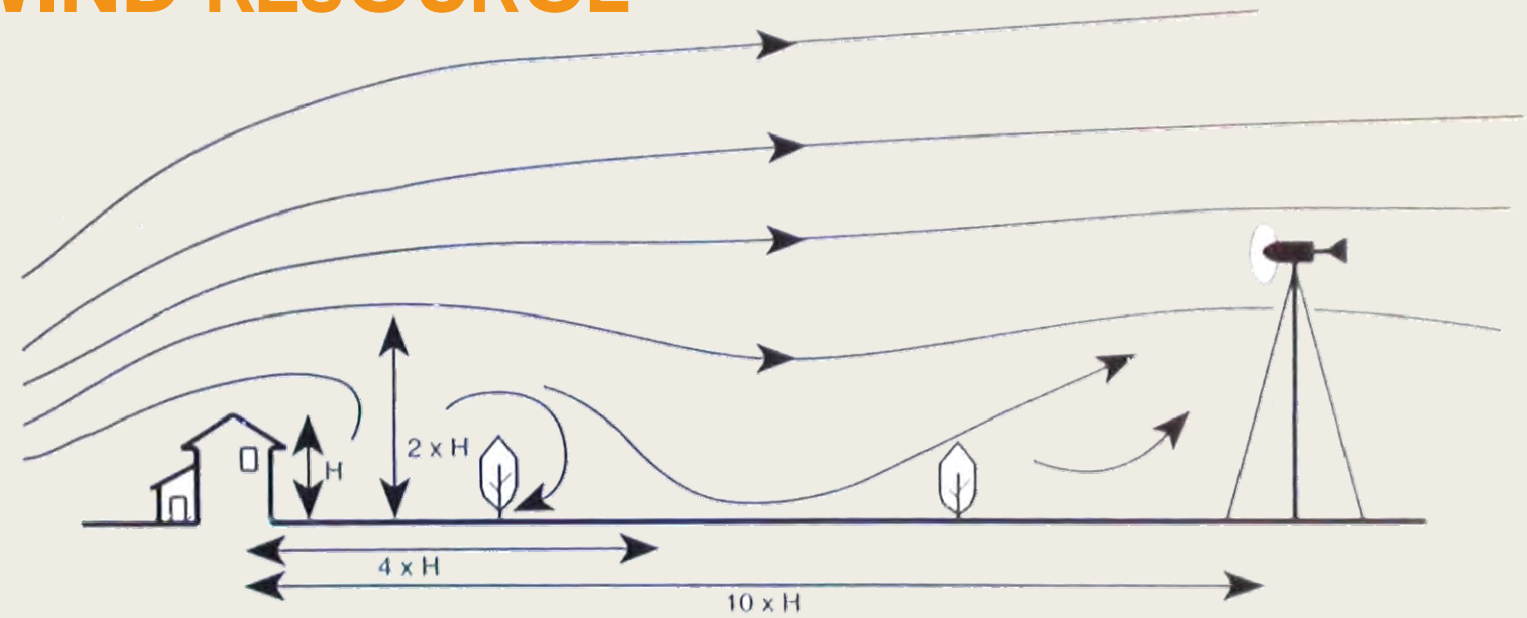
What are the obstacles preventing small wind development in Europe?

SPACE

Wind turbines are not for the built environment. Small wind turbines function best for isolated homes, farms, and businesses.

What are the obstacles preventing small wind development in Europe?

WIND RESOURCE



To produce the same energy at 12m in a field, one needs à 41m tower in a suburb, or 74m tower in a city environment.

There is 93% more energy in the wind at 5m/s than at 4 m/s

TI'ÉOLE
ÉNERGIES ÉOLIENNES

What are the obstacles preventing small wind development in Europe?

RENTABILITY

$$\frac{\text{Cost (Krona)}}{\text{Energy produced (kWh)}}$$

On-grid electricity is cheap, solar is cheap, wind is expensive.
Installing a small wind turbine is too expensive.

Can DIY small wind turbines be a practical solution?

Reliability

Hugh Piggott's designs have been around since the 1970s.

People all over the world are building turbines based on Hugh's designs, as well as sharing knowledge and technology.

TI'ÉOLE
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Can DIY small wind turbines be a practical solution?

Rendement

Spending less, or nothing, on manufacturing costs, means more money can be spent on magnets and copper. Making a high quality generator.

Can DIY small wind turbines be a practical solution?

Maintenance

In most cases can be done by the user, in other cases he can get some help from his friends. Getting an installer out usually costs more than the value of the energy produced by the turbine.

Can DIY small wind turbines be a practical solution?

Propagation

Someone who has built their own wind turbine is no longer a consumer, but an actor in developing small wind. Teaching friends, family, and neighbors to build and maintain their own wind turbine.

The Future of Small Wind

Jay Hudnall

jay@tieole.com

TI'ÉOLE
ÉNERGIES ÉOLIENNES


SVENSK
vindkraft
FÖRENING

Svensk Vindkraftförening

Svensk Vindkraftförening är främst en ägarförening men öppen för alla, bland våra medlemmar finns både privatpersoner, leverantörer och vindkraftutvecklare.

