



**Babelbee**



**Open  
Source**

**Electric  
Power**

**Monitor-  
ing**

**Manage-  
ment**

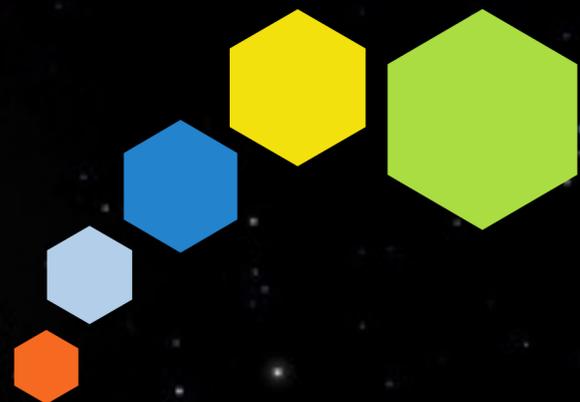
# Babelbee

*“A Building Block for decentralized Grid Management”*

– Tomi Engel, Karlsruhe, 2015.06.06

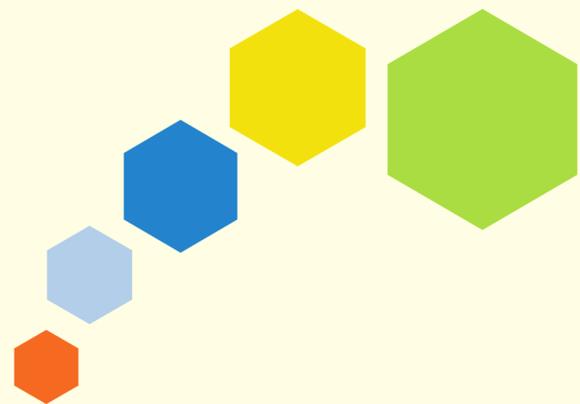


# Evolution of the Babelbee





# Evolution of the Babelbee

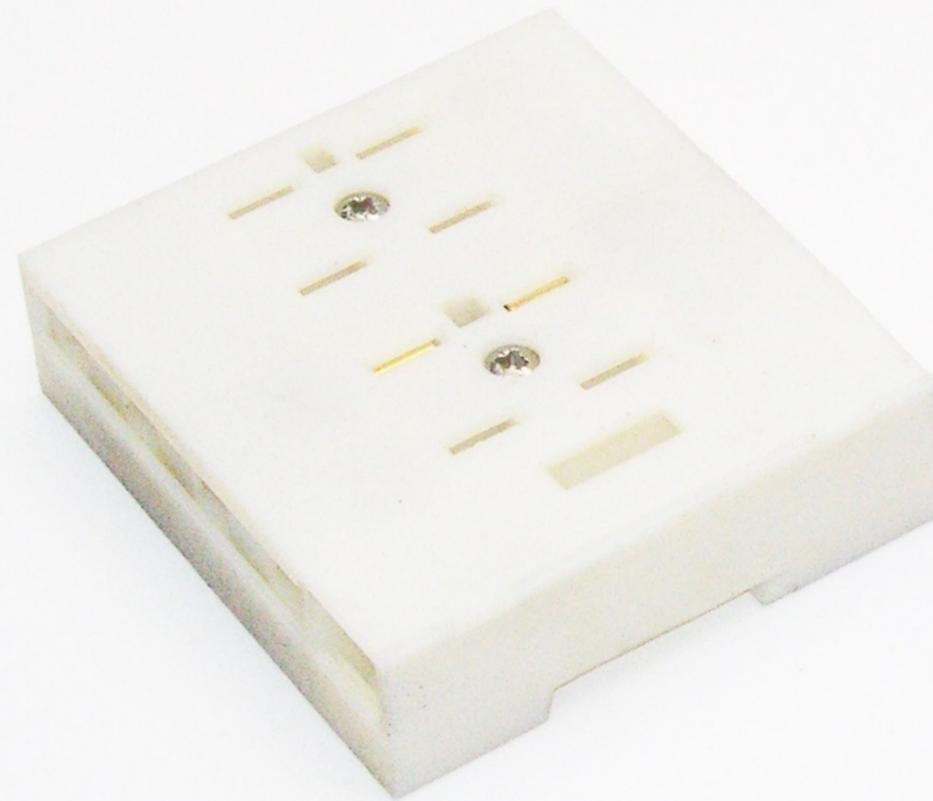




# Evolution of the Babelbee



**2008**

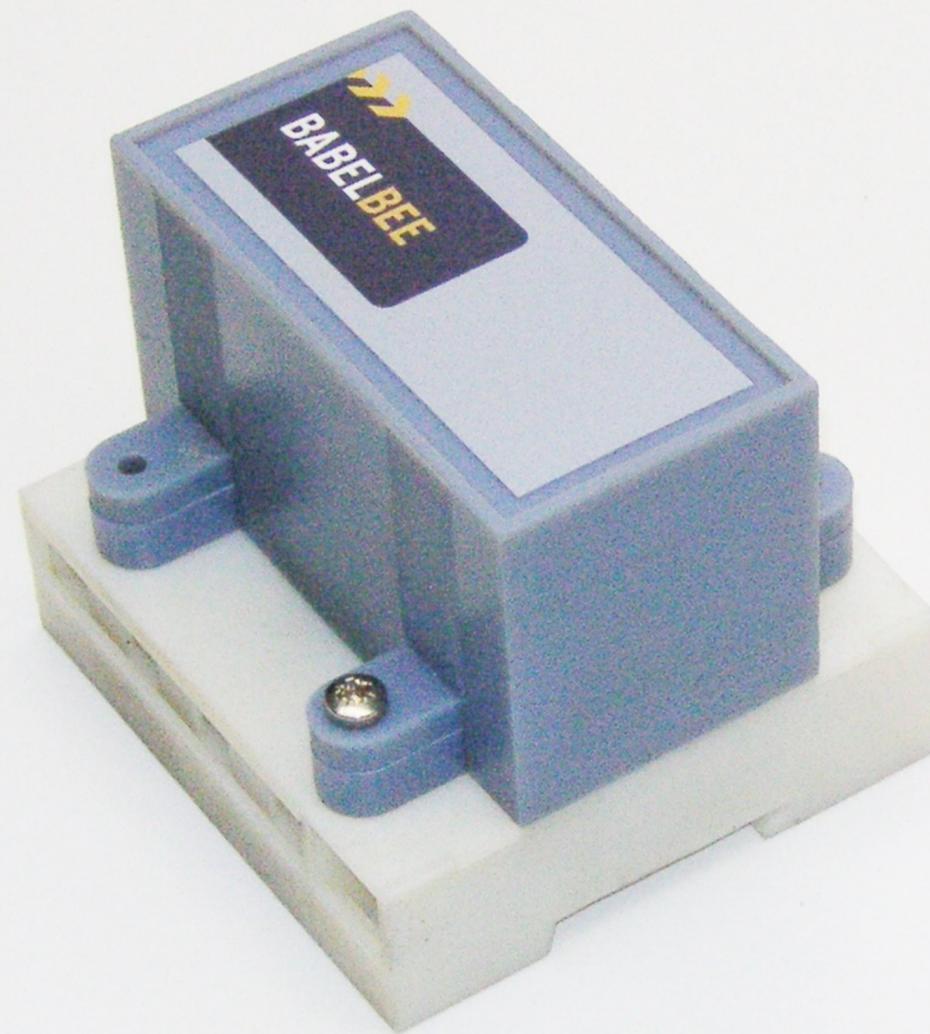




# Evolution of the Babelbee



**2008**

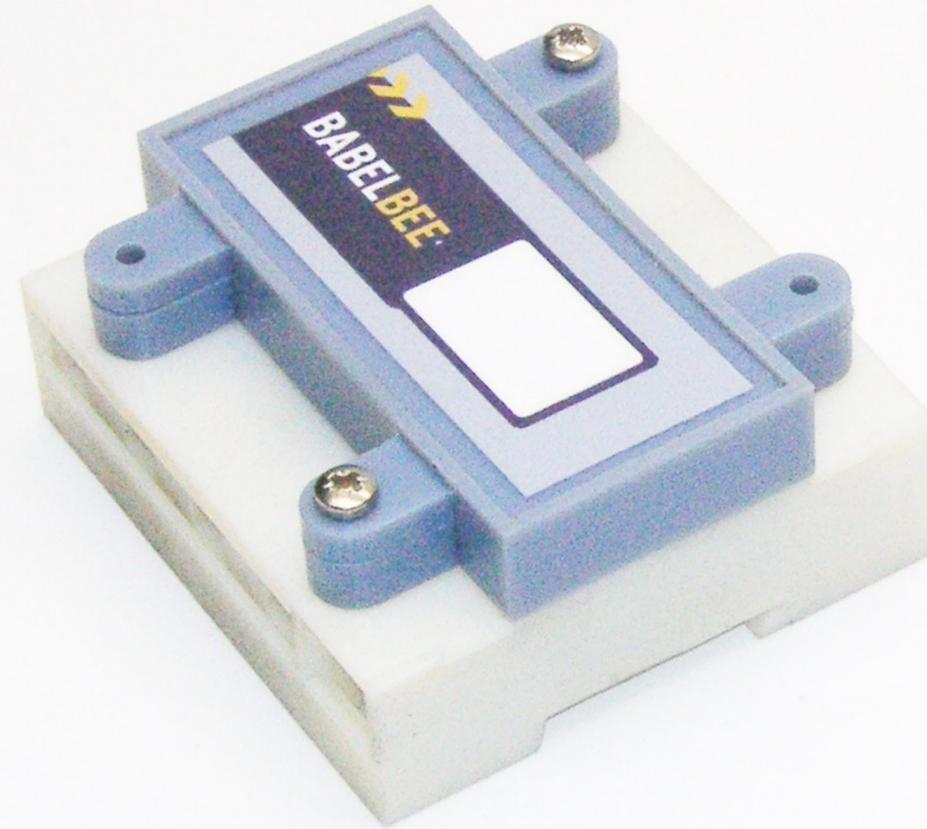




# Evolution of the Babelbee



**2008**

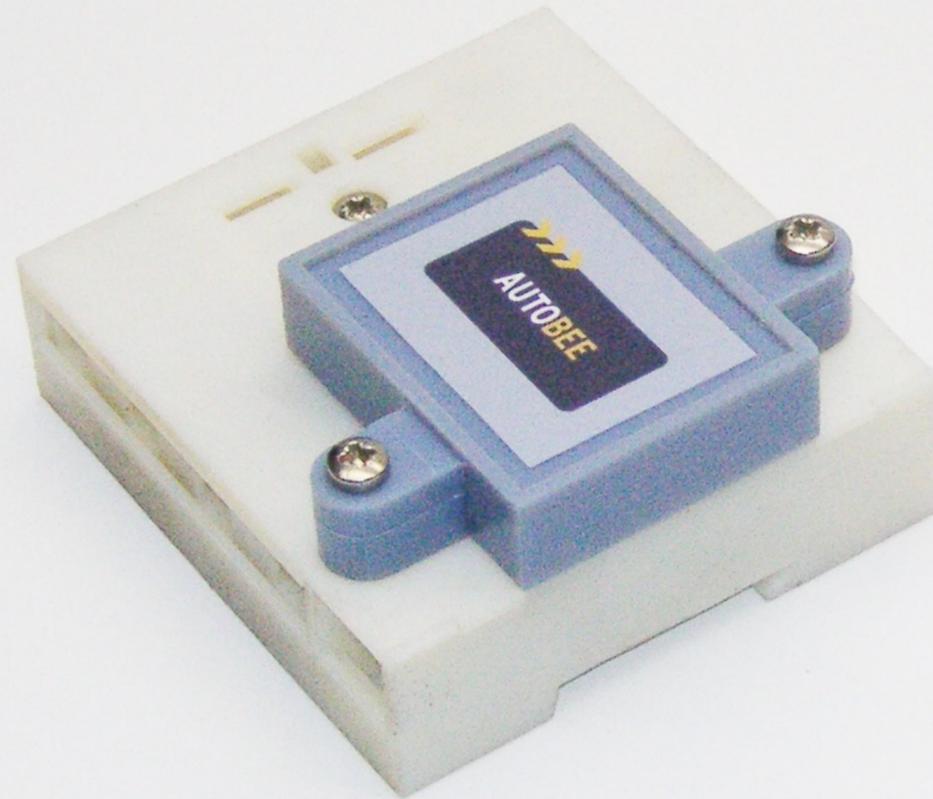




# Evolution of the Babelbee



**2008**

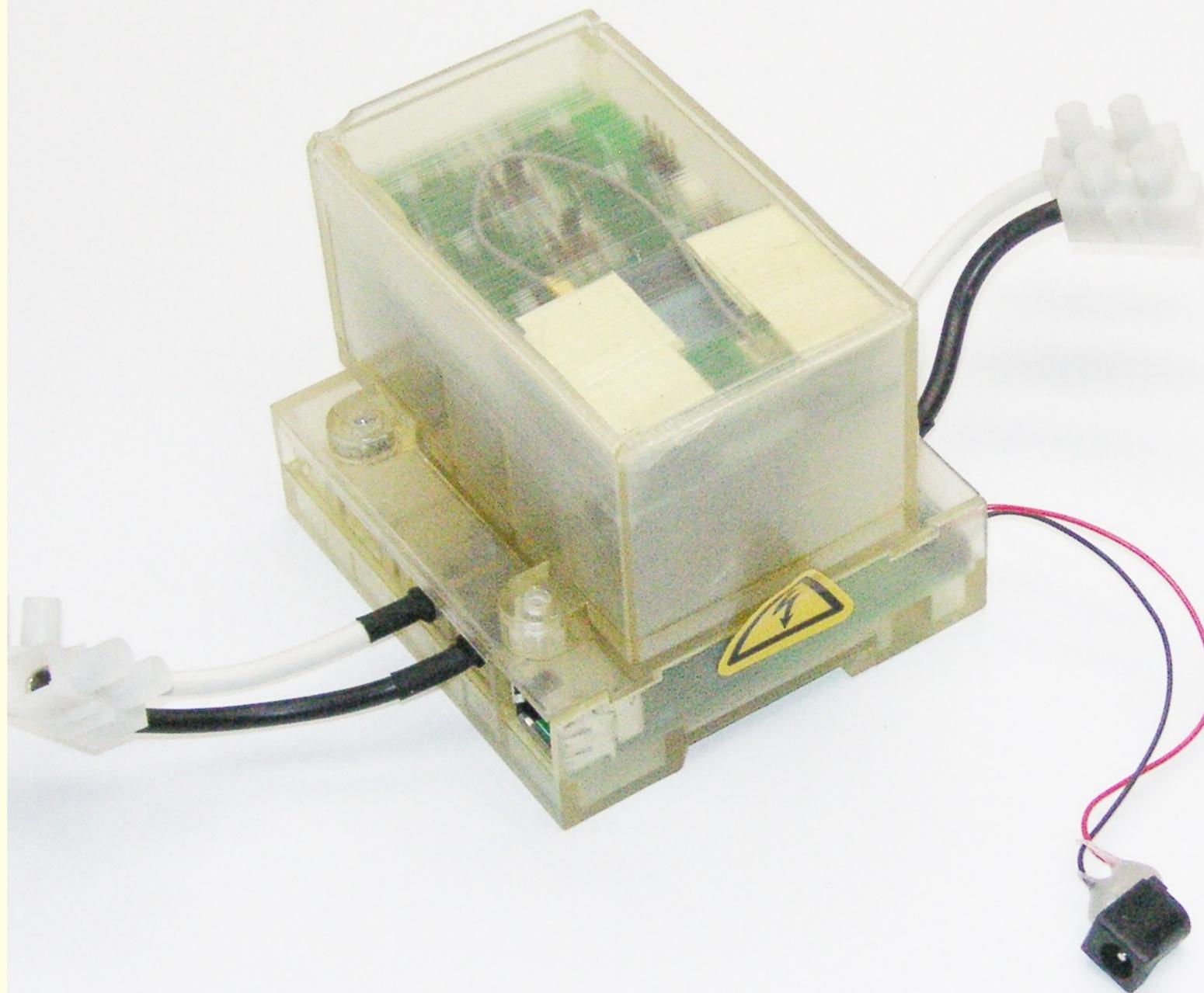




# Evolution of the Babelbee



**2011**

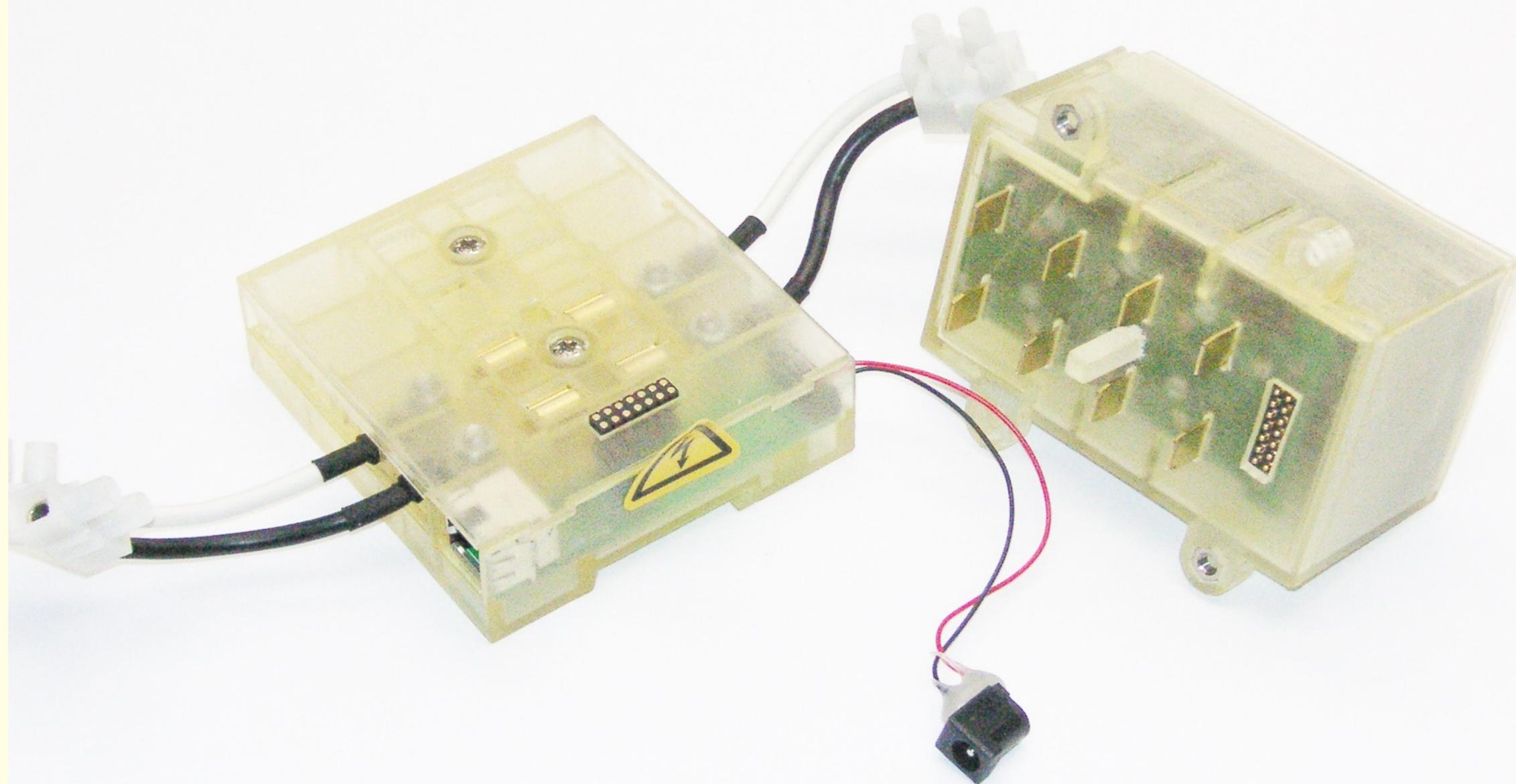




# Evolution of the Babelbee



**2011**

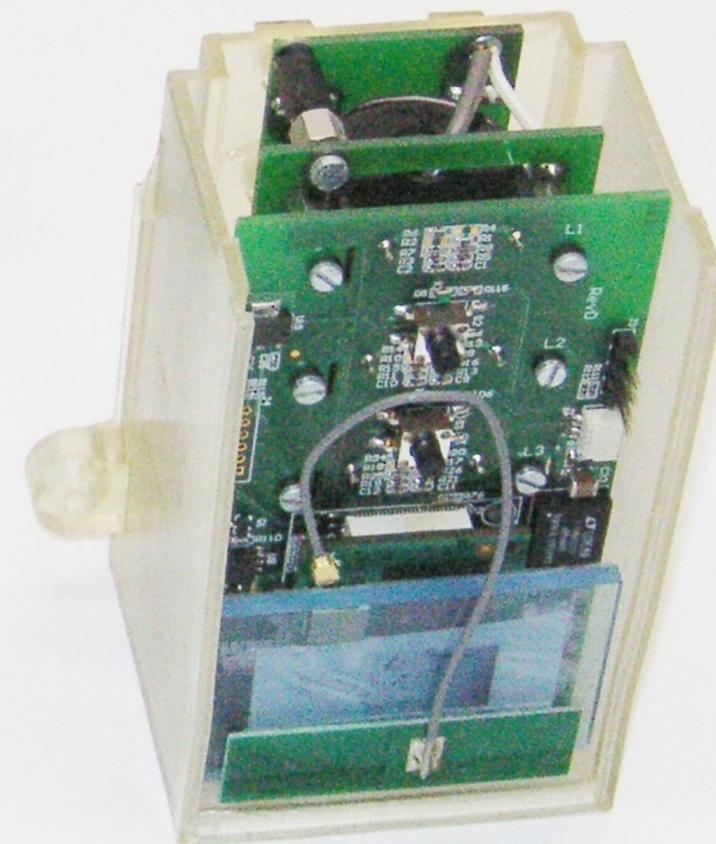
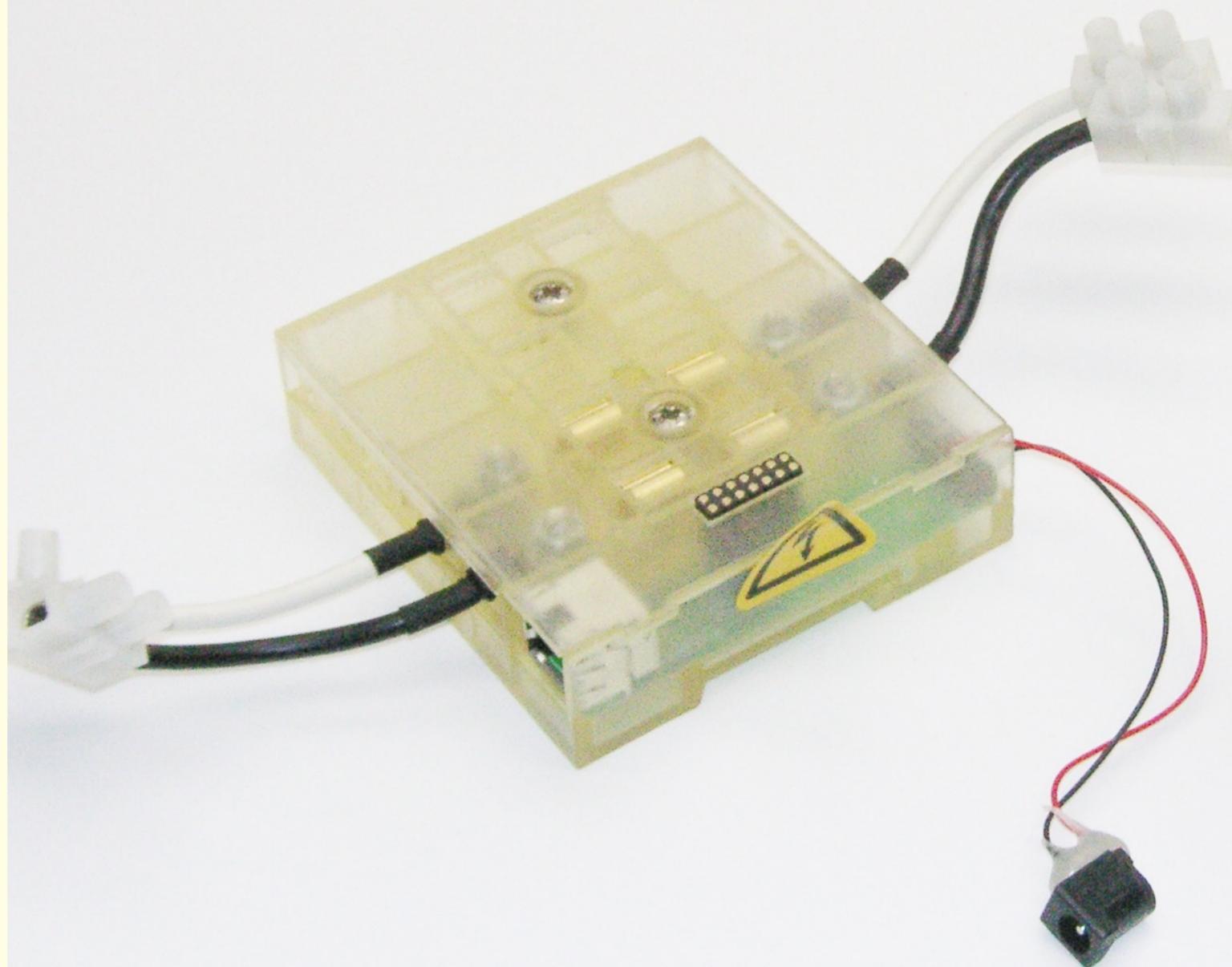




# Evolution of the Babelbee



**2011**

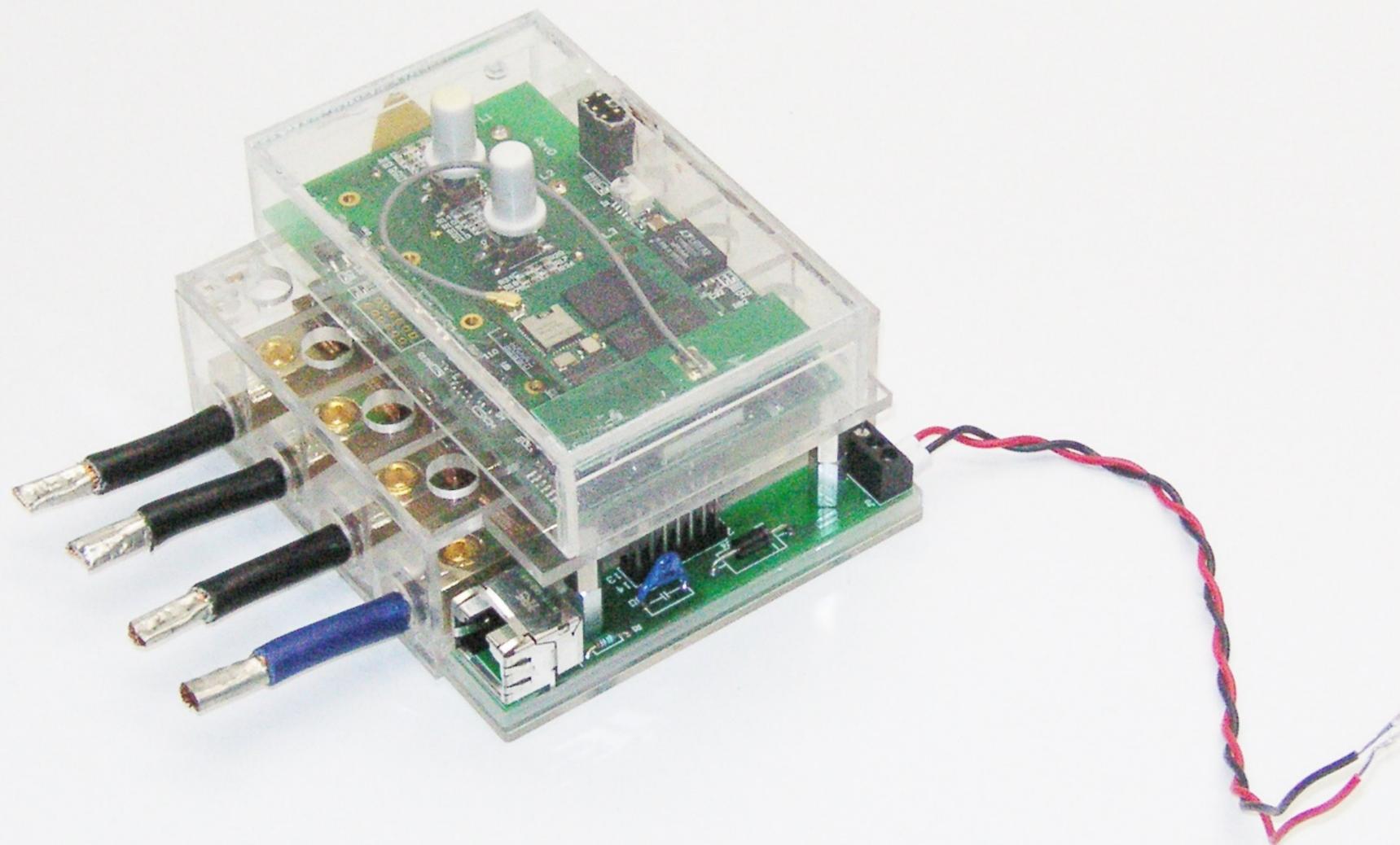




# Evolution of the Babelbee



**2011**

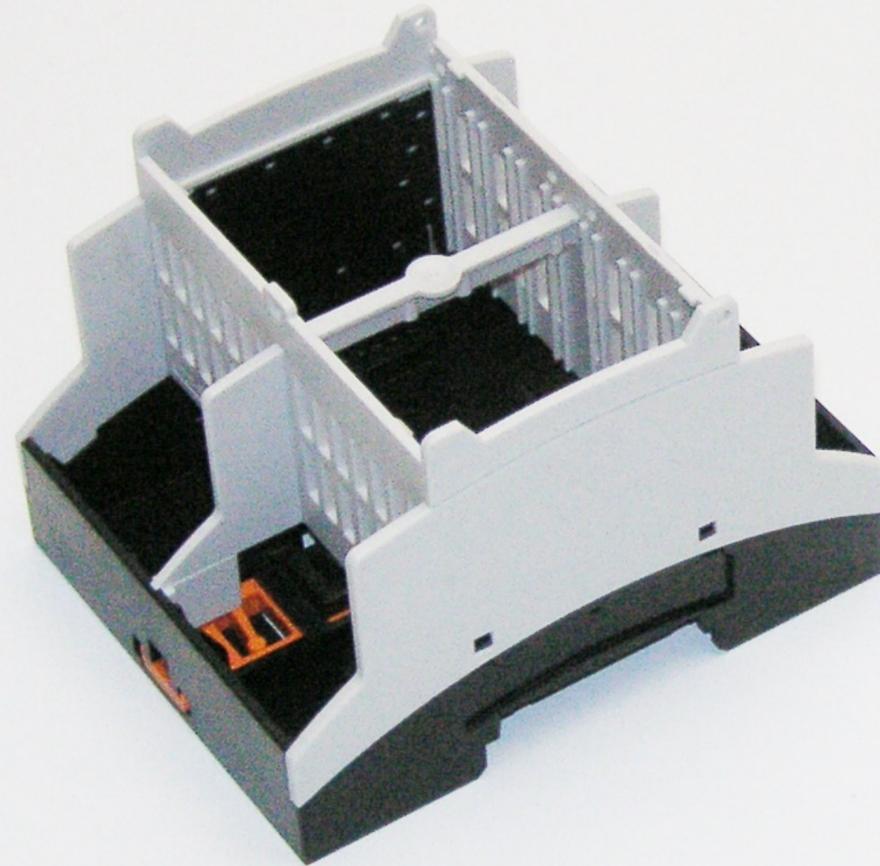




# Evolution of the Babelbee



**2012**

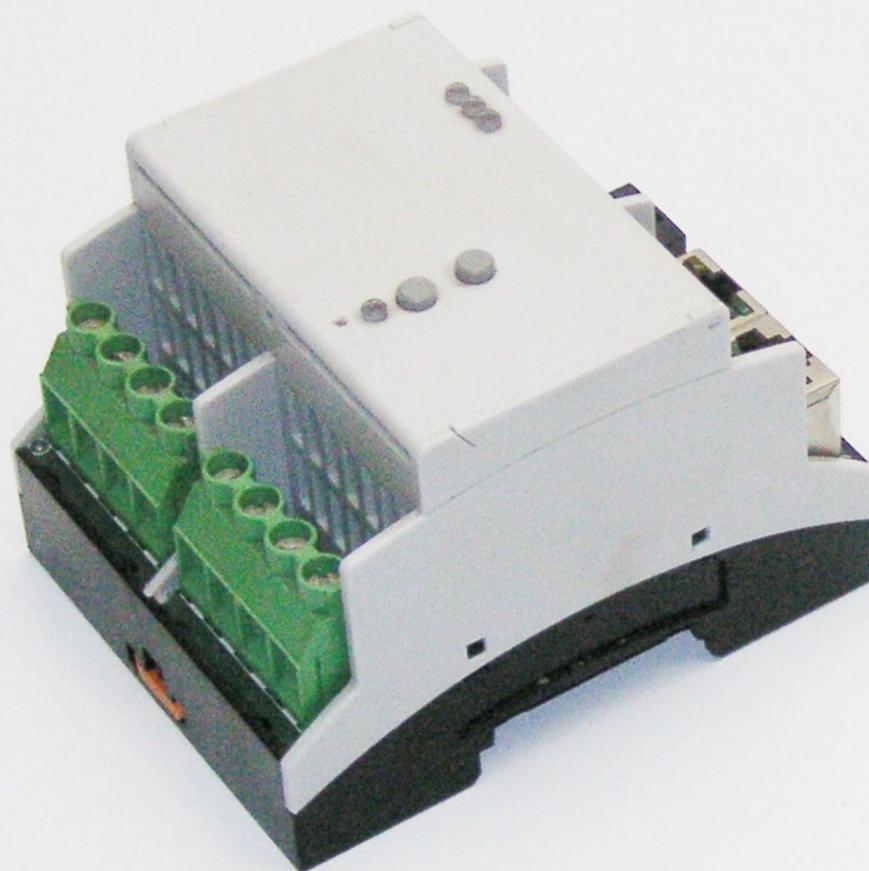




# Evolution of the Babelbee



**2013**

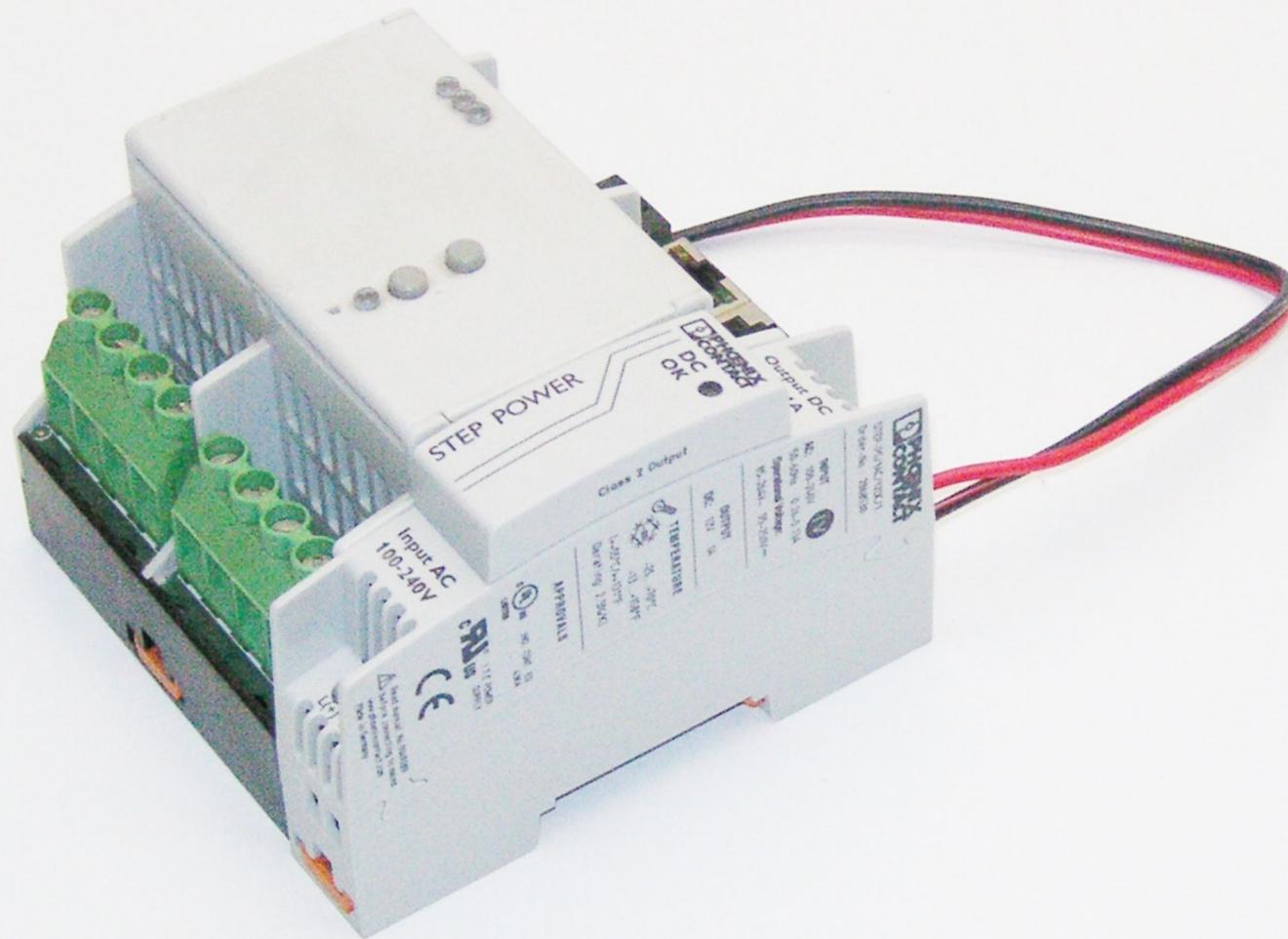




# Evolution of the Babelbee



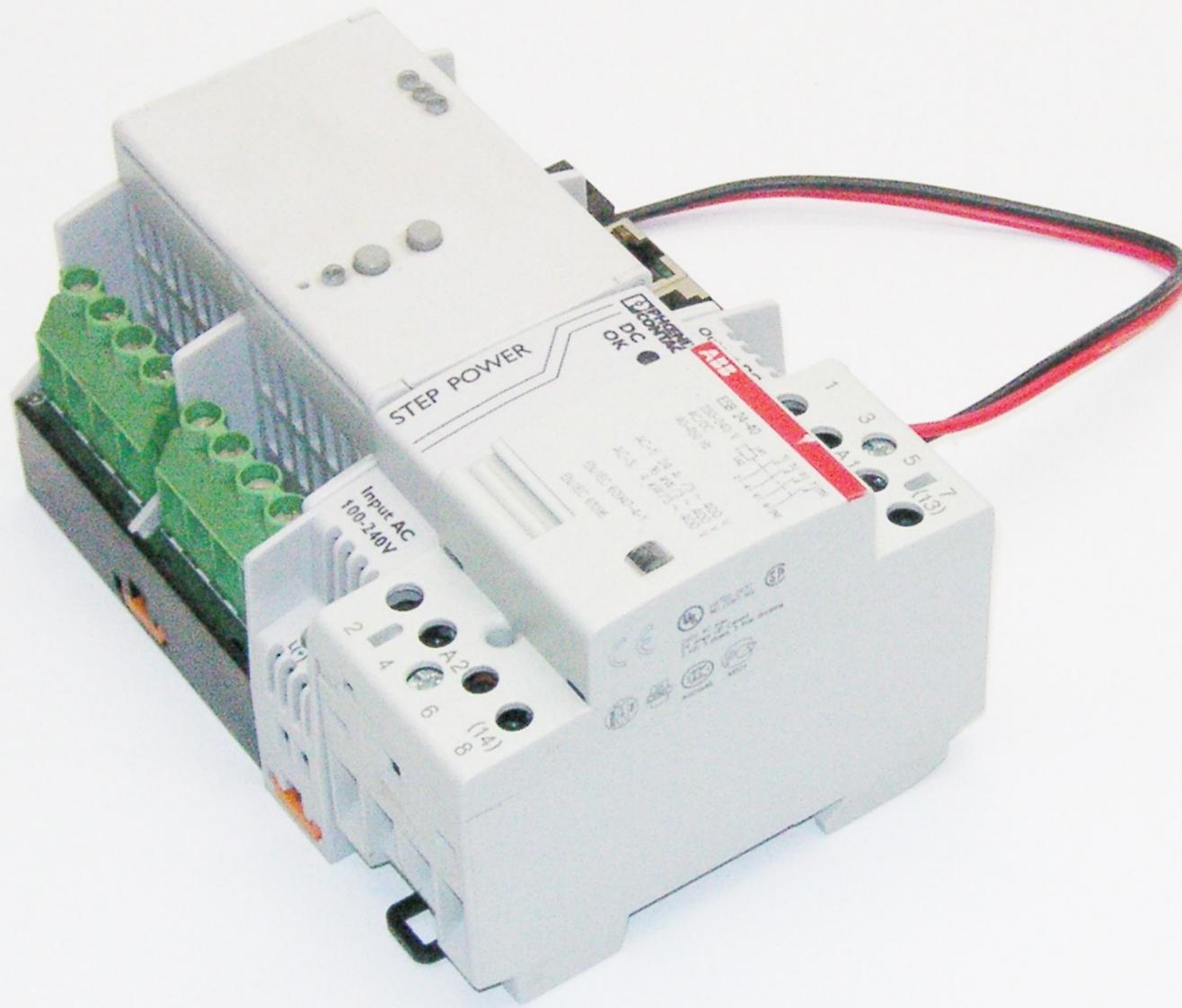
**2013**





# Evolution of the Babelbee

A graphic consisting of five hexagons of increasing size and changing color from orange to light blue, yellow, and green.  
**2013**