Förening har mer än 30 års erfarenhet av vindkraft och har cirka 1500 medlemmar.

Fakta:

- Etablerad 1986
- Är en ideell och politiskt obunden förening
- Är en etablerad remissinstans
- Delar ut årligen ut Årets vindkraftpris

Föreningen främjar vindkraftutvecklingen genom att:

- Förmedla kunskap
- Främja teknisk utveckling
- Skapa rimliga ekonomiska villkor
- Samverkar med myndigheter och organisationer

Som medlem får du ta del av:

- Föreningens samlade kunskap om vindkraft
- Föreningens nätverk
- Föreningens event, seminarier och konferenser
- Föreningens remissvar
- Tillgång till medlemssidorna via vår hemsida
- Tillgång till våra sociala medier
- Stämmodagen
- Våra medlemsförmåner

Våra medlemsförmåner

- Ramavtal med elhandelbolag
- Skräddarsydd Vindkraftförsäkring
- Juridisk rådgivning

- Årsprenumeration Tidningen Svensk Vindkraft
- Rabatter och erbjudanden

Svensk Vindkraftförening som konferensvärd

Winterwind International Wind Energi Conference

Winterwind en konferens där de senaste tekniska innovationerna och utmaningarna för vindkraft i kalla klimat diskuteras.

Konferensen har en bred publik bestående av representanter från branschen. De senaste åren har deltagarantalet legat konstant runt 500 deltagare från 20 länder.

Konferensen erbjuder parallella seminarier, panel-debatter, utställning samt socialt nät verkande.

Ett tekniskt besök står också alltid på programmet. Svensk Vindkraft förening har arrangerat konferensen årligen sedan 2008. ’

Åre 8-10 februari 2016

Winterwind
INTERNATIONAL WIND ENERGY CONFERENCE

Svensk Vindkraftförening står värd för World Wind Energy Conference WWEC 2017

Konferensen arrangeras årligen av World Wind Energy Association (WWEA) i samarbete med en nationell medlemsorganisation. Det blir första gången som världsvindkonferensen hålls i Sverige.

Konferensen kommer ge ett utmärkt tillfälle för svenska aktörer att synas globalt och för världen att se möjligheter i Sverige. Malmö rankas idag som en av världens mest hållbara städer.