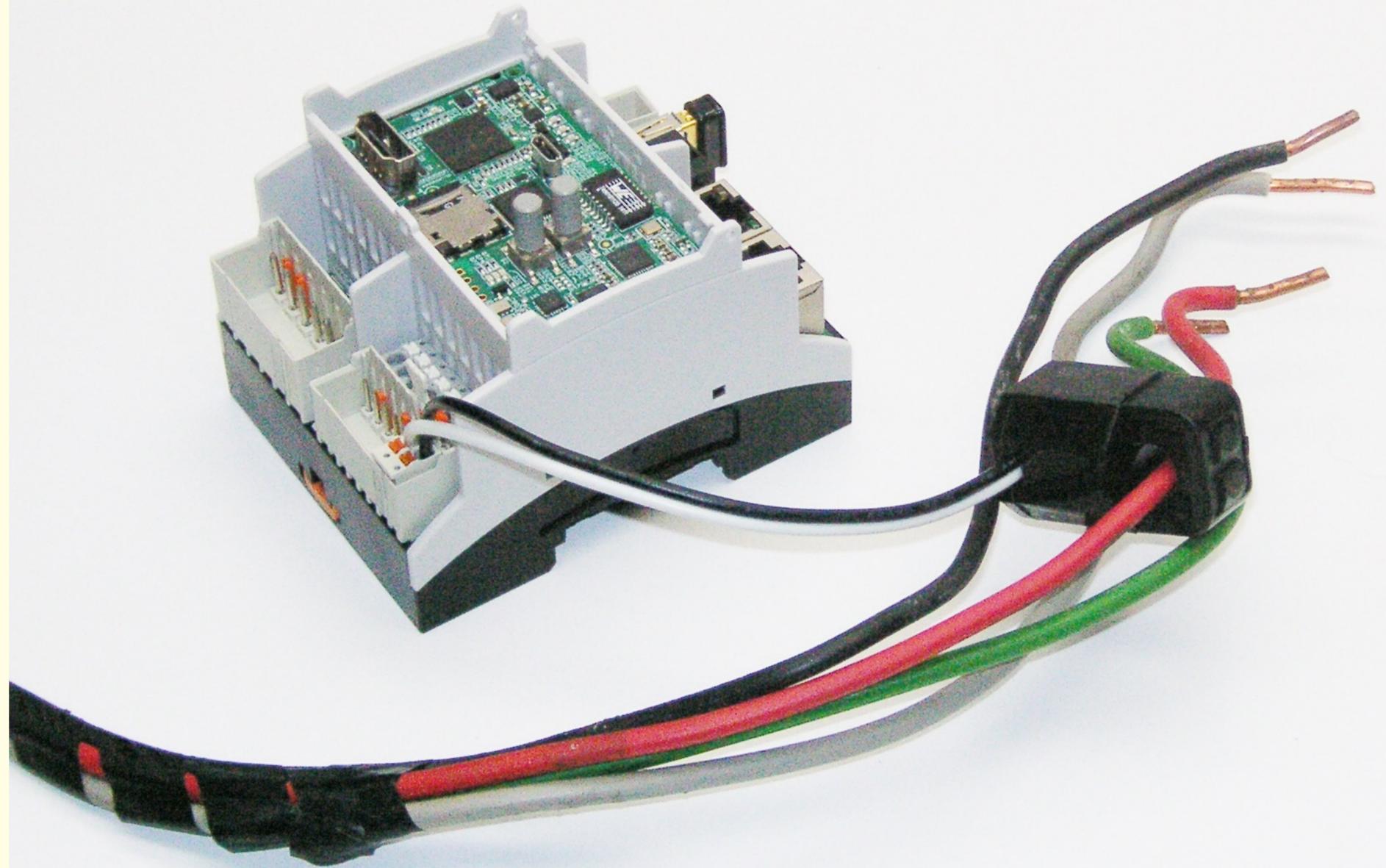




# Evolution of the Babelbee



**2014**

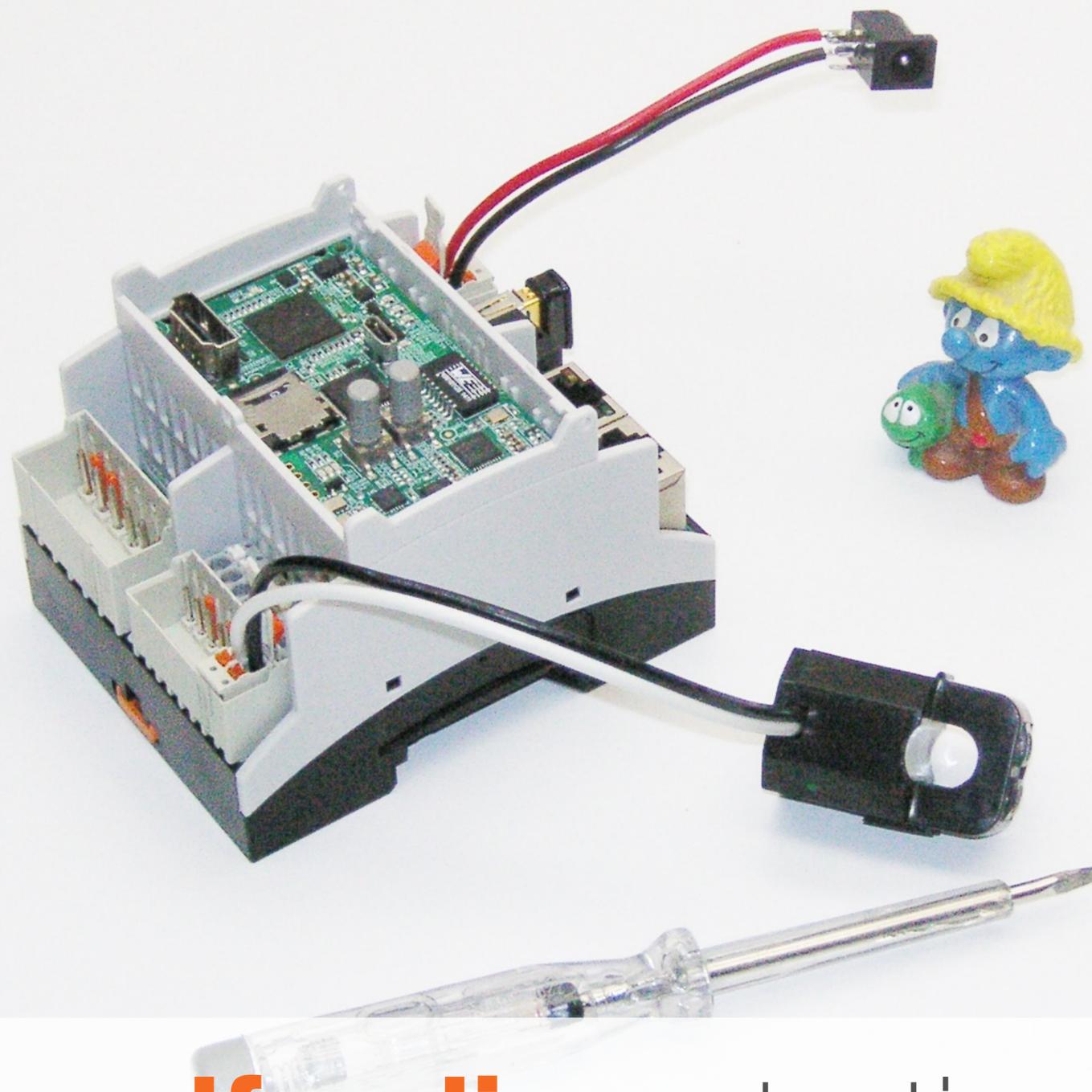




## Evolution of the Babelbee



**2015**



**Crowdfunding** starting soon...

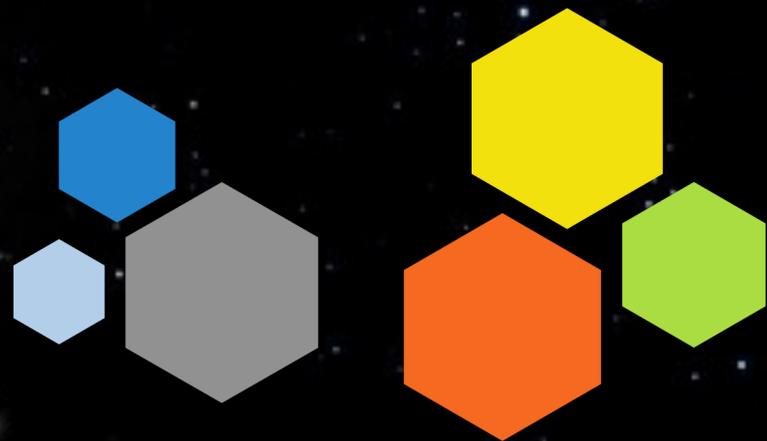


**Why it is froody!**

*More with less...*

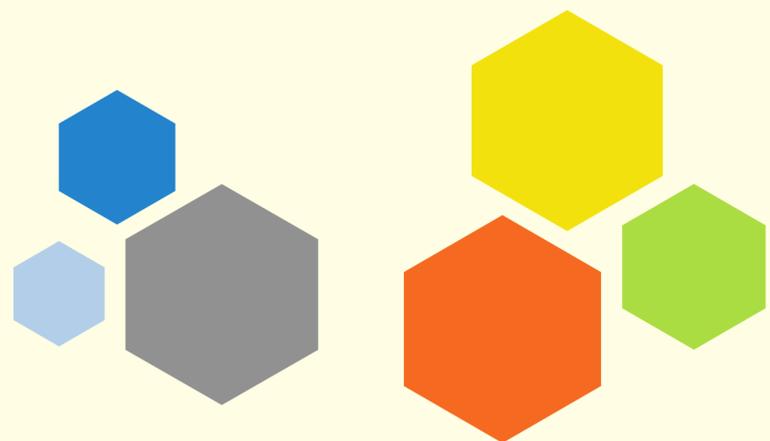


**Why it is froody**



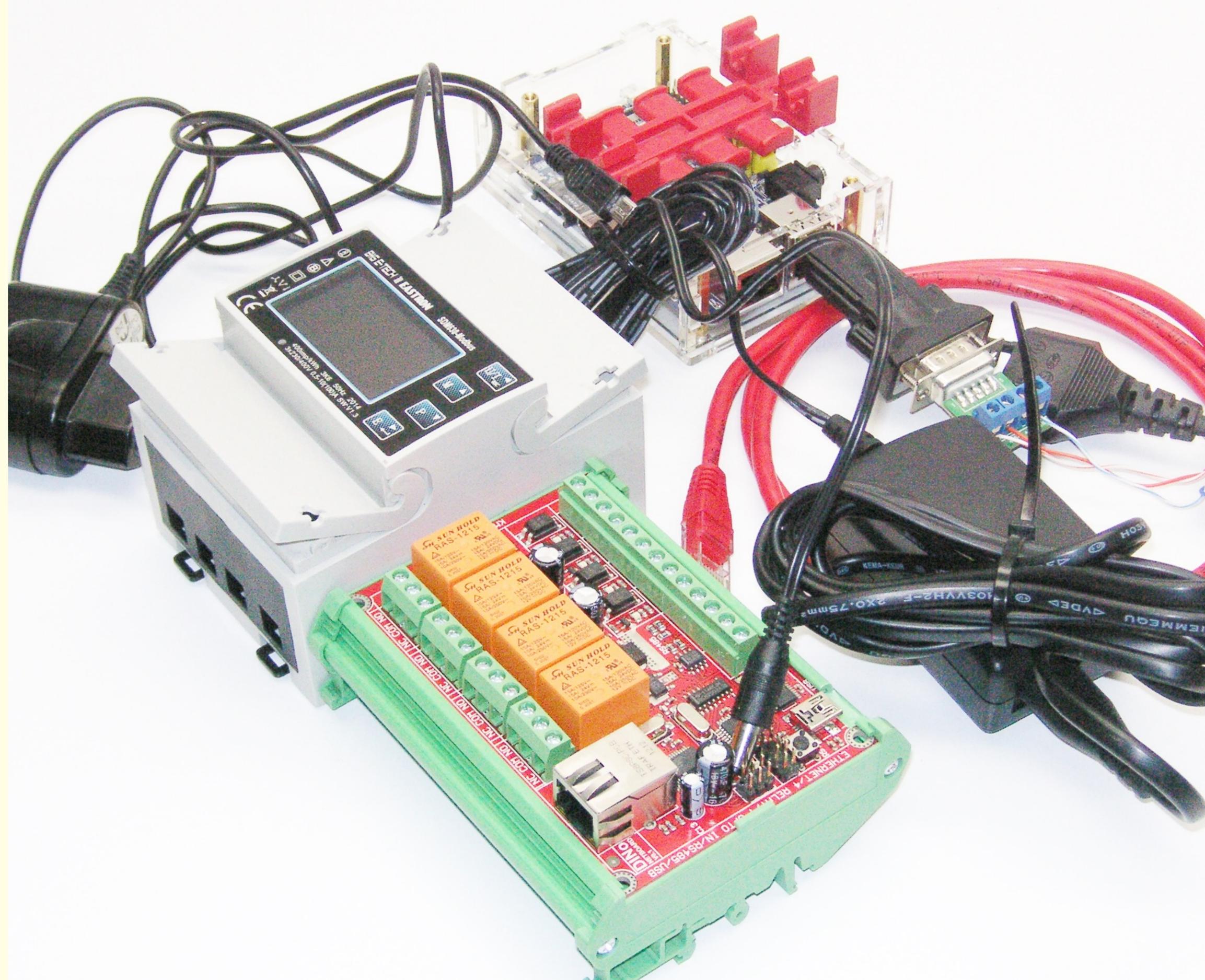
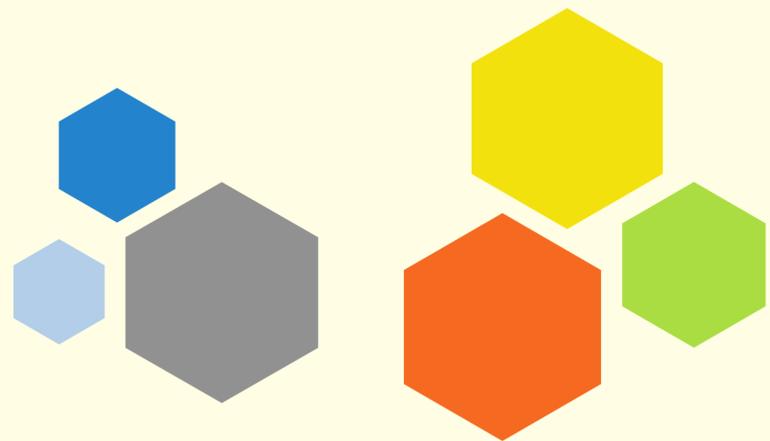


**Why it is froody**



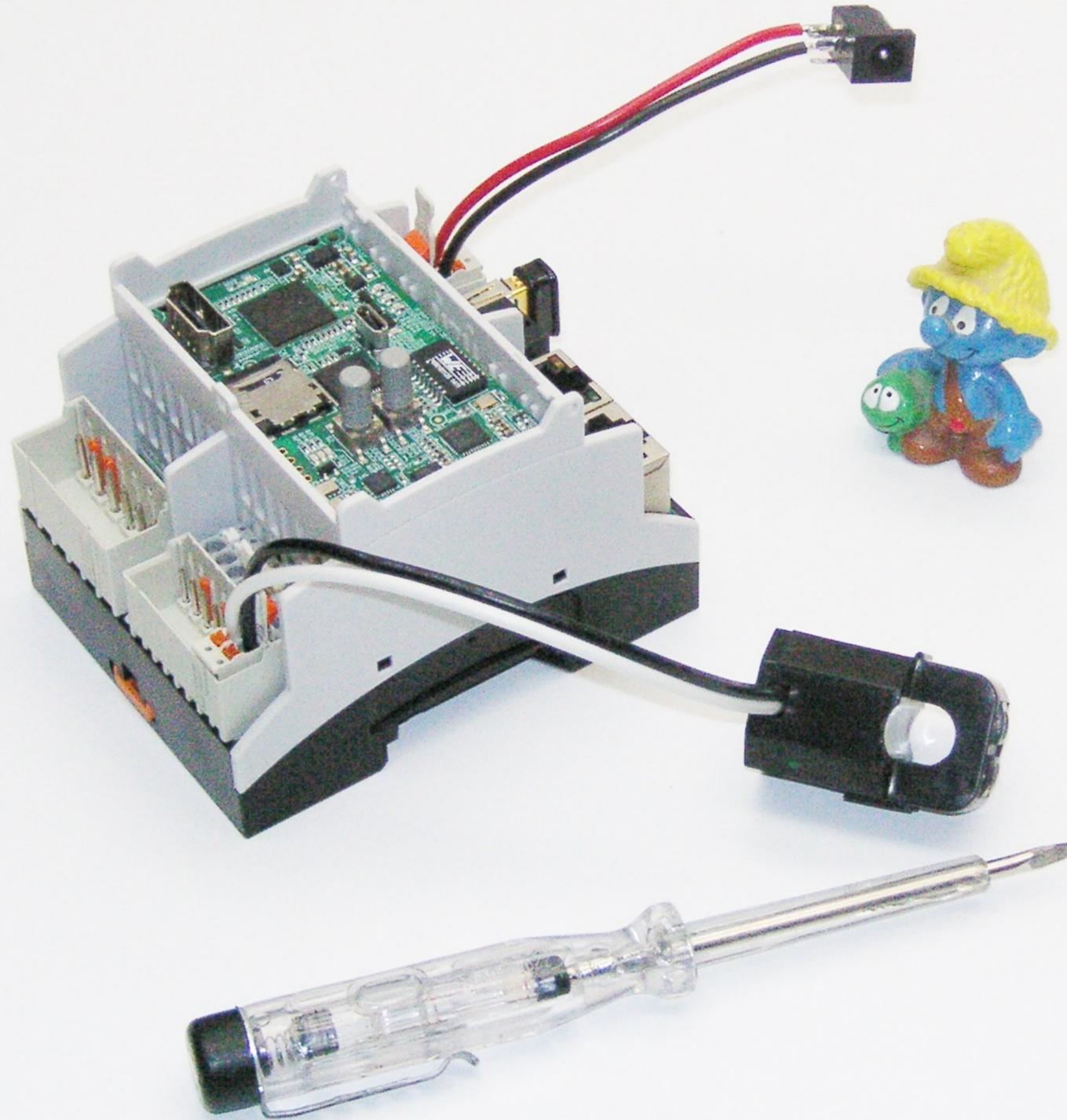
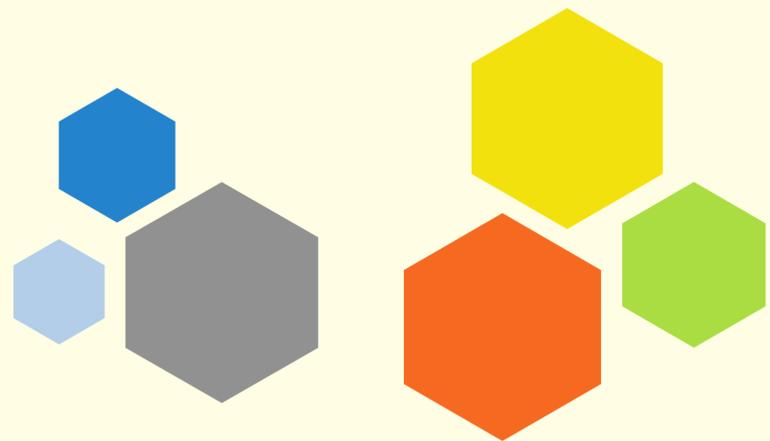


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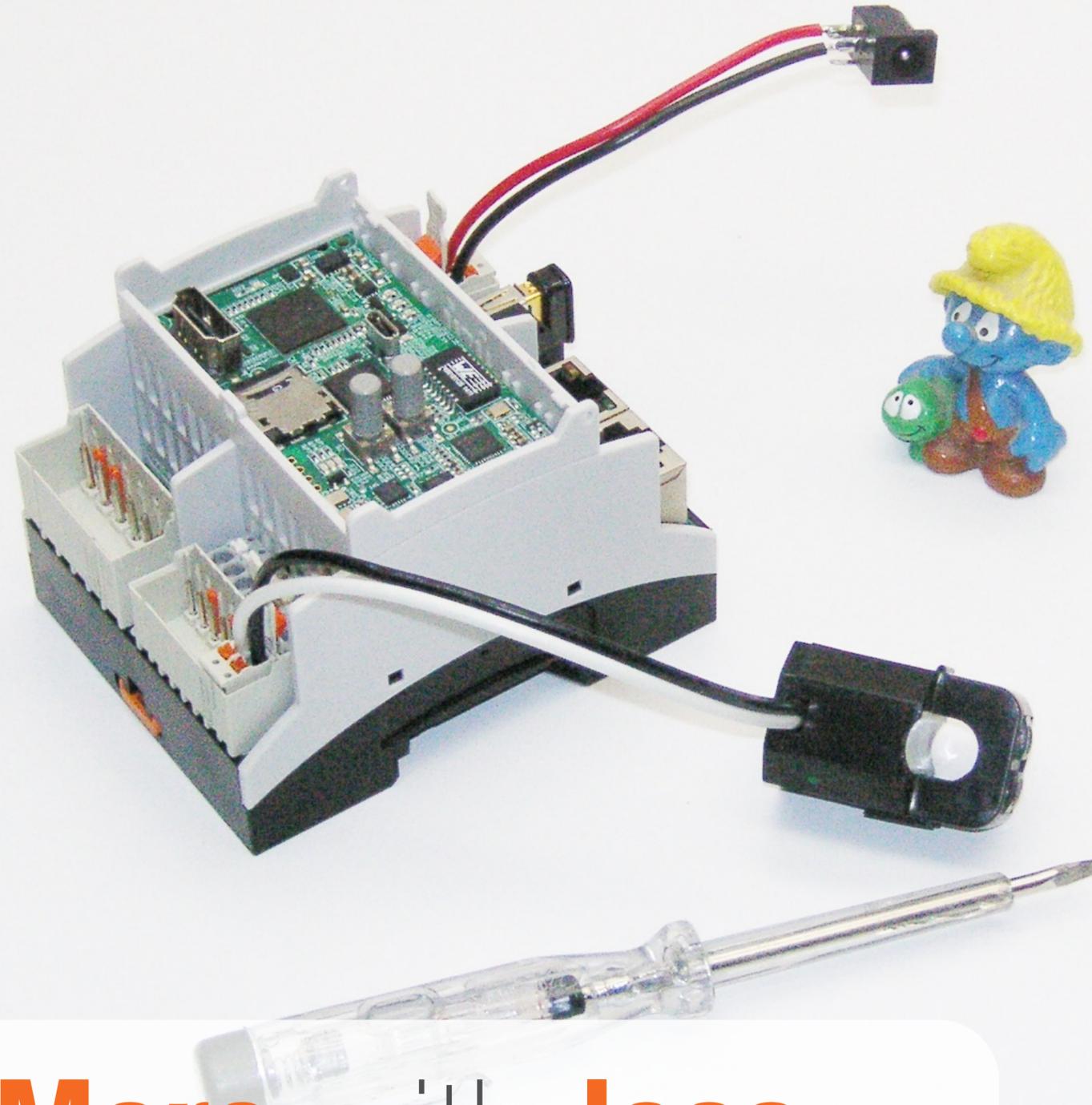
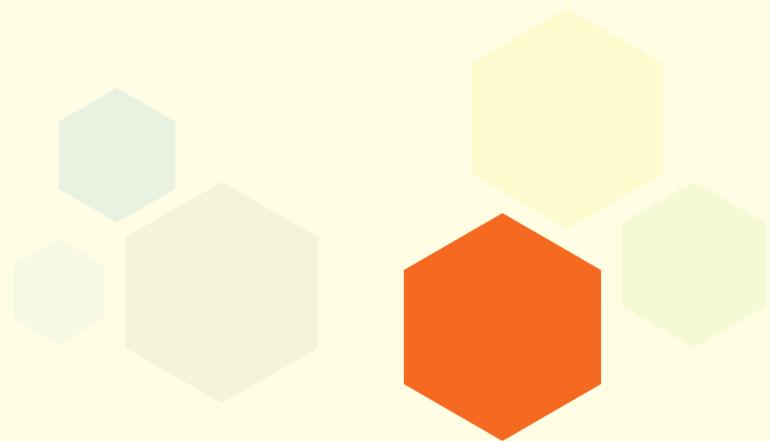


**Why it is froody**





**Why it is froody**



**More** with **less**...

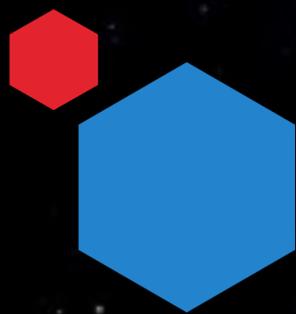


# Reality rules

*The laws of the universe do not care about human theories!*

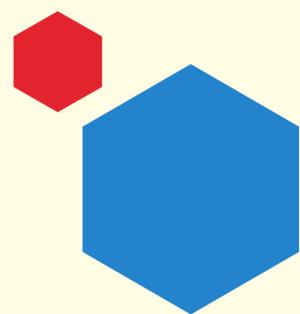


# Reality rules



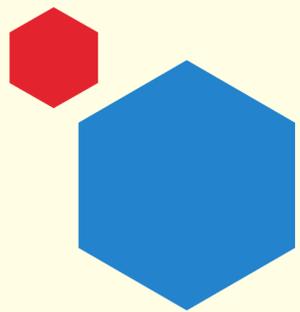


## Reality rules





# Reality rules

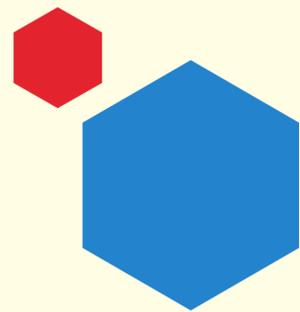


There is never  
enough free space





# Reality rules

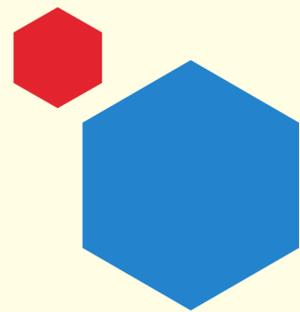


The future is here  
to stay!





**Reality rules**



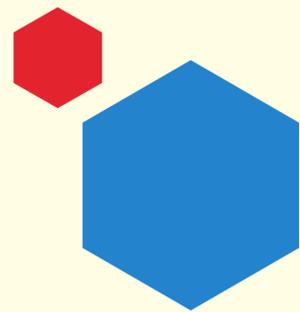
Decentralized is ...  
decentralized?

**80 GW<sub>p</sub>**

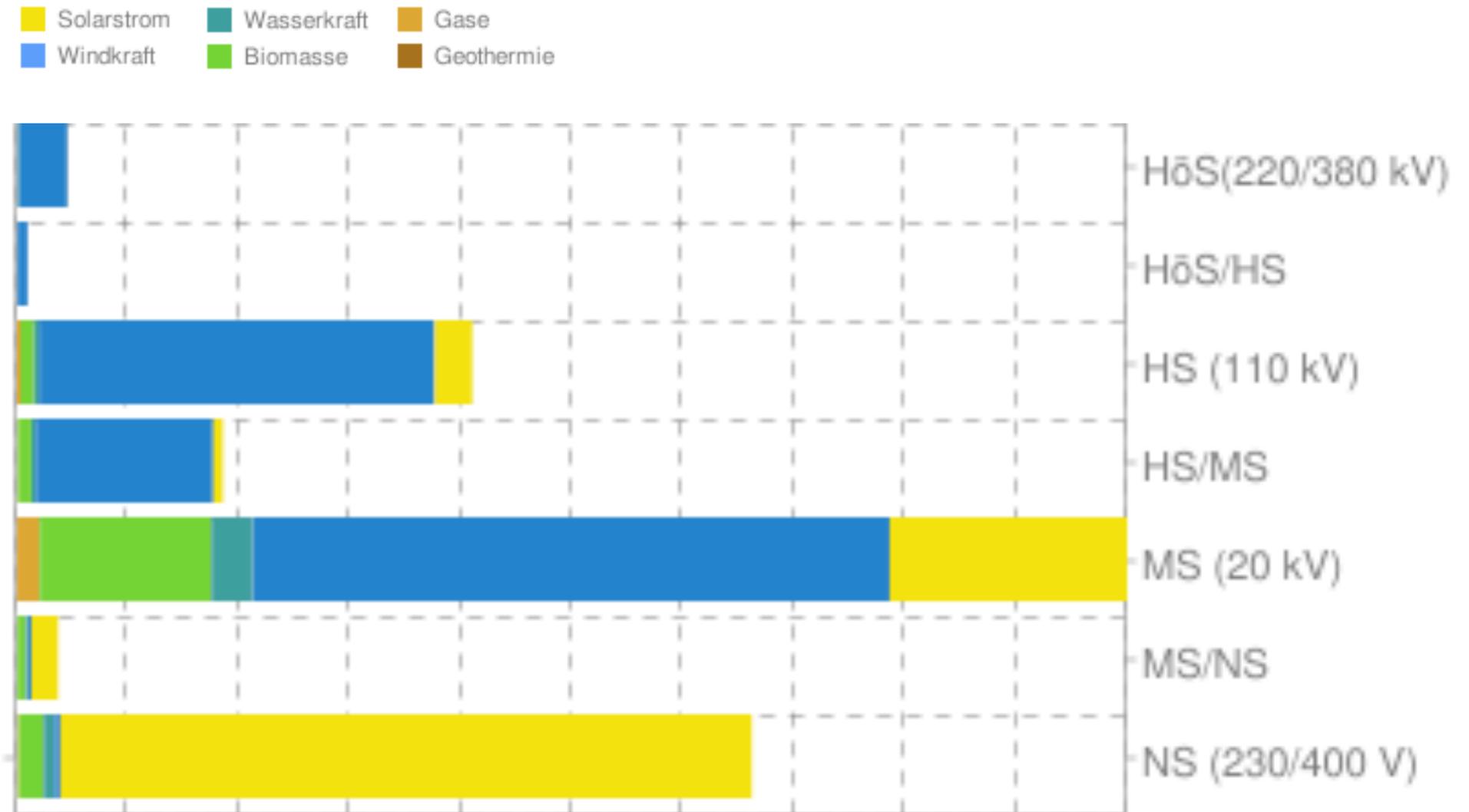
**renewable power plants (Germany, 2014)**



## Reality rules



Decentralized is ...  
decentralized?

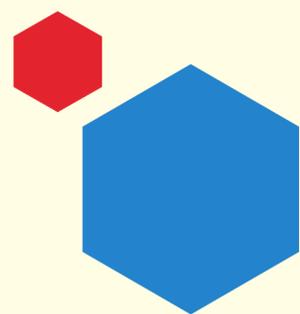


www.energymap.info: Power in kW<sub>p</sub>

**ca. 80 GW<sub>p</sub> renewable power plants (Germany, 2014)**

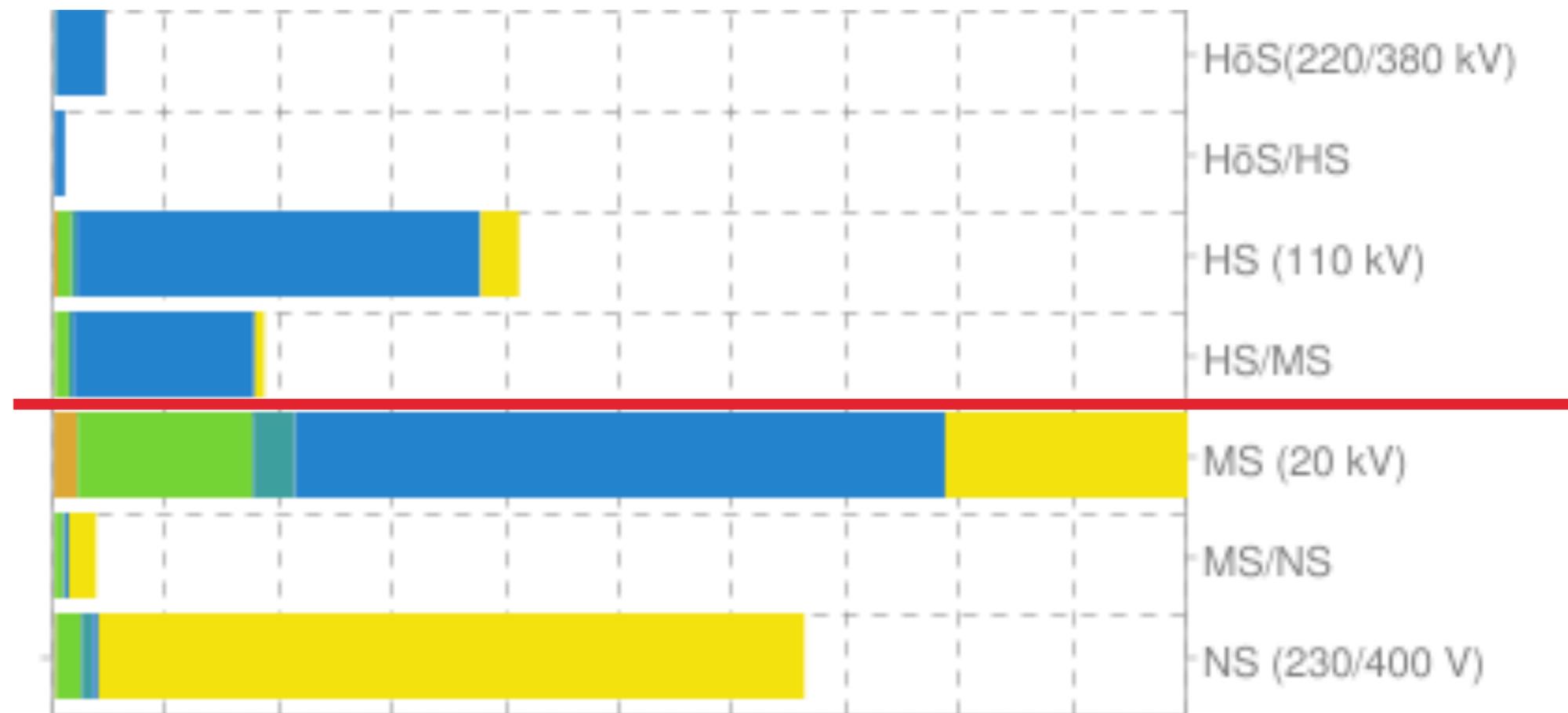


## Reality rules



Decentralized is ...  
decentralized?

Solarstrom    Wasserkraft    Gase  
Windkraft    Biomasse    Geothermie



www.energymap.info: Power in kW<sub>p</sub>

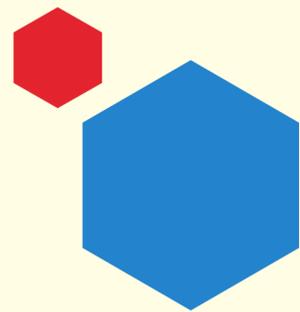
30 %

70 %

ca. 80 GW<sub>p</sub> renewable power plants (Germany, 2014)

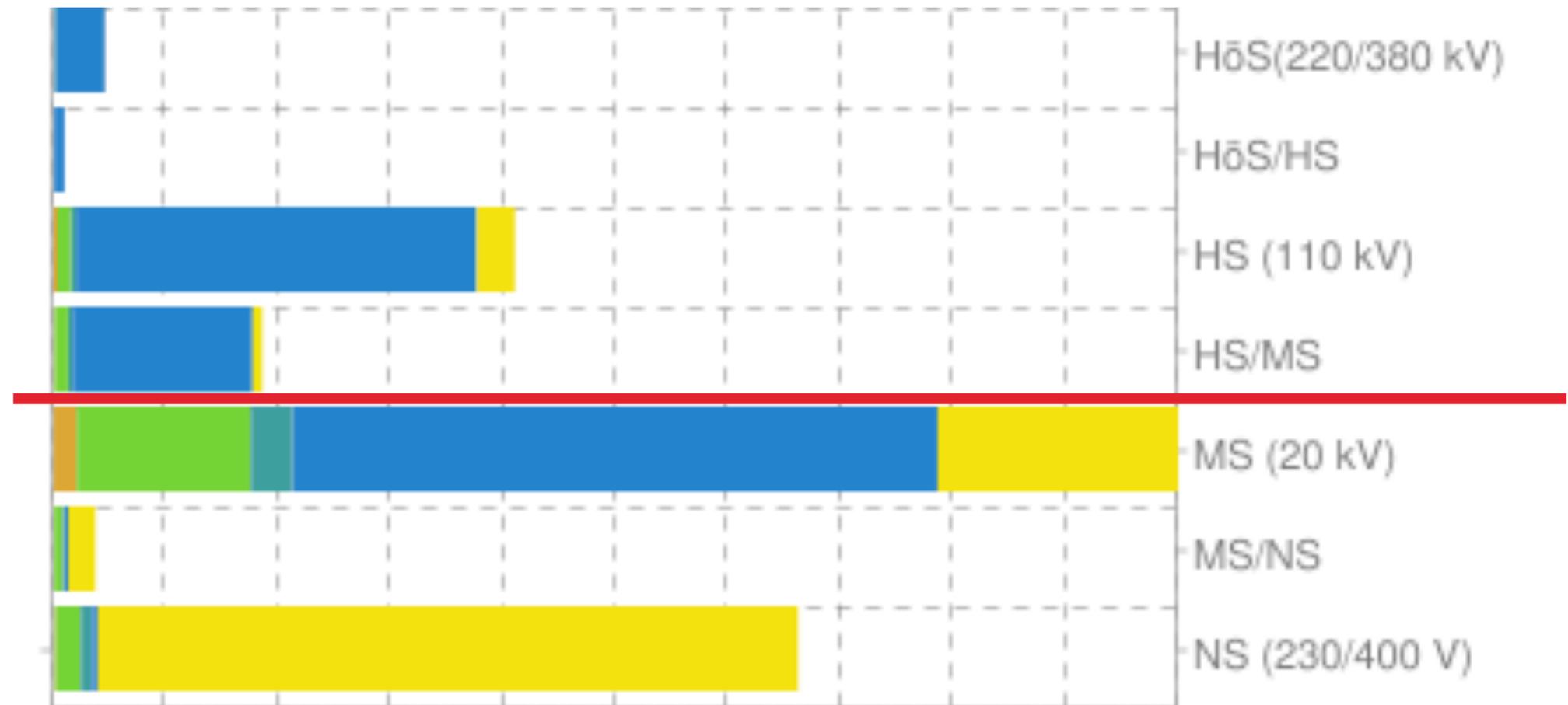


## Reality rules



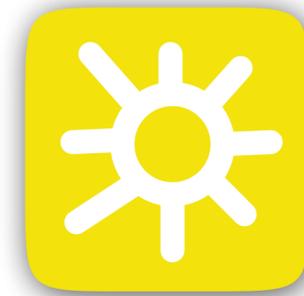
Decentralized is ...  
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Solarstrom    Wasserkraft    Gase  
Windkraft    Biomasse    Geothermie



www.energymap.info: Power in kW<sub>p</sub>

5 %

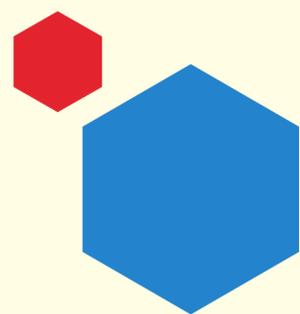


95 %

ca. 80 GW<sub>p</sub> renewable power plants (Germany, 2014)

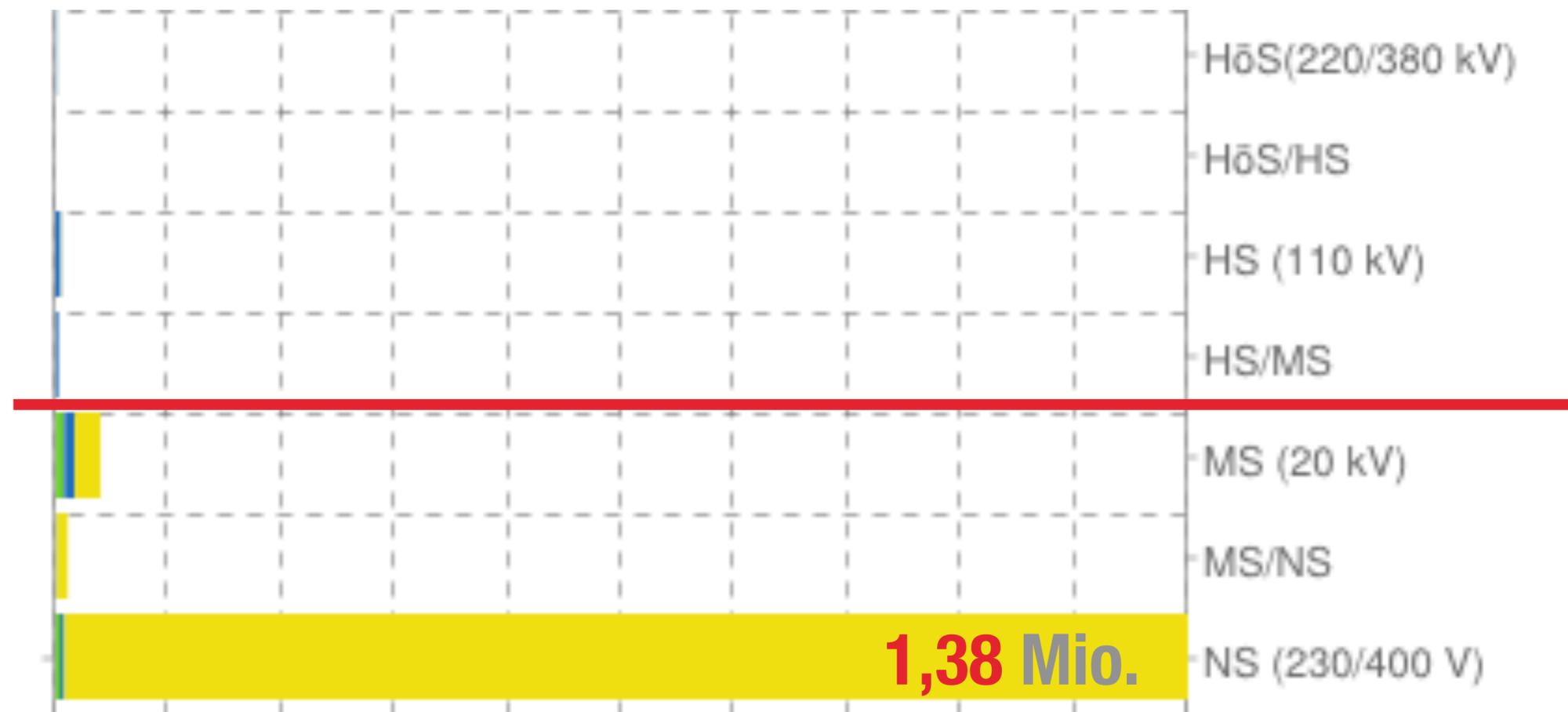


## Reality rules



Decentralized is ...  
decentralized?

Solarstrom    Wasserkraft    Gase  
Windkraft    Biomasse    Geothermie



www.energymap.info: Unit count



**95 %**

**1,45 Mio. renewable power plants (Germany, 2014)**



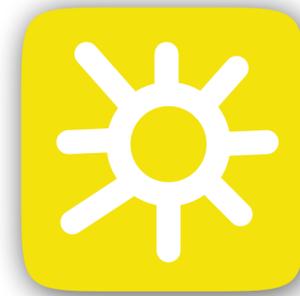
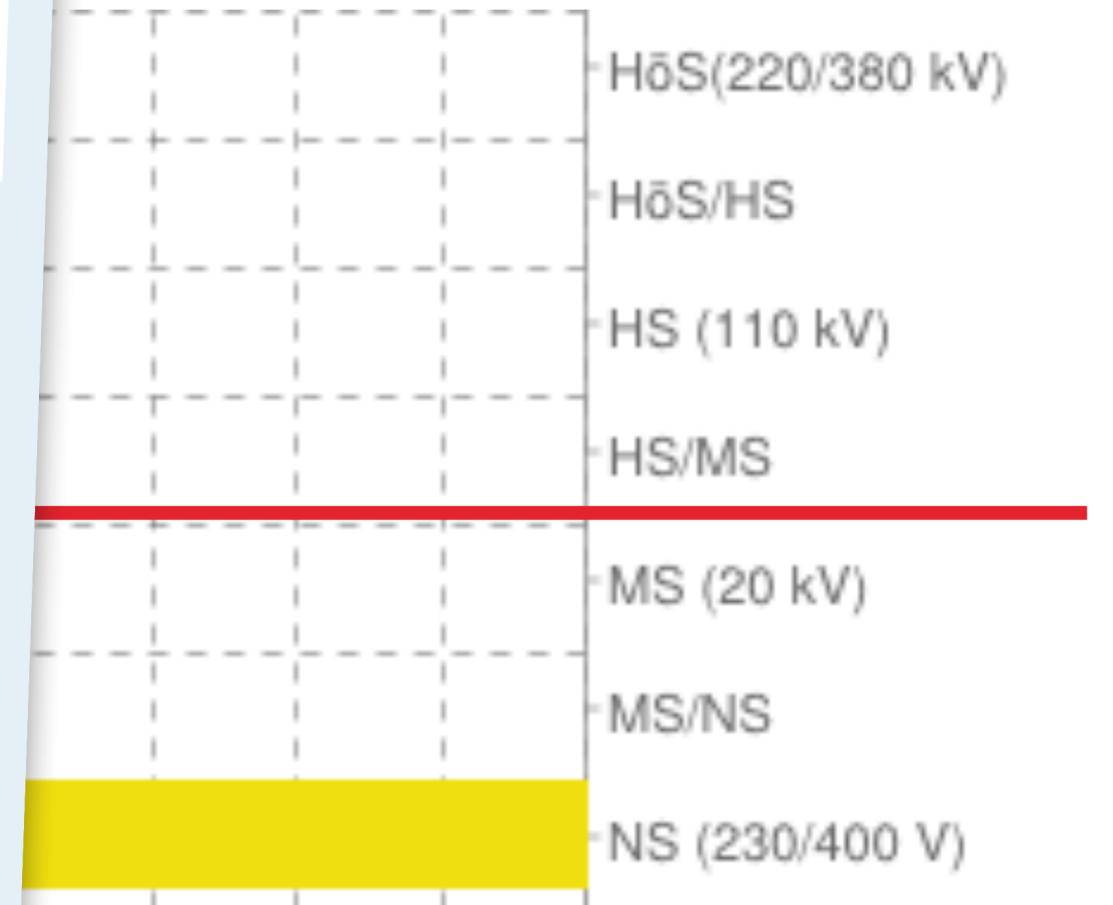
## Baustein für die Energiewende: 7 Eckpunkte für das „Verordnungspaket Intelligente Netze“

### I. Die Notwendigkeit eines energiewendetauglichen Smart Metering

**Die fluktuierende Stromerzeugung aus erneuerbaren Energien stellt besondere Anforderungen an das Stromversorgungssystem.** Dieses muss zur Netz- und Marktintegration der Erneuerbaren stets ausreichend Kapazitäten und Flexibilitäten zum Ausgleich oder zur Abnahme des volatilen erneuerbaren Stroms bereithalten. Zusammengehalten wird ein solches System von intelligenten Netzen, die nicht nur Strom transportieren und verteilen, sondern stets auch das notwendige Gleichgewicht zwischen Erzeugung und Verbrauch sicherstellen müssen. Die hohen Anforderungen hat nicht zuletzt die im September 2014 veröffentlichte BMWi Verteilernetzstudie aufgezeigt.

Kommunikation wird zu einer Grundanforderung solcher intelligenten Netze. Deshalb ist es erforderlich, dass Erzeugungsanlagen, steuerbare Lasten sowie insbesondere Eigenerzeugung mit Eigenverbrauch und alle diejenigen, die Flexibilität anbieten bzw. von variablen Tarifen profitieren wollen, sichere standardisierte Kommunikationsverbindungen nutzen können. So kann gewährleistet werden, dass insbesondere Netzbetreiber, Lieferanten, Vermarkter, Dienstleister und Bilanzkreisverantwortliche zeitnah über zuverlässige Informationen verfügen, die nicht nur Prognosen auf Basis von Schätzungen, Vorjahreswerten oder unpräzisen Standardlastprofilen sind. Zur Gewährleistung von Datenschutz und Datensicherheit muss die erforderliche Datenkommunikation im intelligenten Netz geregelt werden. Von der notwendigen Kommunikationsinfrastruktur sollten auch andere Sparten (wie z. B. Gas, Wasser, Heizwärme und sog. Mehrwertdienste) profitieren können. Allein dadurch sind Kosteneinsparungen, Effizienz- und Komfortgewinne möglich. Mit den richtigen Schritten kann Deutschland hier, wie bei der Energiewende insgesamt, ein Vorreiter sein.

Versehen mit dem Schutzprofil des Bundesamts für Sicherheit in der Informationstechnik (BSI)...



95 %

Power plants (Germany, 2014)



Bundesministerium  
für Wirtschaft  
und Energie

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Versehen mit dem Schutzprofil des Bundesamts für Sicherheit in der Informationstechnik (BSI):

s to build a

# Grid

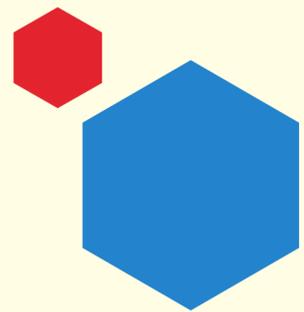
install

# Meters

power plants (Germany, 2014)



**Reality rules**



The solution is to build a

**Smart Grid**

and install

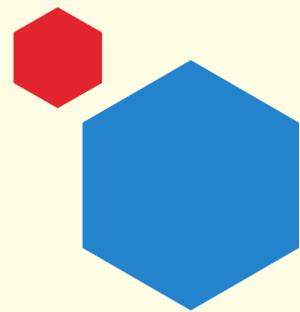
**Smart Meters**



**1,45 Mio. renewable power plants (Germany, 2014)**



## Reality rules



The solution is to build a

Smart Grid

and install

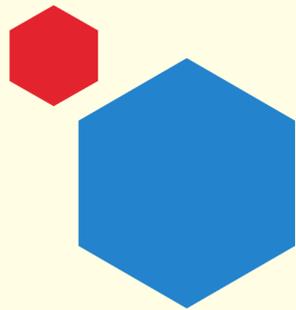
Smart Meters



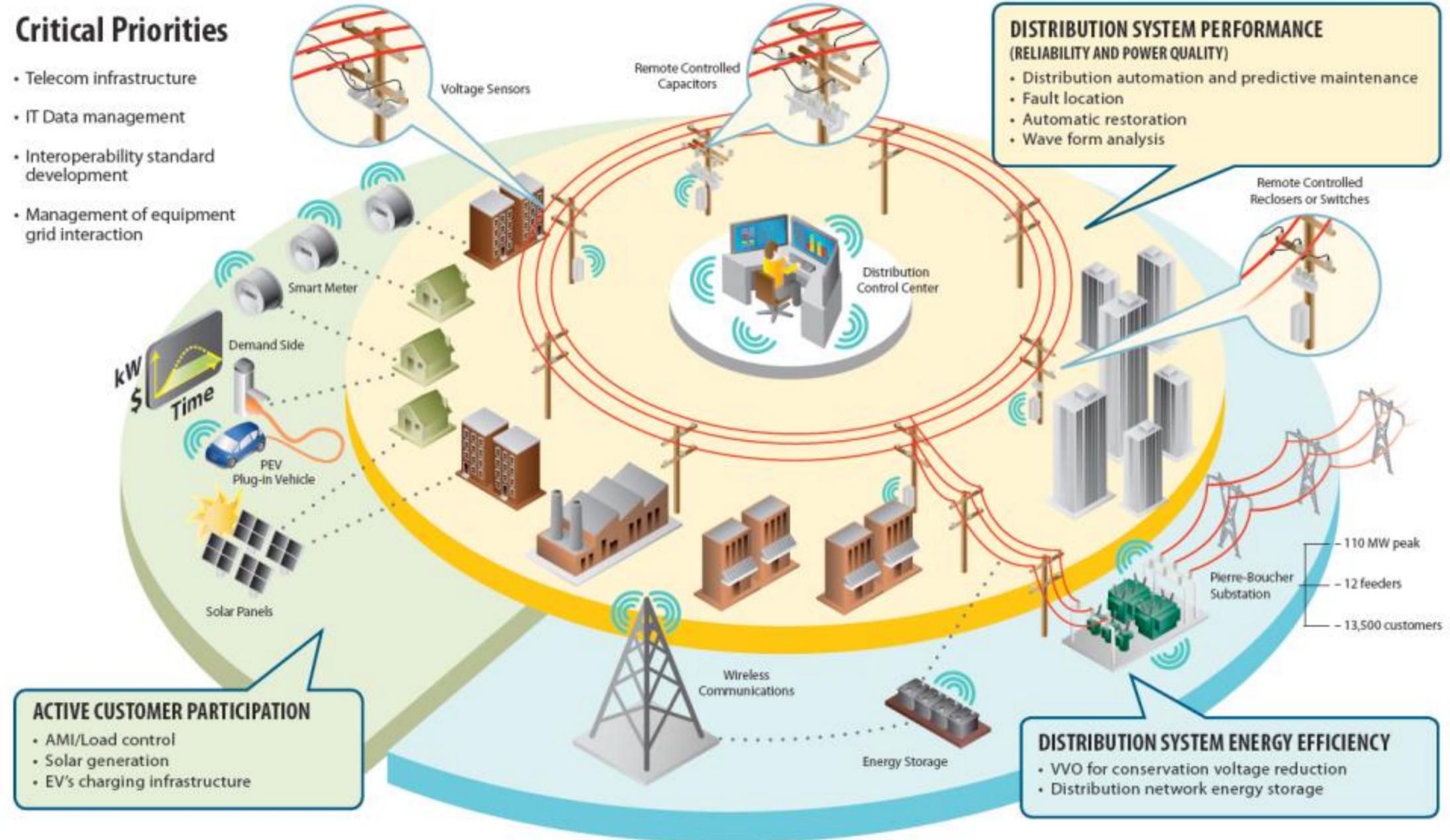
**30 Mio.** ? power plants (Germany, 2014) **2030** ?