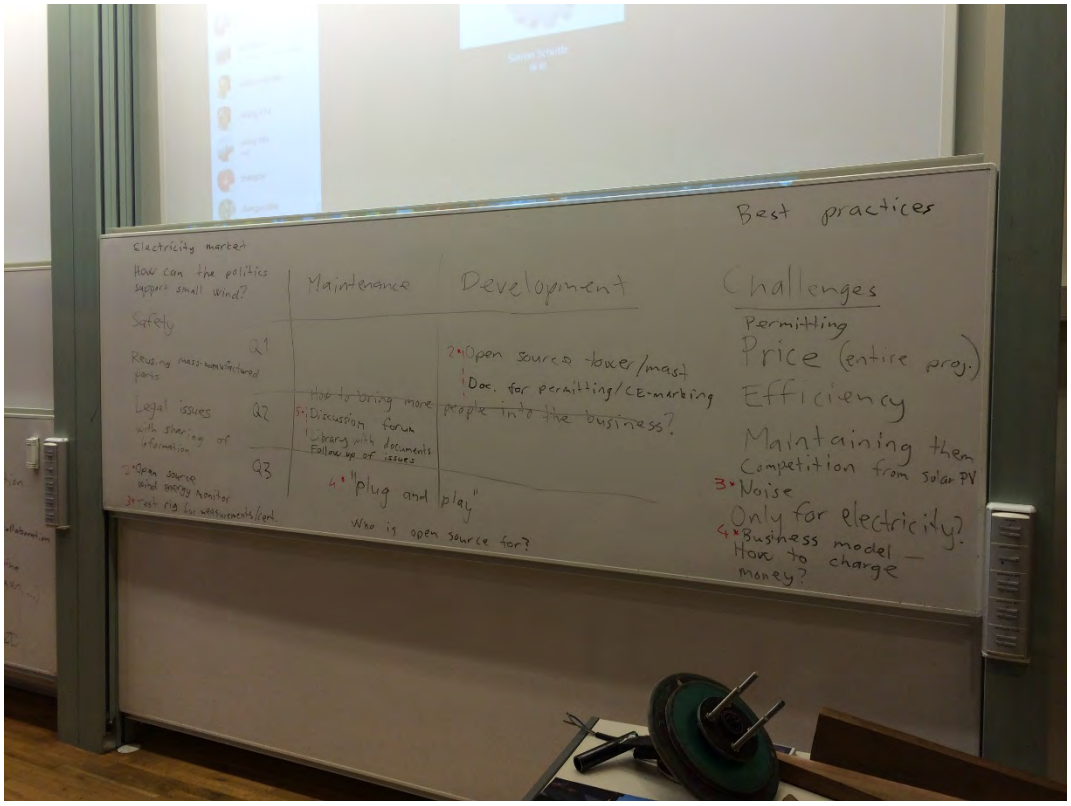
Malmö 12-14 juni 2017

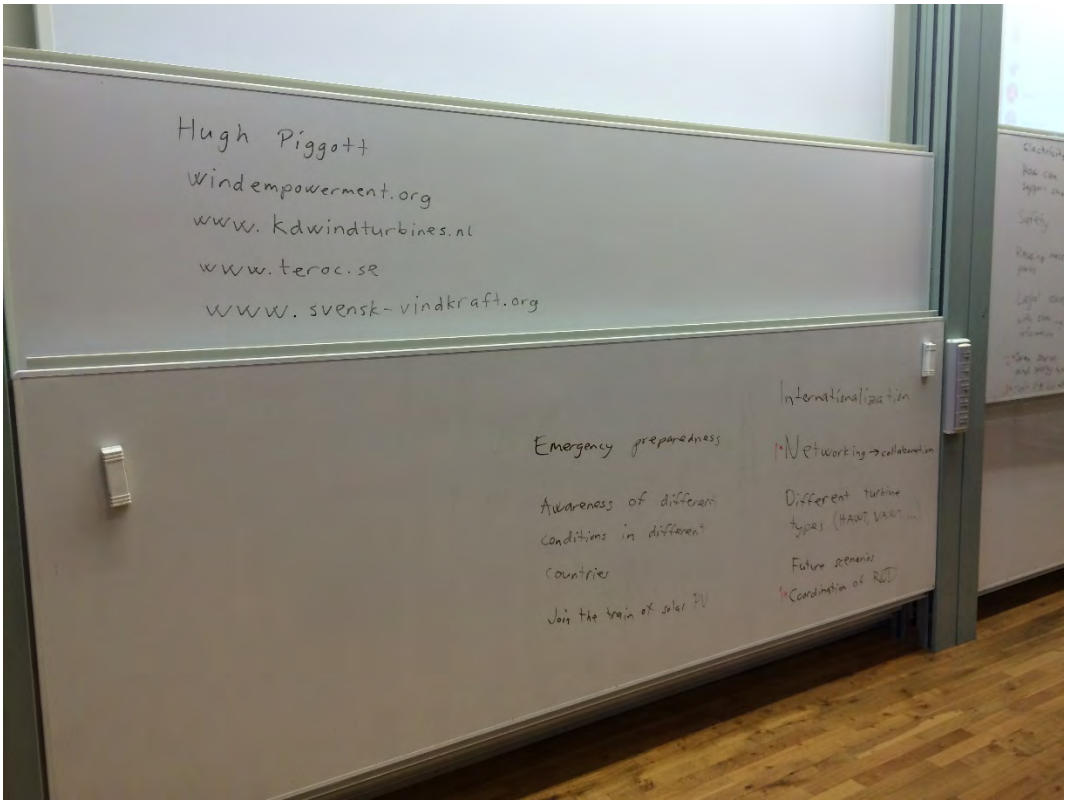
WWEA
World Wind Energy Association

BRAINSTORMING AND DISCUSSIONS


Brainstorming & discussion
Q1-How to support small wind turbines manufacturers in R&D?
Q2-How to support the owners of small wind turbines?
Q3-How to promote open source projects for facilitating and boosting the small wind turbine market in Sweden?

NOTES FROM THE BRAINSTORMING AND DISCUSSIONS





Among all the topics/ideas raised up during the brainstorming session, the attention of the discussion session focused on five topics/ideas.

1. Networking/Collaboration/Coordination

- UniLab – research sharing platform under development
- Joint research project application
- WindEmpowerment – small wind research sharing through the website and coordinated by members?
- WindEmpowerment for research and development
- Building an international library of small wind documentation. An RSS type system which can be integrated into the websites of national small wind associations.
- Interesting small wind reports kdwindturbines.nl
- Coordinate R&D between universities and companies
- Organize conferences and workshops
- Governmental support for small-wind turbines policies
- Swedish wind power association for technical support to owners of small wind turbines and for support research and development
- Facebook and LinkedIn group to share photos, information, events.

2. Open source tower, wind energy monitoring, controllers, and others.

- What role can/should WindEmpowerment play in developing and coordinating these open source projects?
- Sharing and improving the Hugh Piggott generator design spreadsheet
- Excel tower design guide for steel, guy-wired towers
- Arduino projects for wind speed and energy monitoring
- Projects for students at the university
- Sharing data regarding wind speed and energy production at different sites with different small wind turbines

3. Noise and testing

- Using existing installations to do testing
- Develop a small wind test facility at one of the universities in Sweden
- Test system components
- Collaboration among universities to share tests facilities

3. Business model

- Plug-and-play small wind kits
- Build-it-yourself turbine and tower kits (innoventum.se)

- Propose to students from the economy department to conduct market survey and elaborate business models for small wind turbines
- Compare successful business models for small wind turbines market

5. Maintenance

- Create a blog/forum for small wind turbines owners to share experiences, materials, projects and contacts
- Suggested Facebook as an easy platform to share photos, information, events.

COURSE ON HOW TO BUILD SMALL WIND TURBINES