# Reality rules

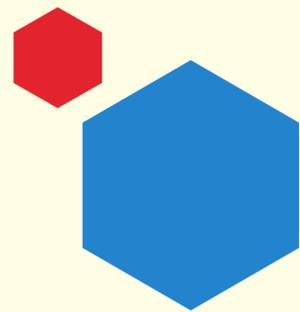


... even if all buzzwords are in place





## Reality rules



... even if all  
buzzwords are in place

### Critical Priorities

- Telecom infrastructure
- IT Data management
- Interoperability standard development
- Management of equipment grid interaction

# Distribution Control Center

### DISTRIBUTION SYSTEM PERFORMANCE (RELIABILITY AND POWER QUALITY)

- Distribution automation and predictive maintenance
- Fault location
- Automatic restoration
- Wave form analysis

Remote Controlled  
Reclosers or Switches

Distribution  
Control Center

110 MW peak  
- 12 feeders  
- 13,500 customers

### ACTIVE CUSTOMER PARTICIPATION

Micro-Grids  
Distributed Energy Resources  
Demand Response

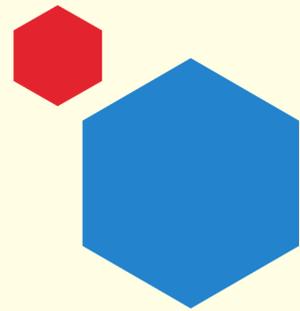
Wireless  
Communications

### DISTRIBUTION SYSTEM ENERGY EFFICIENCY

AVO for conservation voltage reduction  
Distribution network energy storage



## Reality rules



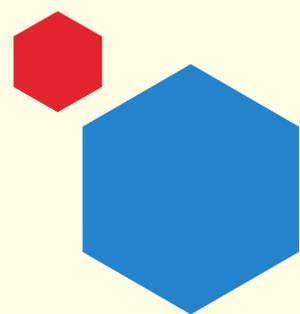
All buzzwords are  
in place

# The all mighty “puppet master”



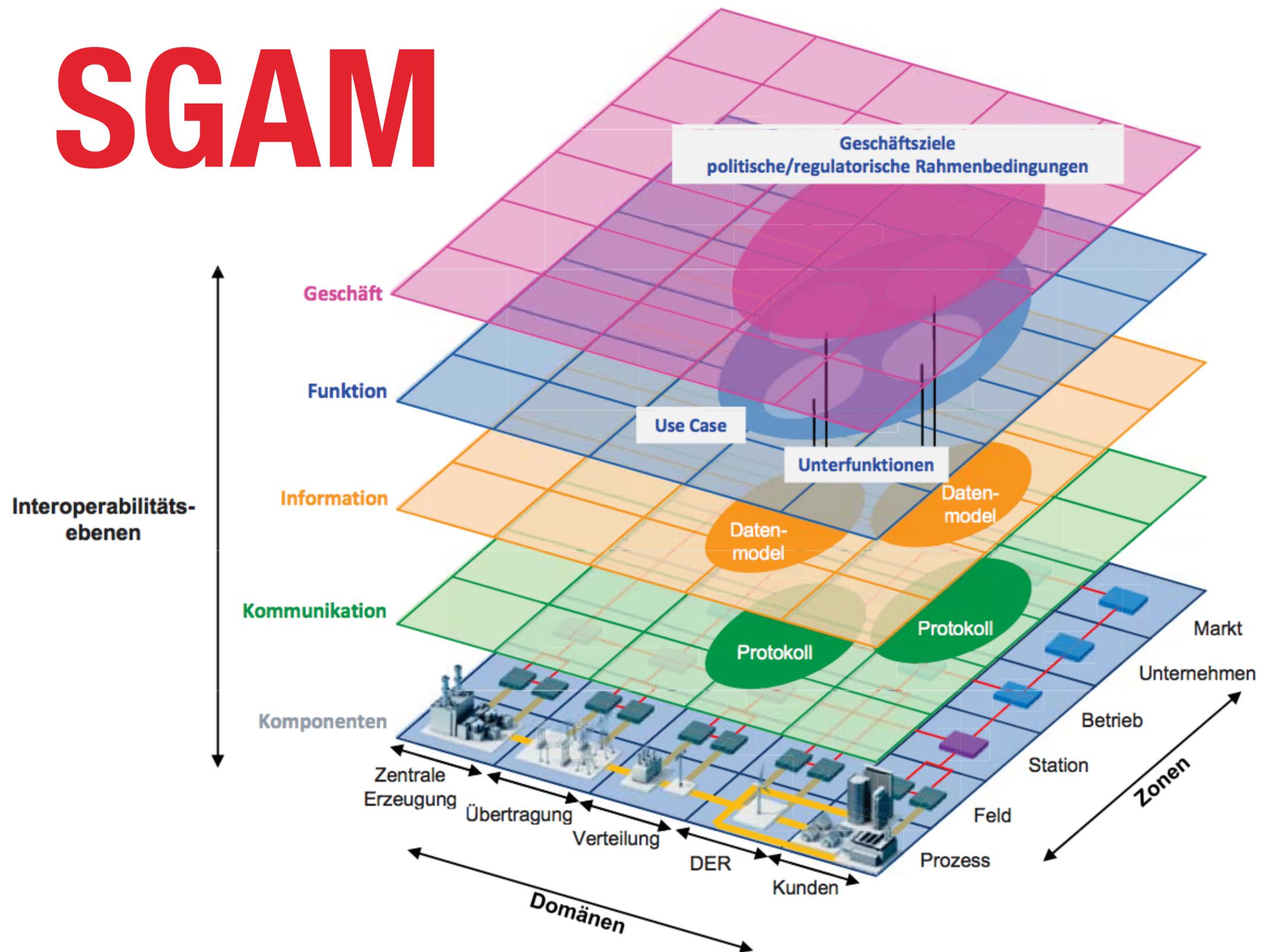


## Reality rules



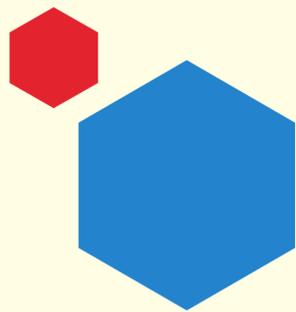
... even if all buzzwords are in place

# SGAM

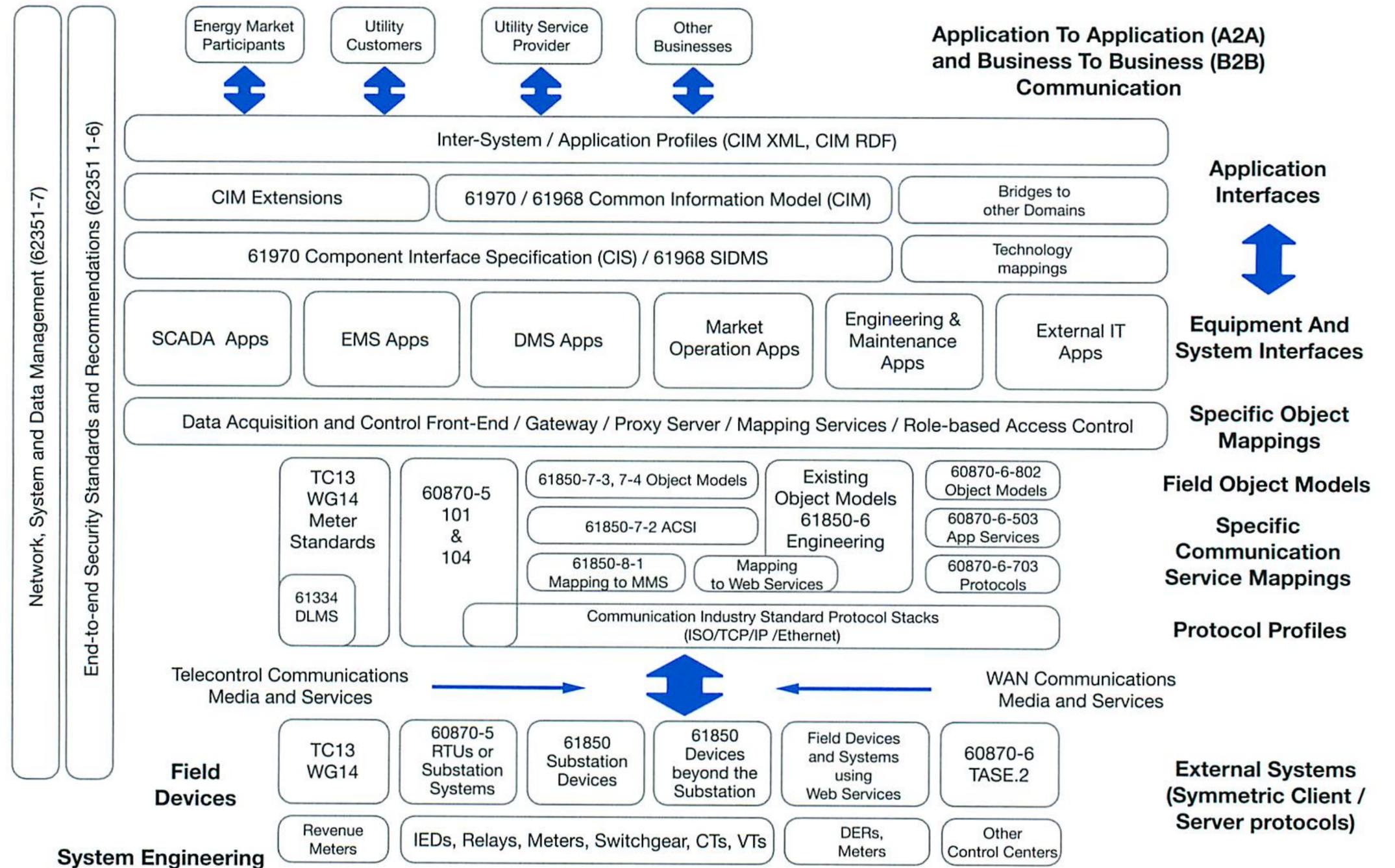




# Reality rules

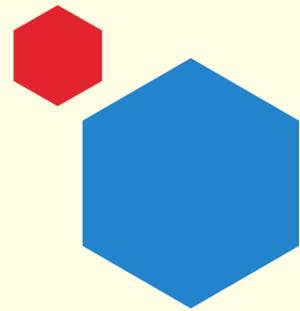


... even if all buzzwords are in place





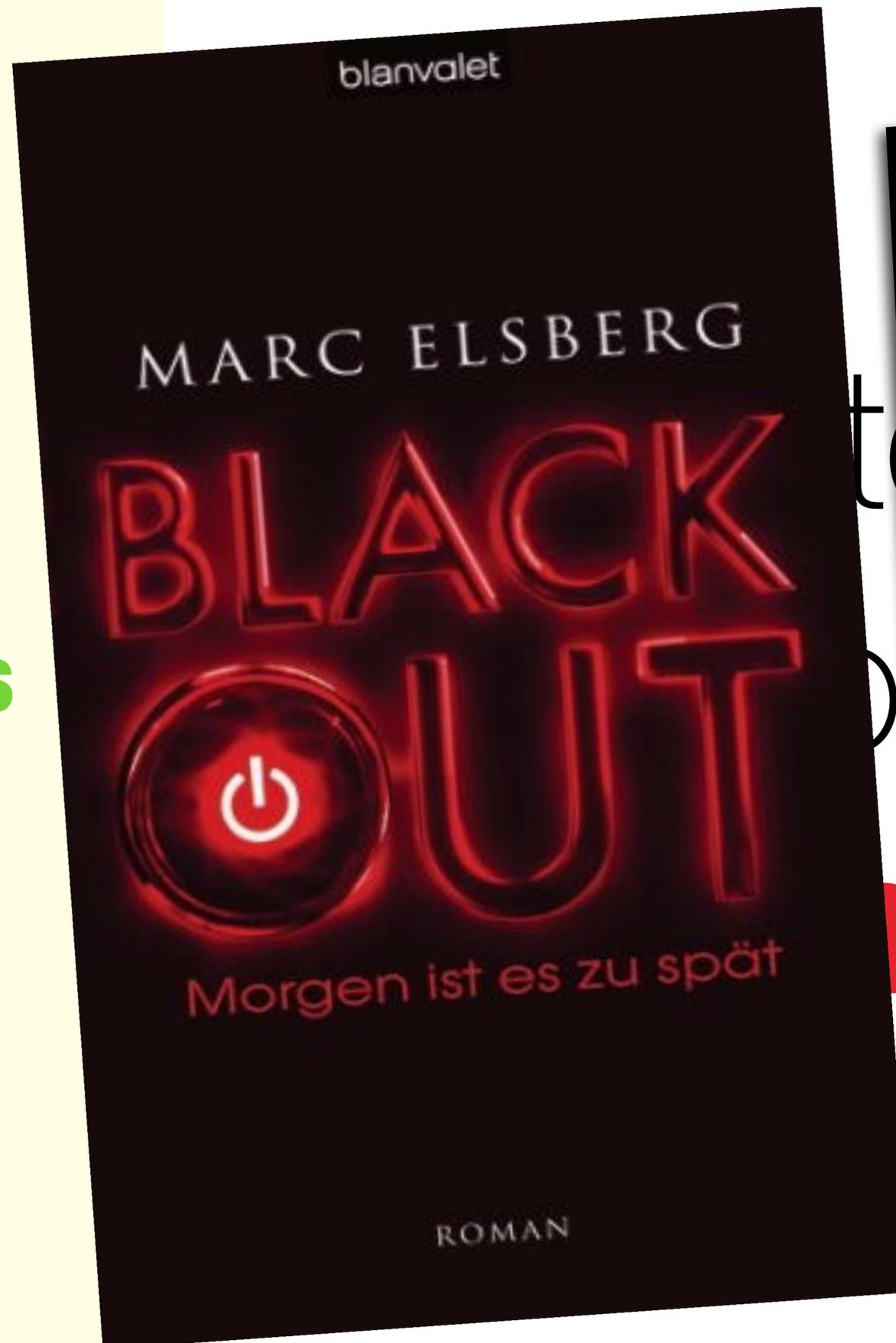
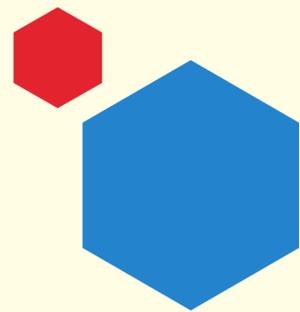
**Reality rules**



Systems **fail**  
due to their own  
**complexity!**



# Reality rules



Deutscher Bundestag

17. Wahlperiode

Drucksache 17/5672

27. 04. 2011

## Bericht

des Ausschusses für Bildung, Forschung und Technikfolgenabschätzung  
(18. Ausschuss) gemäß § 56a der Geschäftsordnung

Technikfolgenabschätzung (TA)

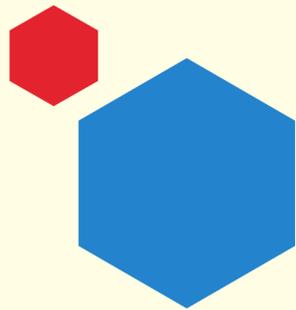
TA-Projekt: Gefährdung und Verletzbarkeit moderner Gesellschaften –  
am Beispiel eines großräumigen und langandauernden Ausfalls  
der Stromversorgung

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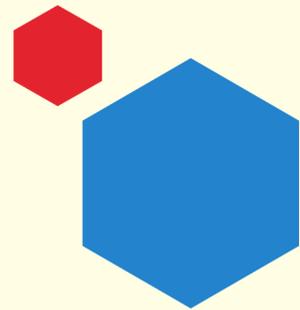
# Communication

**Reality rules**





**Reality rules**



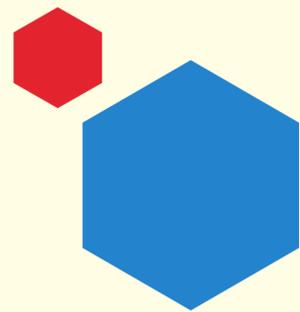
# Communication

requires

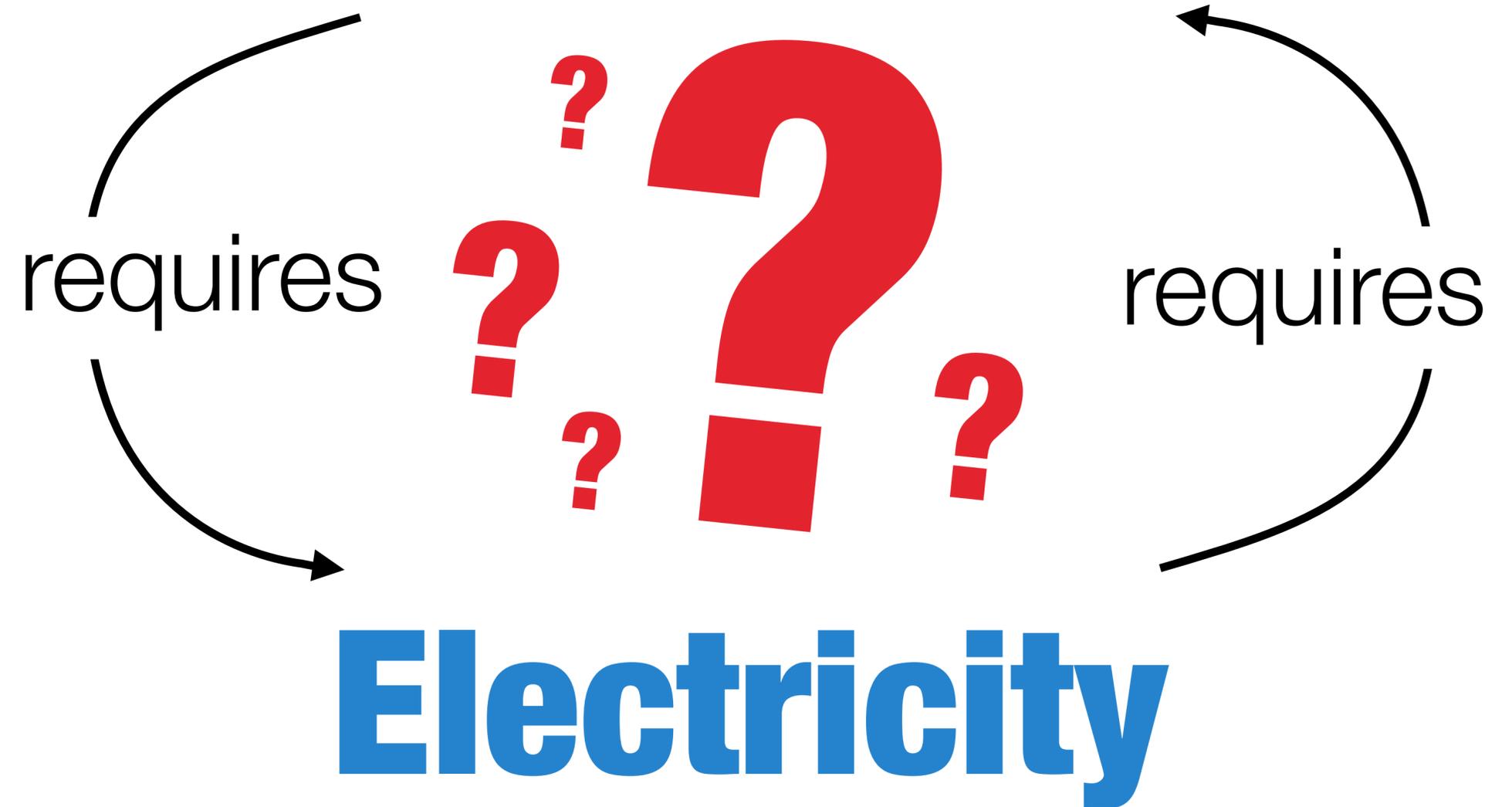
# Electricity



**Reality rules**

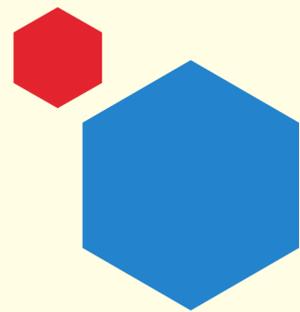


# Communication



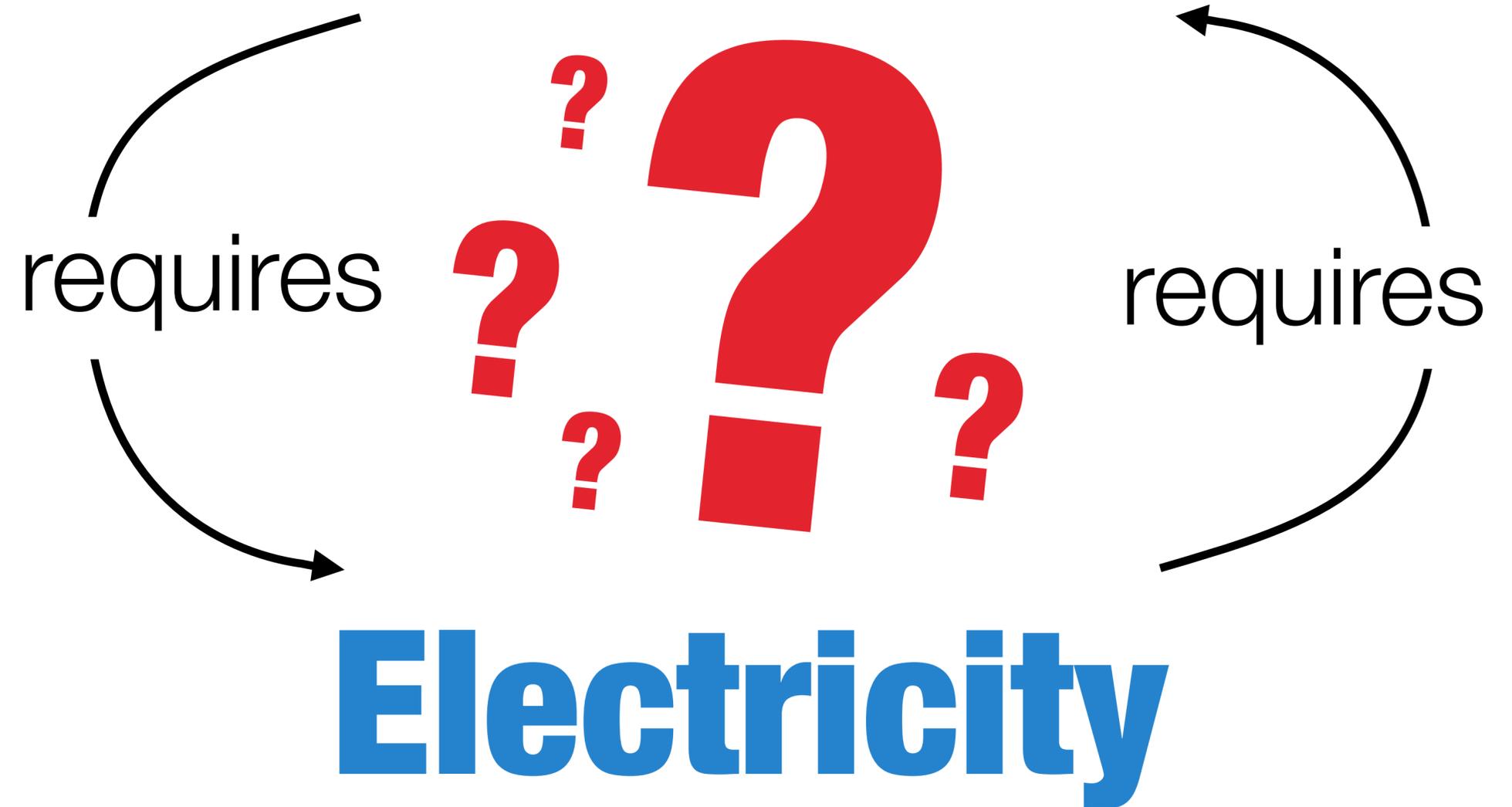


**Reality rules**



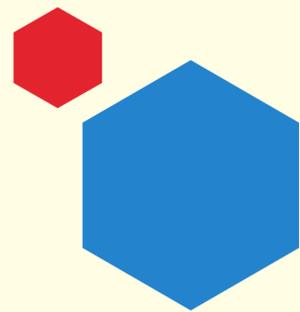
Do not shoot yourself  
into the foot

# Communication



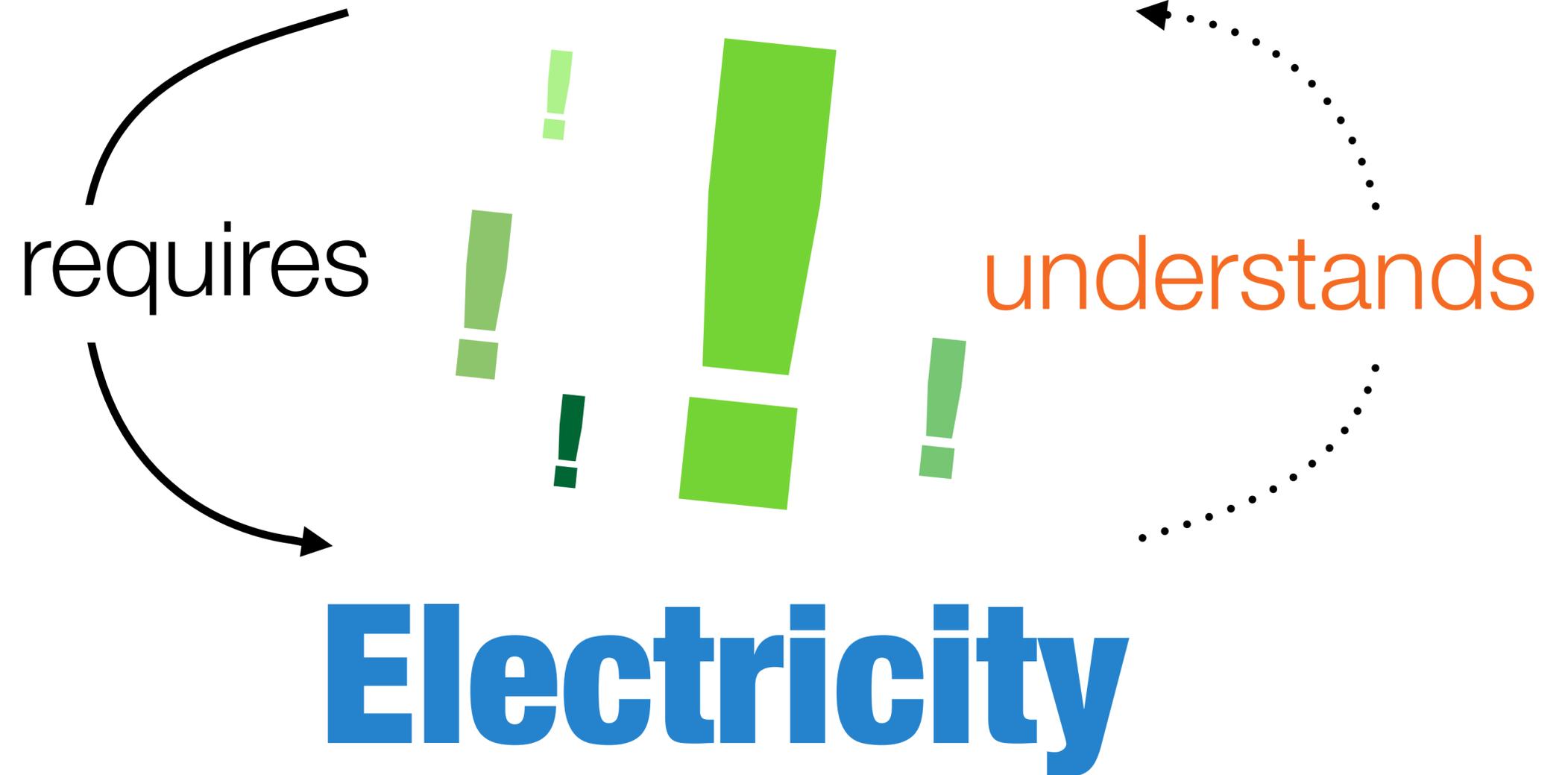


## Reality rules



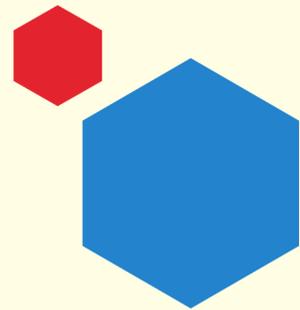
Do not shoot yourself  
into the foot

# Communication





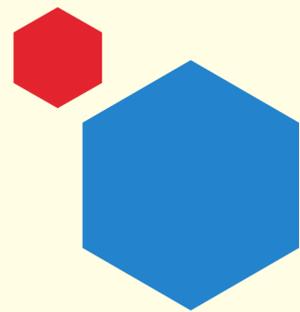
Reality rules



Solid **solutions**  
are **simple!**



## Reality rules



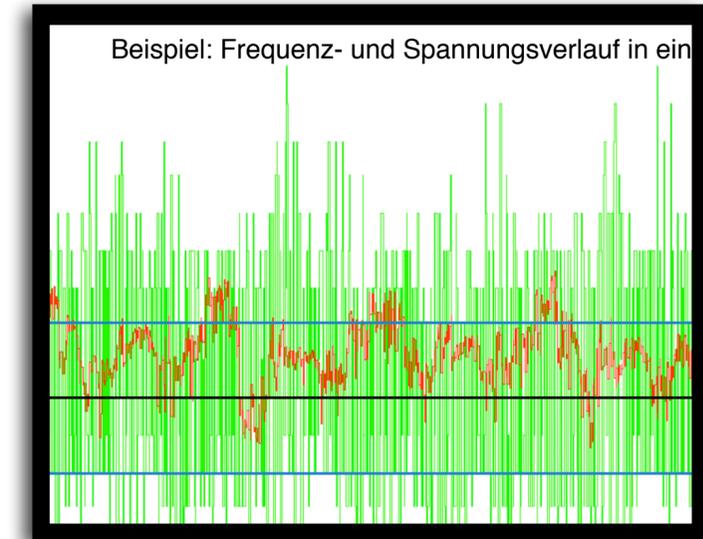
## Weather



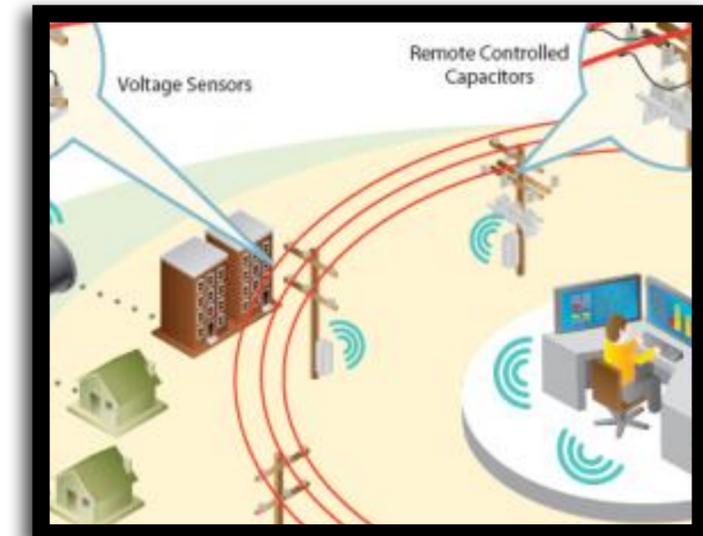
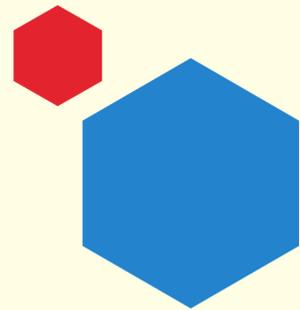
## Weather forecast



# Weather



## Reality rules

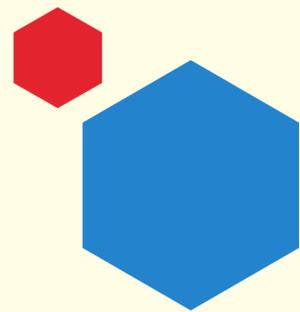


... theory helps.

# Weather forecast



Reality rules



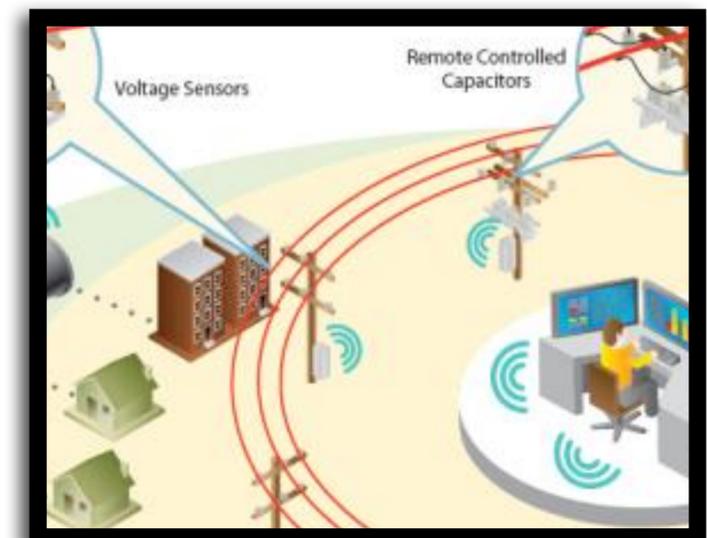
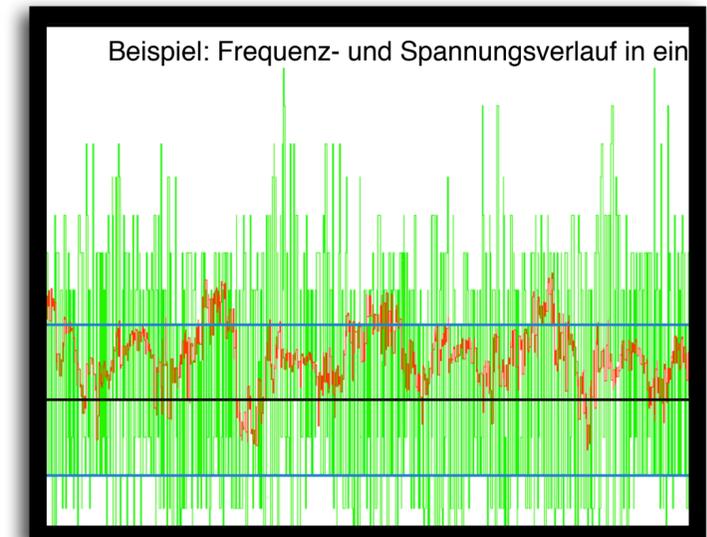
... theory helps.

Weather

**Renewable  
Grid Code**

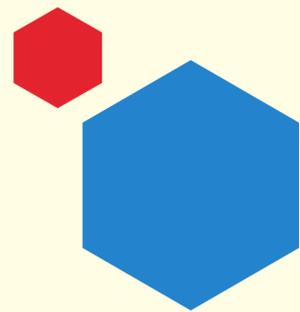
**Smart Grid  
Communication**

Weather forecast





Reality rules



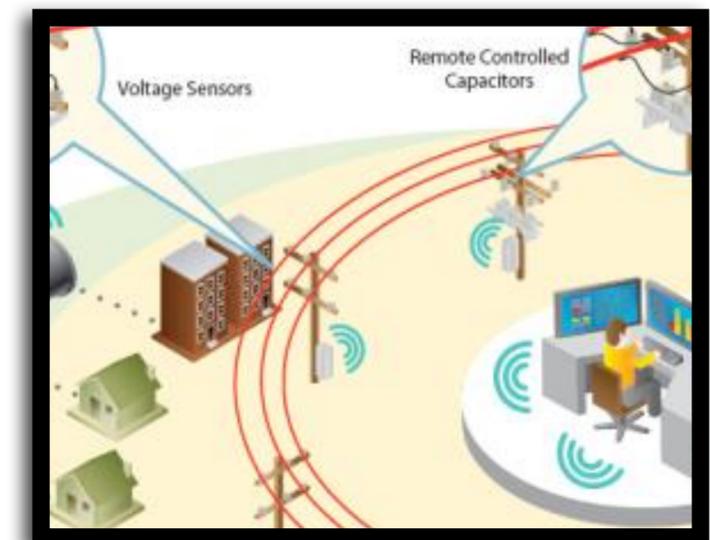
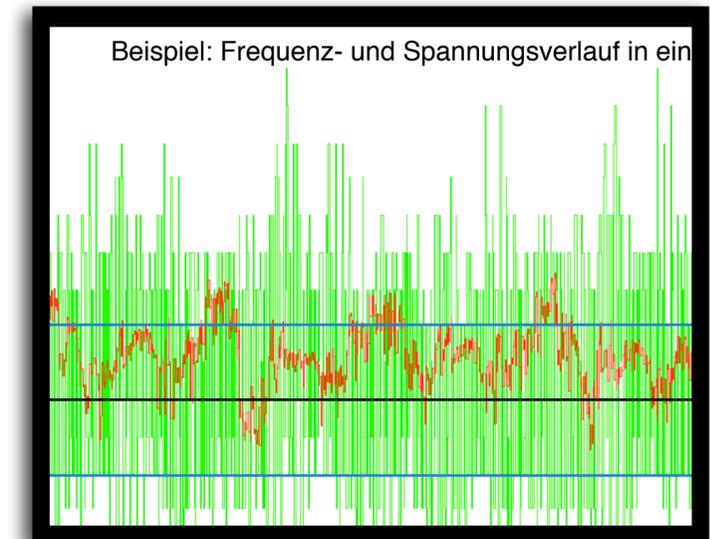
... theory helps.

We must have a

**Renewable  
Grid Code**

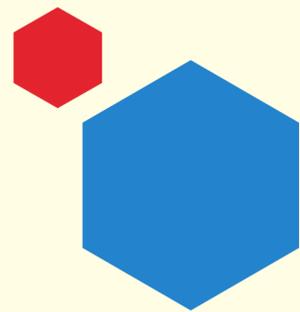
**Smart Grid  
Communication**

could be helpful.

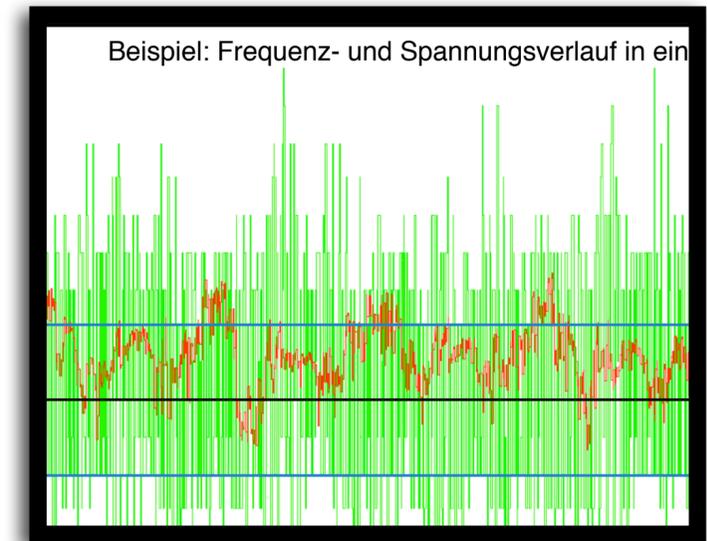




**Reality rules**

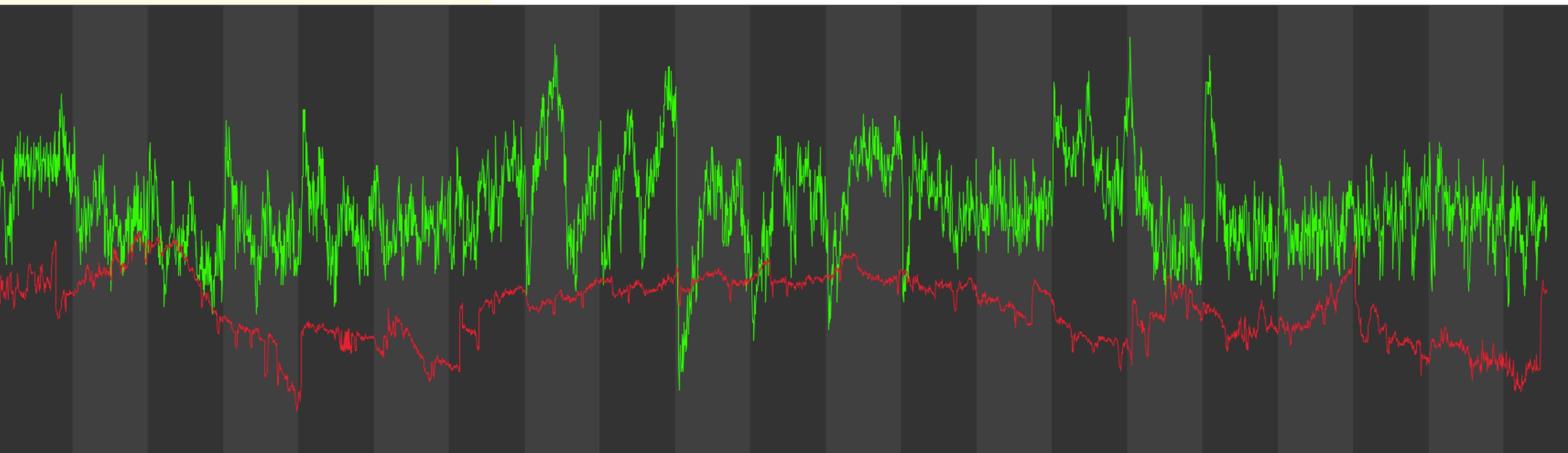


# Renewable Grid Code



**Voltage**  
Local balance

**Frequency**  
Global balance



**Voltage**

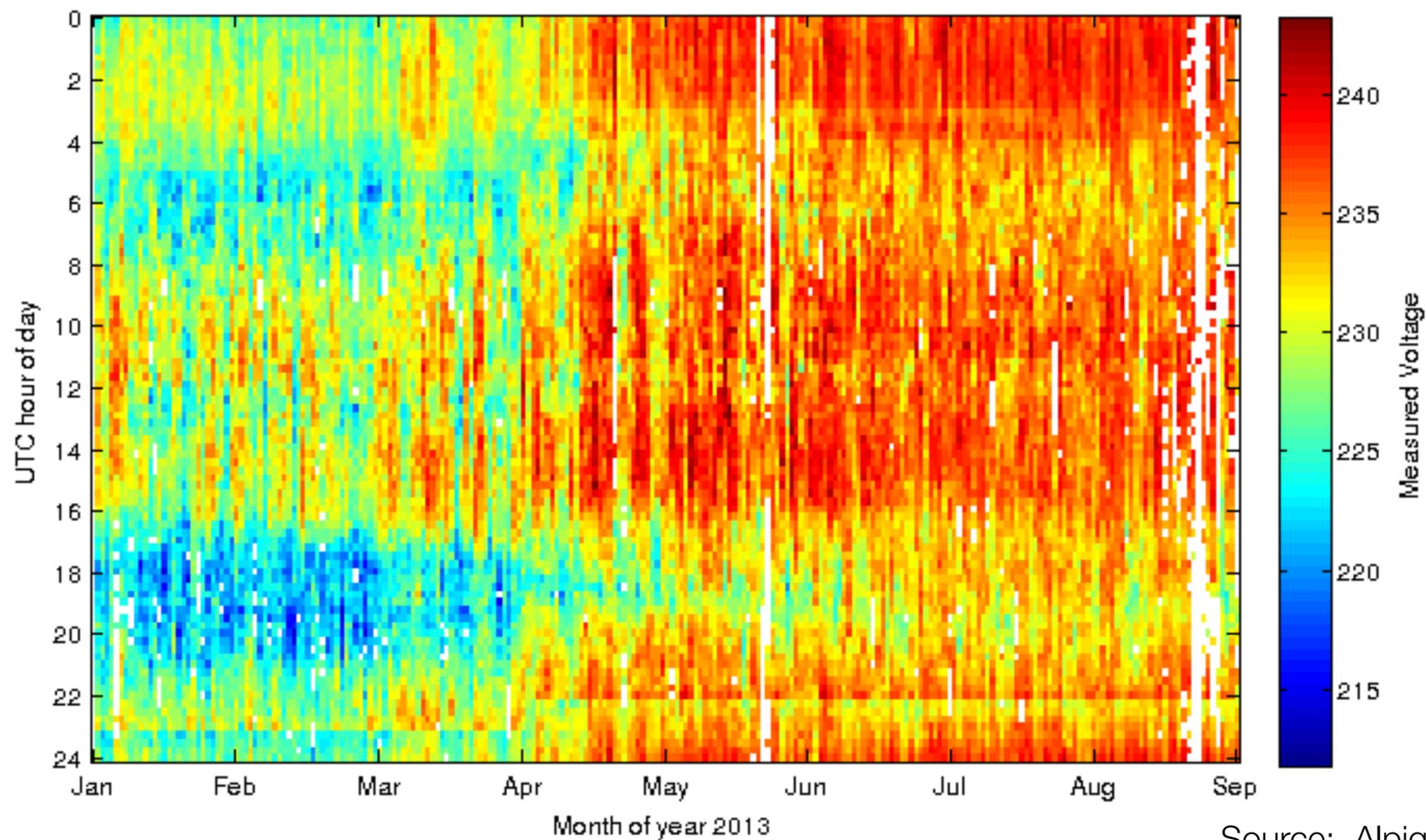
Local balance

**Frequency**

Global balance



## Daily and seasonal patterns of grid voltage

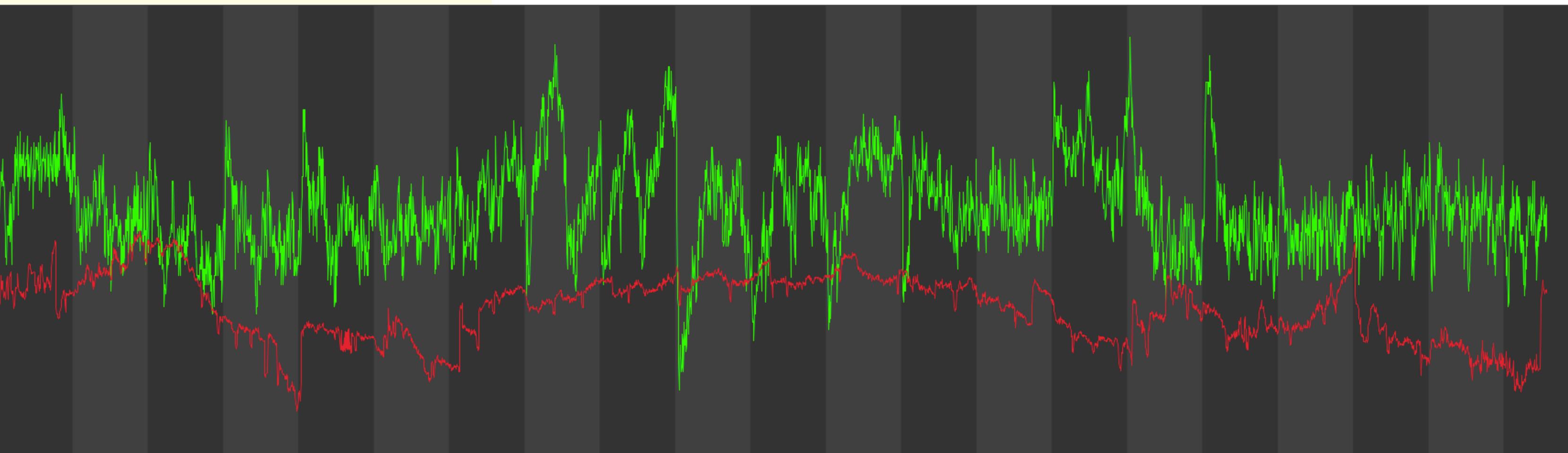


**Voltage**

Local balance

Frequency

Global



**Voltage**

Local balance

**Frequency**

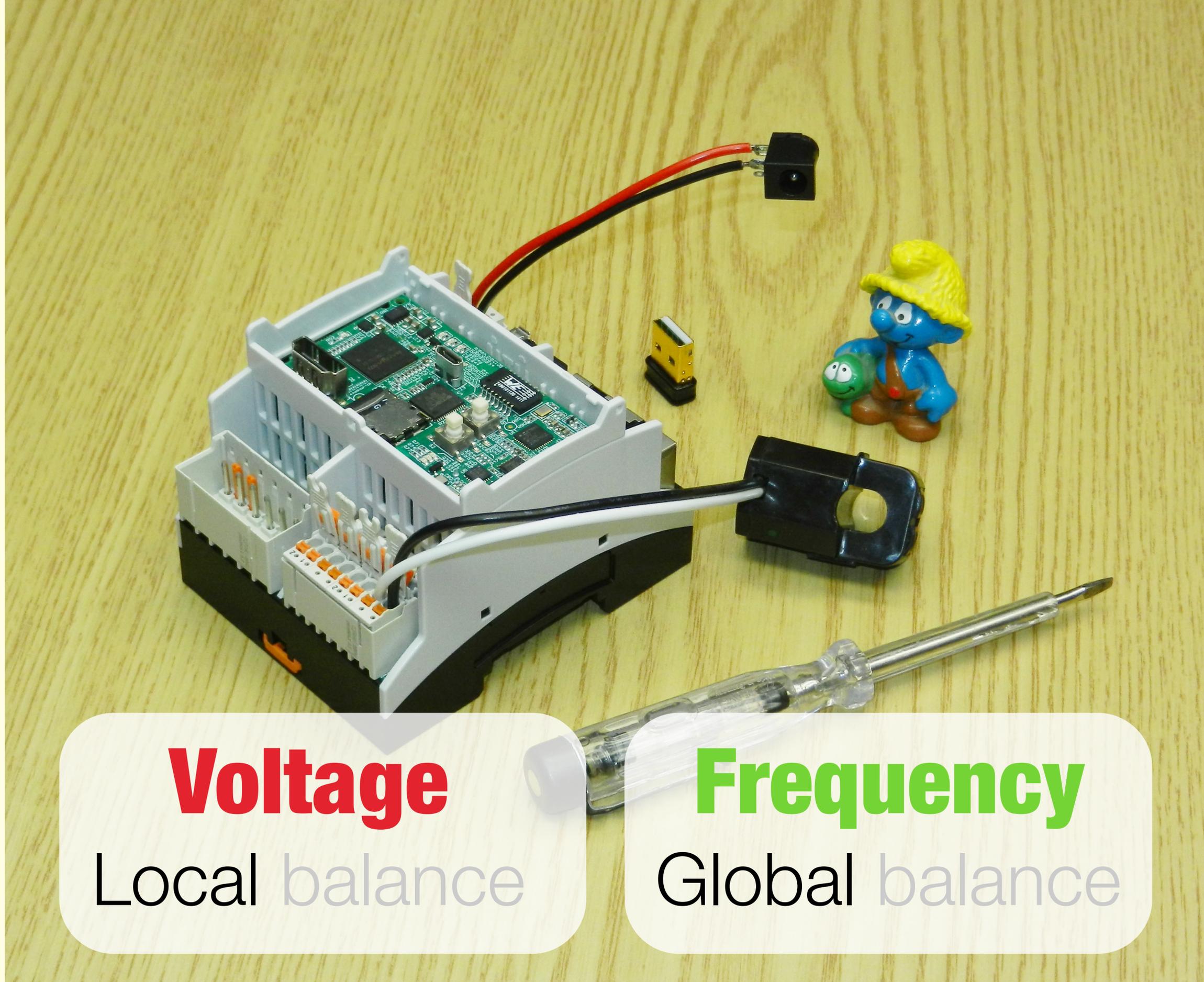
Global balance



**Yes ... it can!**

**Voltage**  
Local balance

**Frequency**  
Global balance

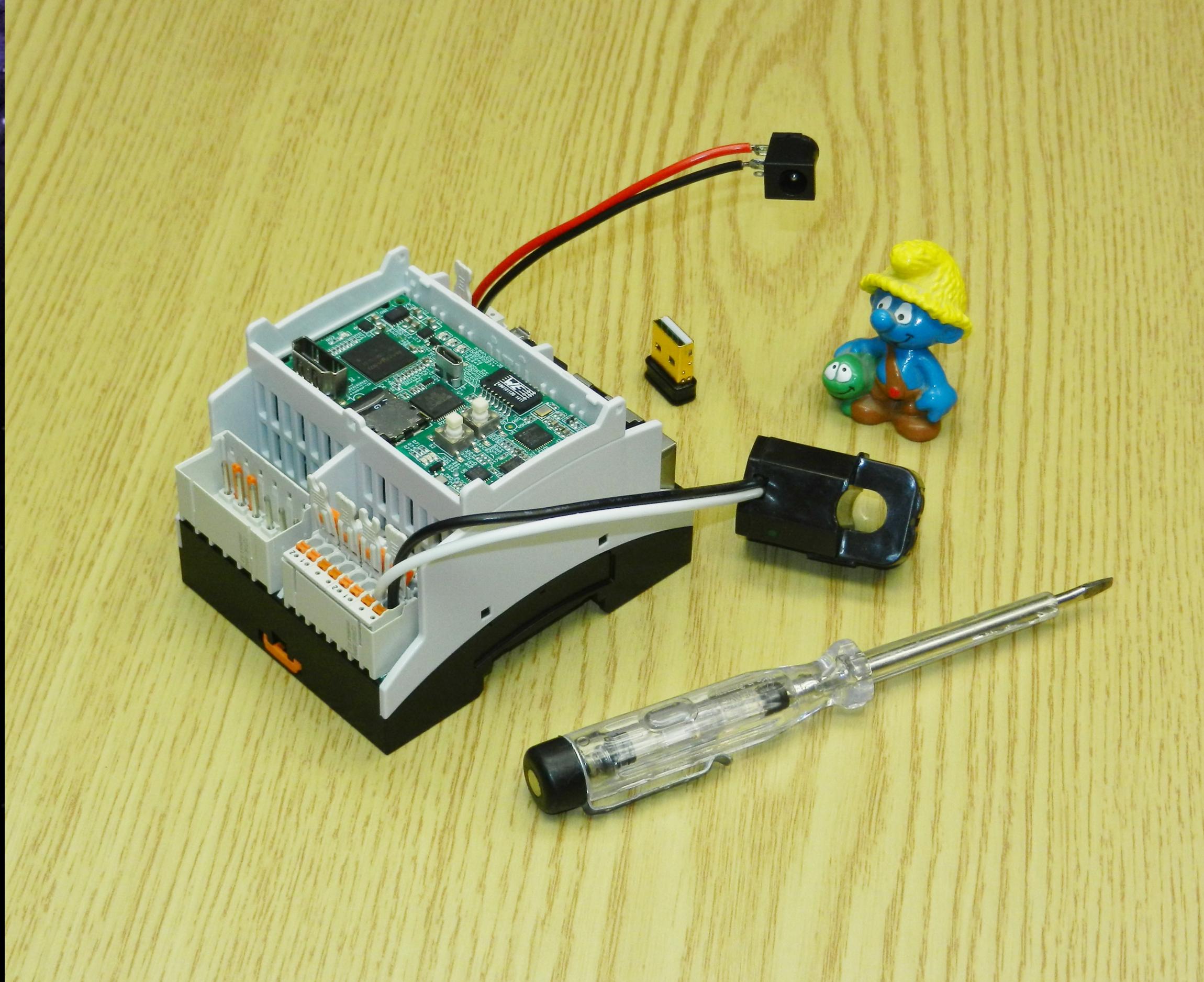
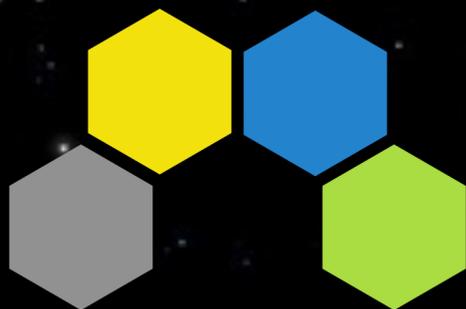




**Yes ... it can!**

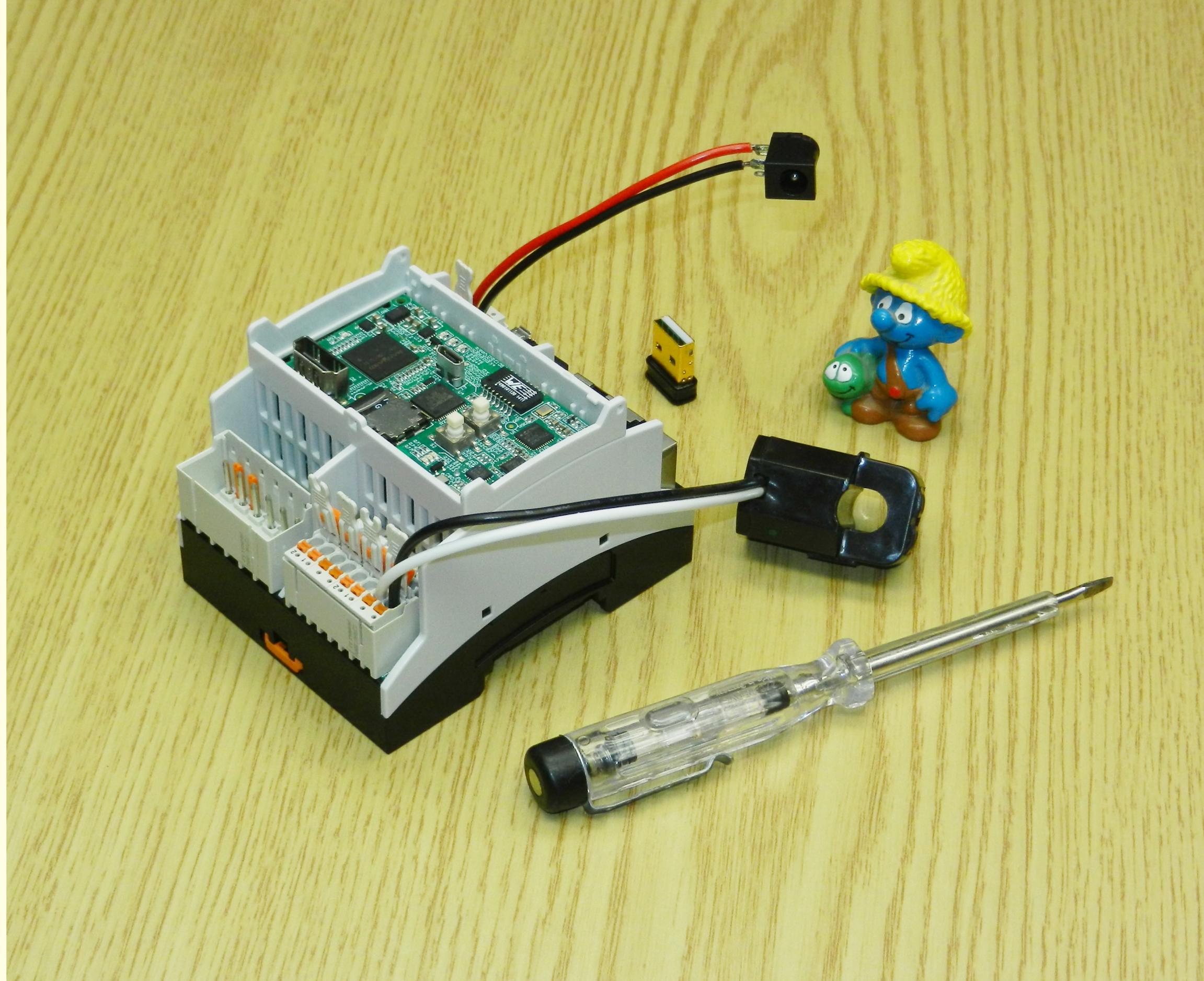
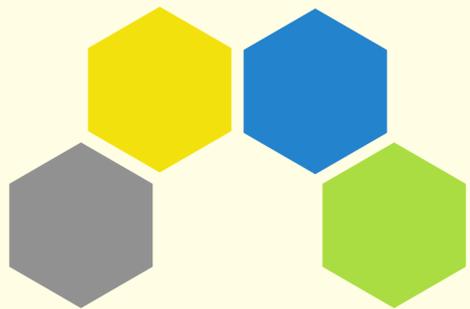


**Yes ... it can!**



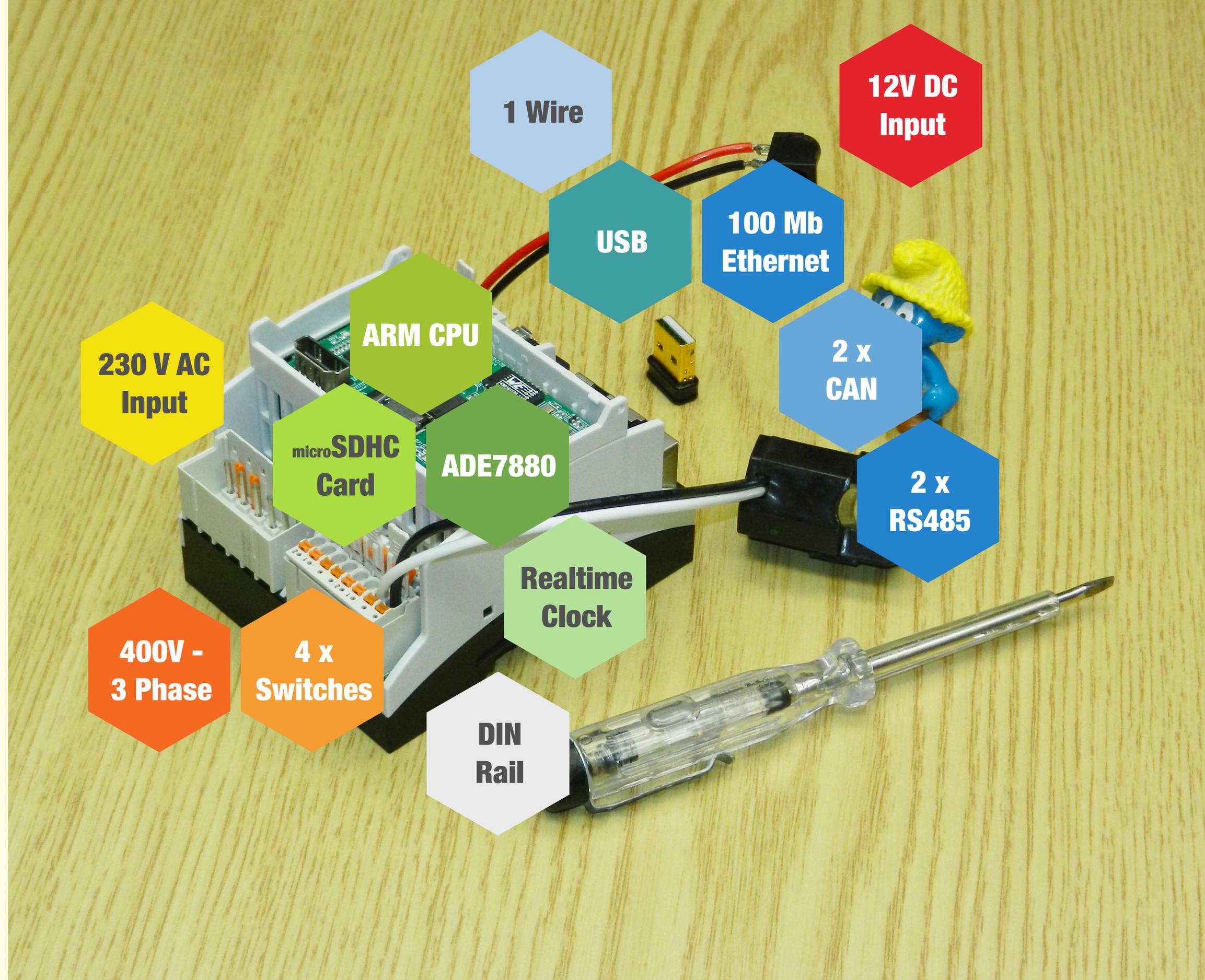
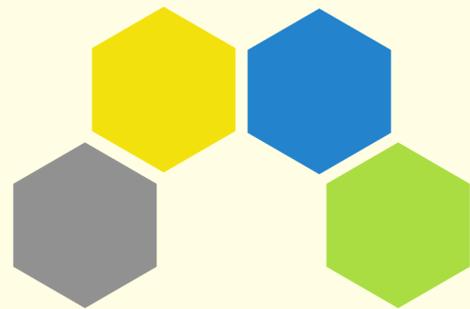


**Yes ... it can!**



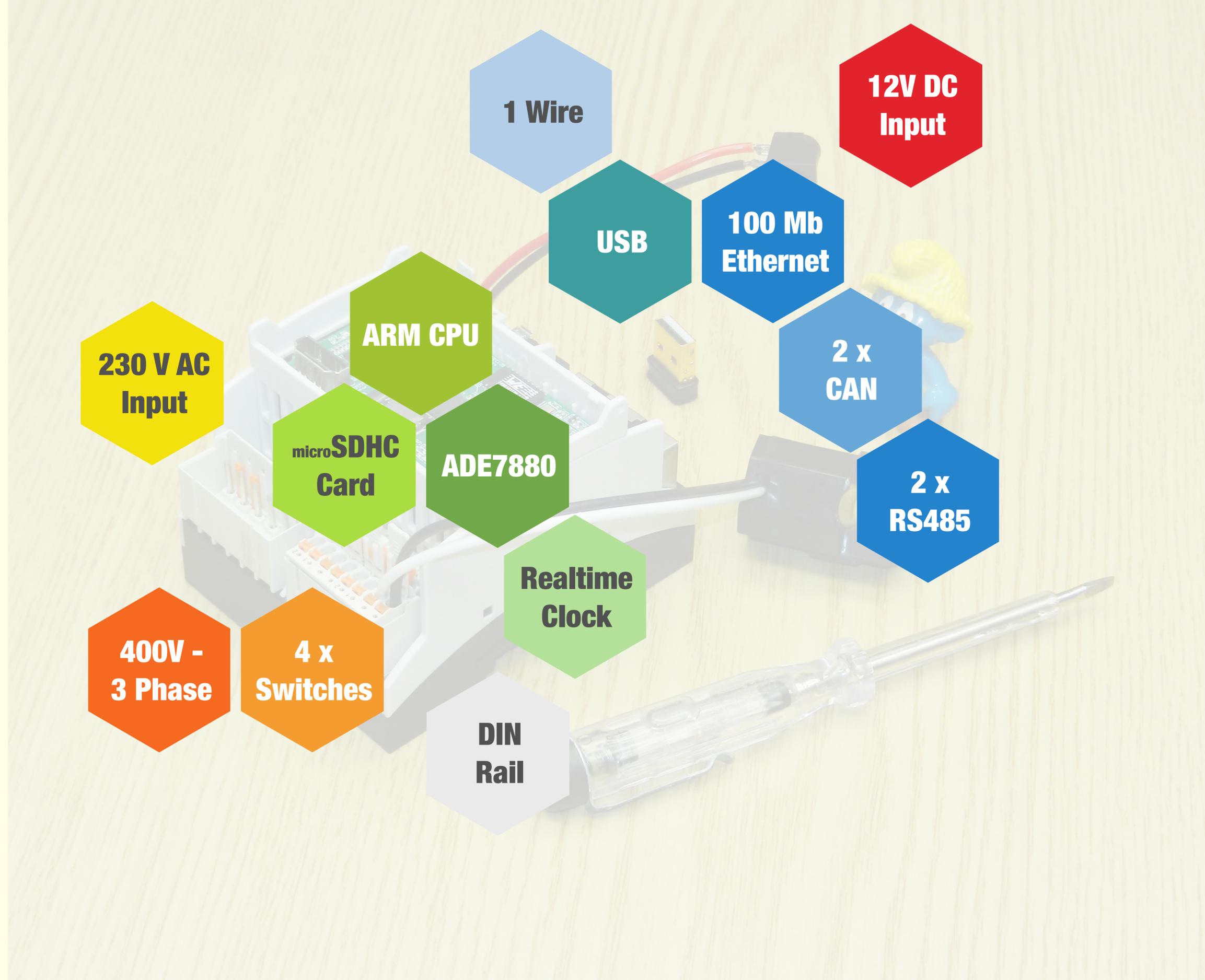
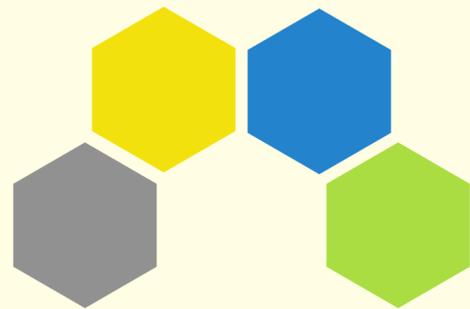


**Yes ... it can!**



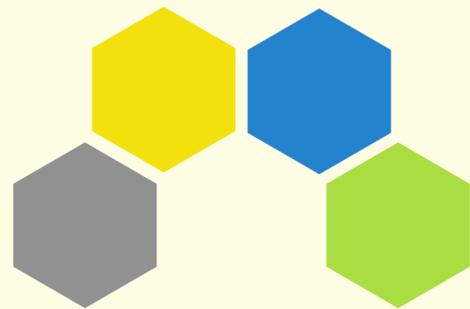


**Yes ... it can!**



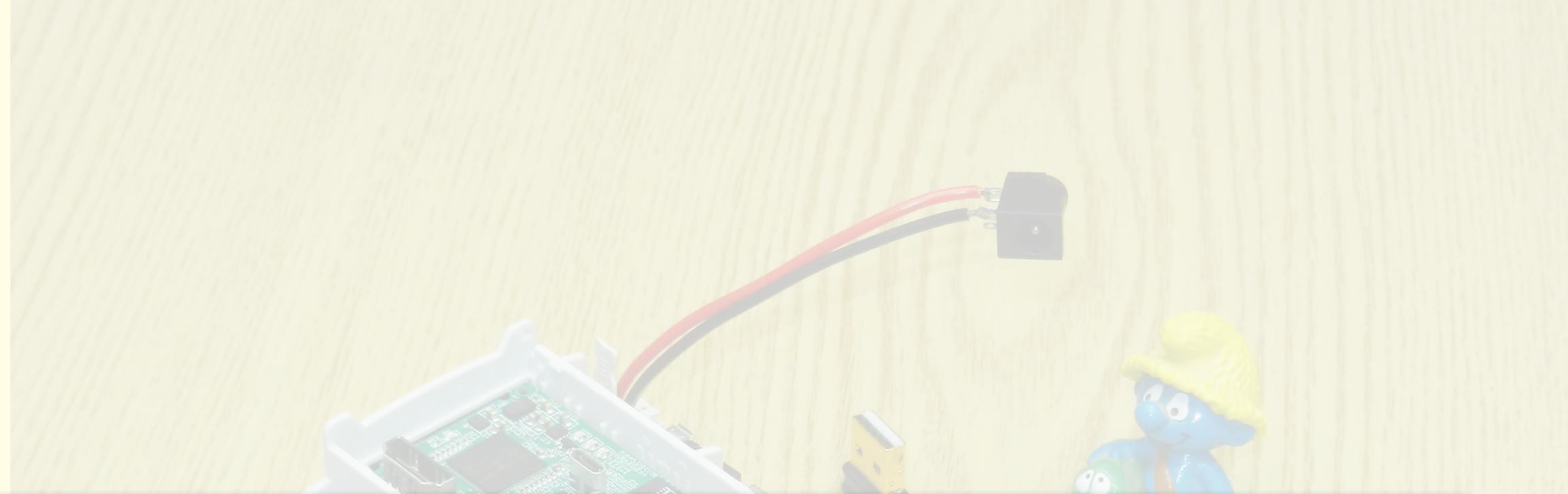
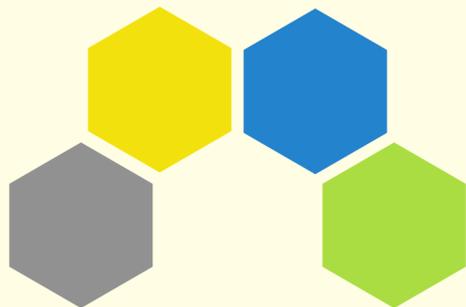


**Yes ... it can!**





Yes ... it can!



# The Linux Kernel Archives



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Protocol	Location
<a href="#">HTTP</a>	<a href="https://www.kernel.org/pub/">https://www.kernel.org/pub/</a>
<a href="#">GIT</a>	<a href="https://git.kernel.org/">https://git.kernel.org/</a>
<a href="#">RSYNC</a>	<a href="rsync://rsync.kernel.org/pub/">rsync://rsync.kernel.org/pub/</a>

Latest Stable Kernel:

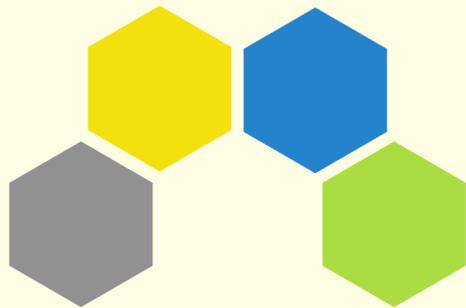


**4.0.4**

mainline:	<b>4.1-rc6</b>	2015-06-01	<a href="#">[tar.xz]</a> <a href="#">[pgp]</a> <a href="#">[patch]</a>	<a href="#">[view diff]</a> <a href="#">[browse]</a>
stable:	<b>4.0.4</b>	2015-05-17	<a href="#">[tar.xz]</a> <a href="#">[pgp]</a> <a href="#">[patch]</a> <a href="#">[inc. patch]</a>	<a href="#">[view diff]</a> <a href="#">[browse]</a> <a href="#">[changelog]</a>
stable:	<b>3.19.8 [EOL]</b>	2015-05-11	<a href="#">[tar.xz]</a> <a href="#">[pgp]</a> <a href="#">[patch]</a> <a href="#">[inc. patch]</a>	<a href="#">[view diff]</a> <a href="#">[browse]</a> <a href="#">[changelog]</a>
longterm:	<b>3.18.14</b>	2015-05-20	<a href="#">[tar.xz]</a> <a href="#">[pgp]</a> <a href="#">[patch]</a> <a href="#">[inc. patch]</a>	<a href="#">[view diff]</a> <a href="#">[browse]</a> <a href="#">[changelog]</a>
longterm:	<b>3.14.43</b>	2015-05-17	<a href="#">[tar.xz]</a> <a href="#">[pgp]</a> <a href="#">[patch]</a> <a href="#">[inc. patch]</a>	<a href="#">[view diff]</a> <a href="#">[browse]</a> <a href="#">[changelog]</a>
longterm:	<b>3.12.43</b>	2015-05-20	<a href="#">[tar.xz]</a> <a href="#">[pgp]</a> <a href="#">[patch]</a> <a href="#">[inc. patch]</a>	<a href="#">[view diff]</a> <a href="#">[browse]</a> <a href="#">[changelog]</a>
longterm:	<b>3.10.79</b>	2015-05-17	<a href="#">[tar.xz]</a> <a href="#">[pgp]</a> <a href="#">[patch]</a> <a href="#">[inc. patch]</a>	<a href="#">[view diff]</a> <a href="#">[browse]</a> <a href="#">[changelog]</a>



Yes ... it can!



babelbee | OpenWrt Barrier Breaker r35052 | Load: 2.71 2.03 1.67 Changes: 0

Status **System** Network Statistics Logout

System Administration Software Startup Scheduled Tasks Time Synchronisation Mount Points LED Configuration Relay Configuration

**Backup / Flash Firmware** Reboot

### Flash operations

Actions Configuration

**Backup / Restore**

Click "Generate archive" to download a tar archive of the current configuration files. To reset the firmware to its initial state, click "Perform reset" (only possible with squashfs images).

Download backup:

Reset to defaults:

To restore configuration files, you can upload a previously generated backup archive here.

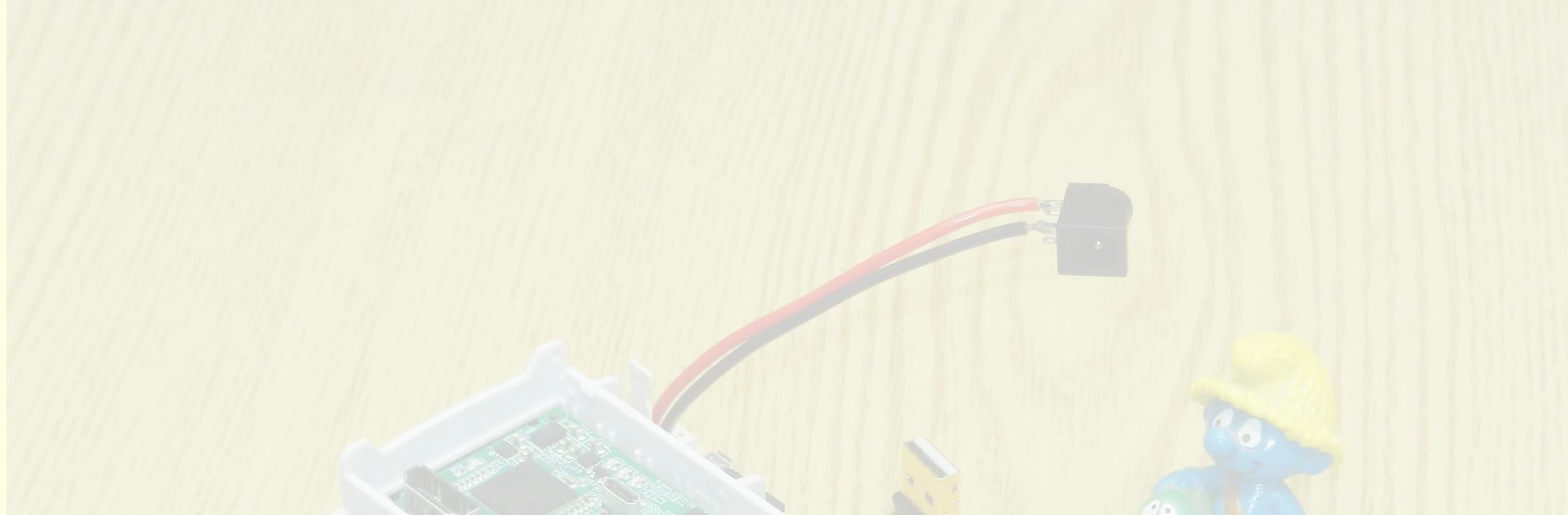
Restore backup:  no file selected

**Flash new firmware image**

Upload a sysupgrade-compatible image here to replace the running firmware. Check "Keep settings" to retain the current configuration (requires an OpenWrt compatible firmware image).

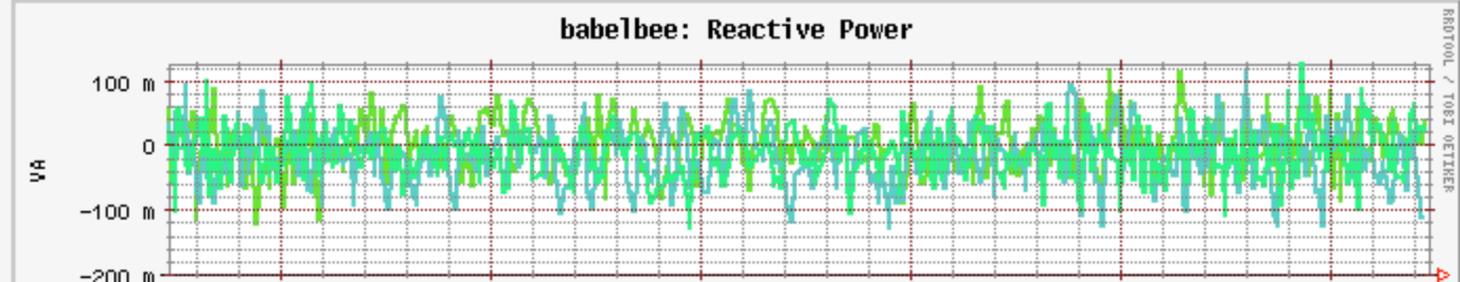
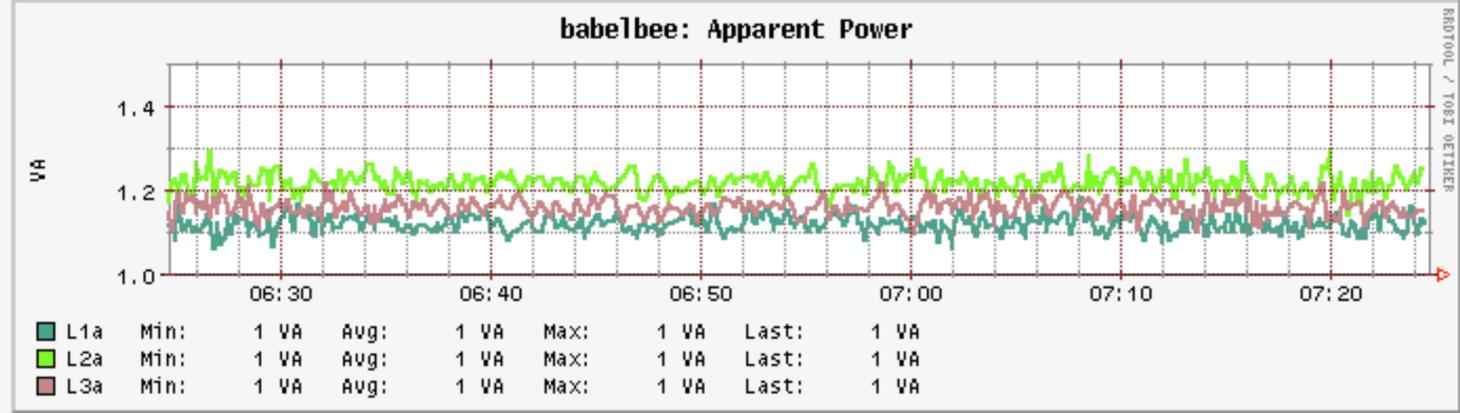
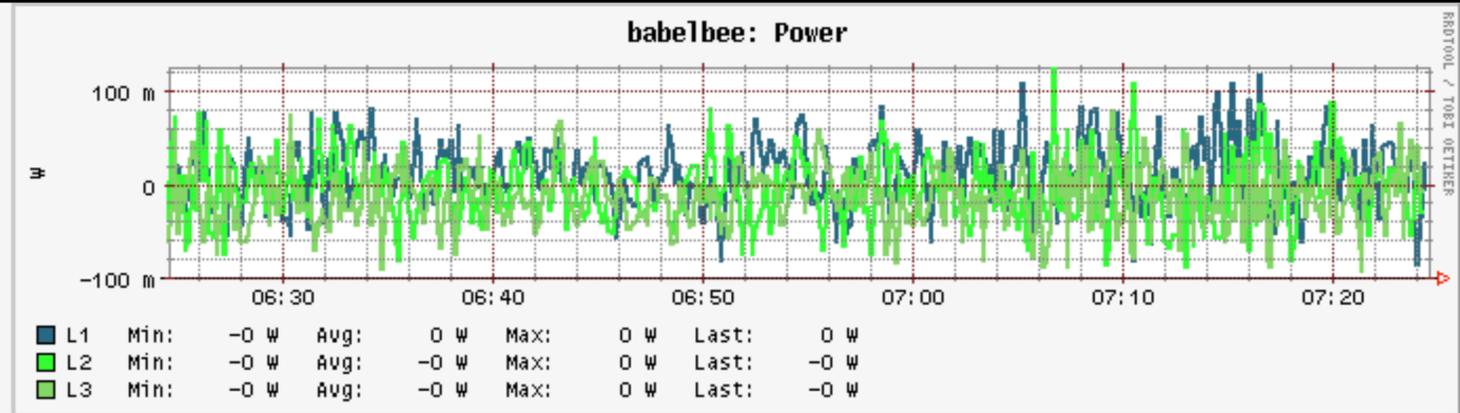
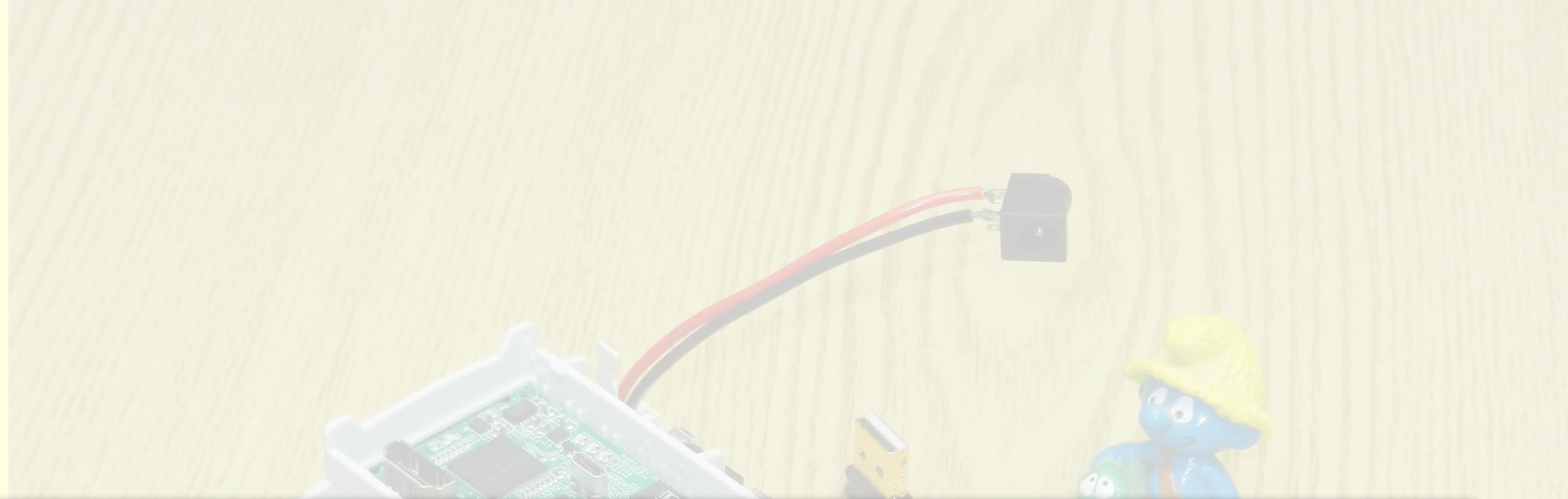
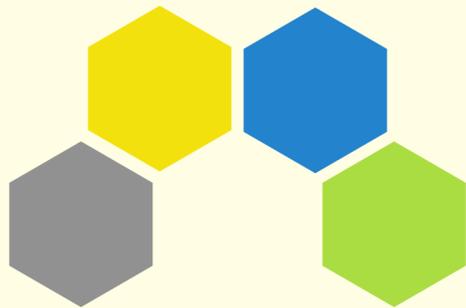
Keep settings:

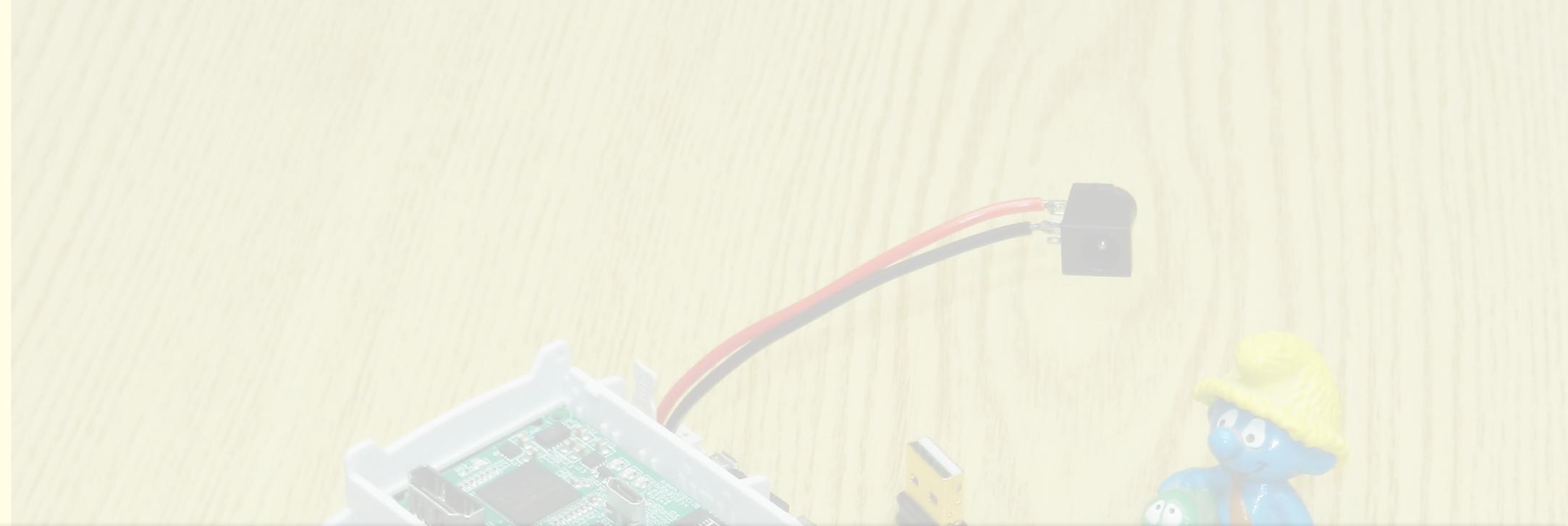
Image:  no file selected



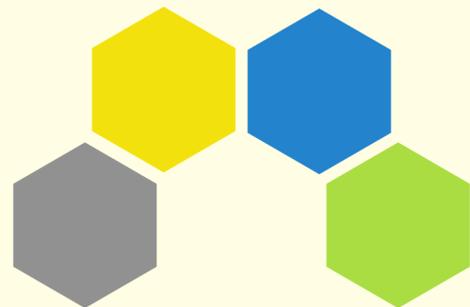


Yes ... it can!





Yes ... it can!



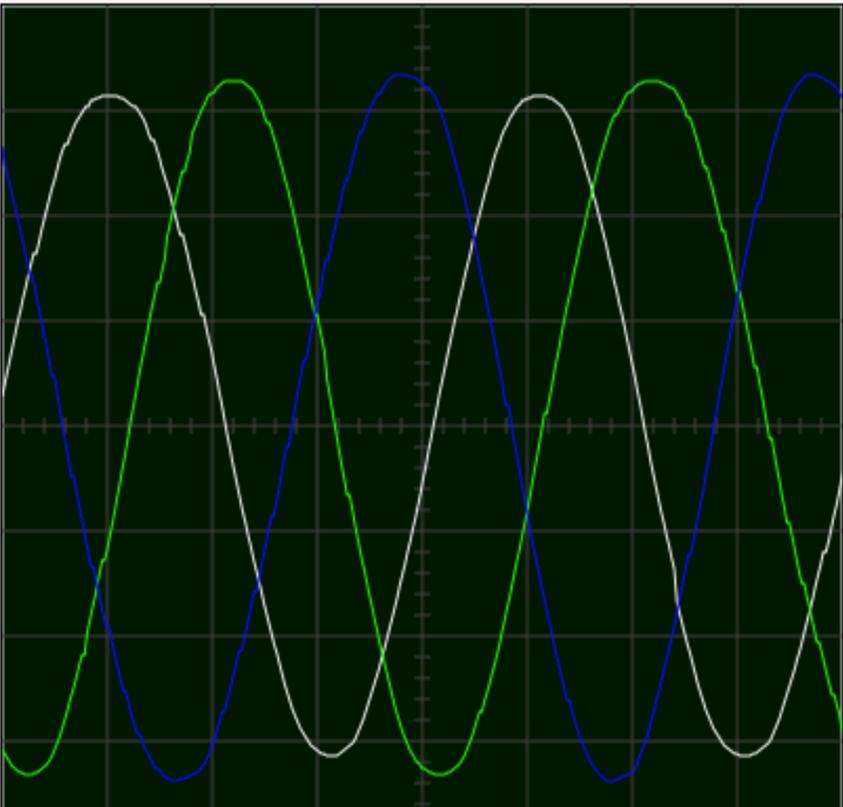
babelbee | OpenWrt Barrier Breaker r35052 | Load: 0.44 0.90 1.22 | Auto Refresh: **on** Changes: 0

**Status** System Network Statistics Logout

Overview Firewall Routes System Log Kernel Log Processes **Realtime Graphs** VnStat Traffic Monitor

Load Traffic Wireless Connections **Oscilloscope**

### Oscilloscope



Channel1/Trigger  
 Disabled  U1  U2  U3  I0  I1  I2  I3

Channel2  
 Disabled  U1  U2  U3  I0  I1  I2  I3

Channel3  
 Disabled  U1  U2  U3  I0  I1  I2  I3

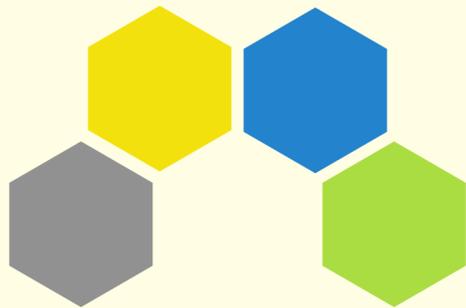
Timebase  
 0.5ms/div  1ms/div  2ms/div  5ms/div  10ms/div  20ms/div

Voltage  
 10V/div  20V/div  50V/div  100V/div  200V/div

Current  
 0.01A/div  0.02A/div  0.05A/div  0.1A/div  0.2A/div  
 0.5A/div  1A/div  2A/div  5A/div  10A/div



Yes ... it can!



## About

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### ❖ What is Lua?

Lua is a powerful, fast, lightweight, embeddable scripting language.

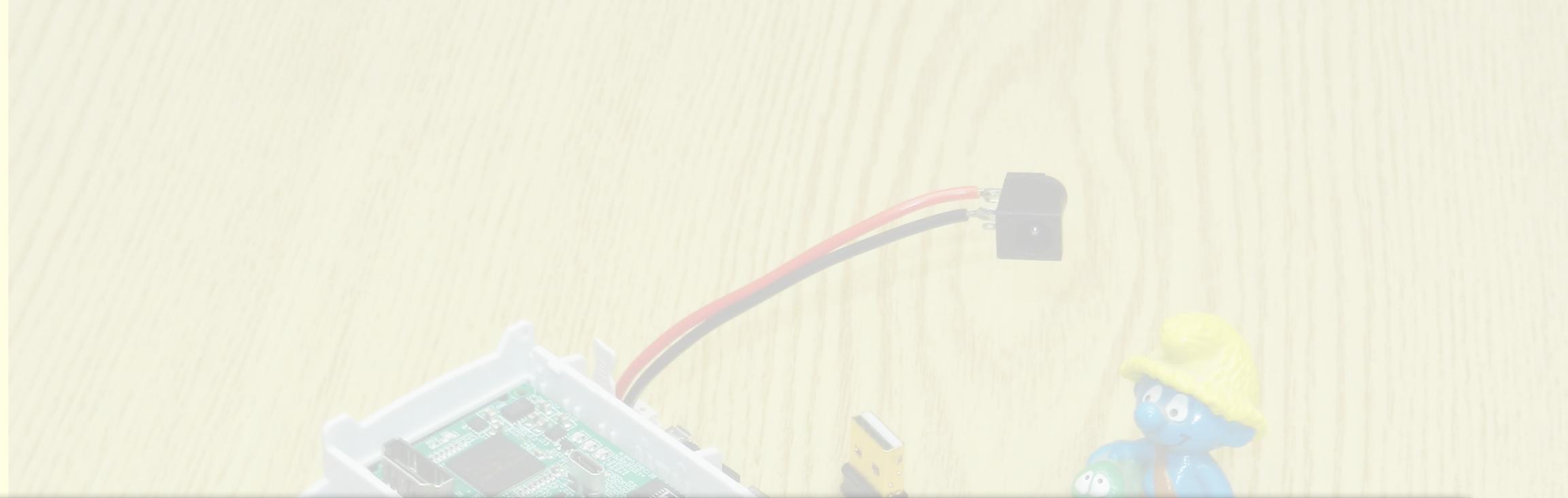
Lua combines simple procedural syntax with powerful data description constructs based on associative arrays and extensible semantics. Lua is dynamically typed, runs by interpreting bytecode for a register-based virtual machine, and has automatic memory management with incremental garbage collection, making it ideal for configuration, scripting, and rapid prototyping.

### ❖ Where does Lua come from?

### ❖ Why choose Lua?

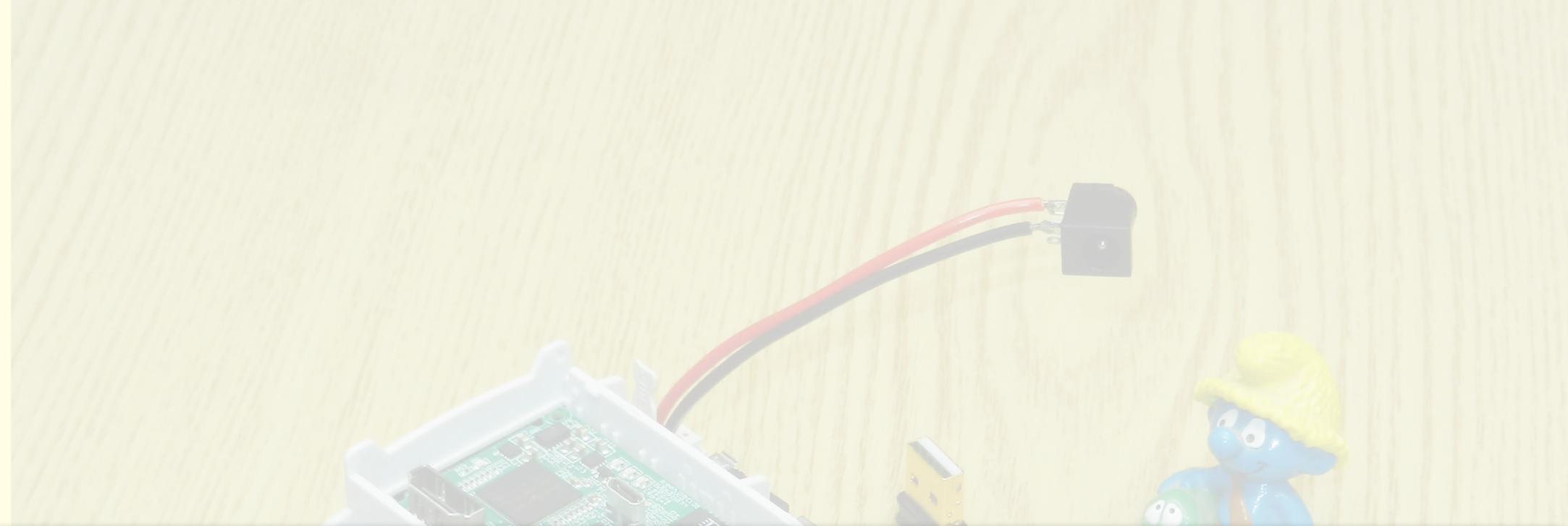
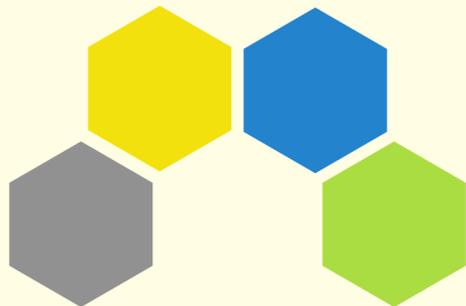
**Lua is a proven, robust language**

Lua has been used in many industrial applications (e.g., Adobe's Photoshop Lightroom), with an emphasis on embedded systems (e.g., the Ginga middleware for digital TV in Brazil) and games (e.g., World of Warcraft and Angry Birds). Lua is currently the leading scripting language in games. Lua has a solid reference manual and there are several books about it. Several versions of Lua have been released and used in real applications since its creation in 1993. Lua featured in HOPL III, the Third ACM SIGPLAN History of Programming Languages Conference, in June 2007. Lua won the Front Line Award 2011 from the Game





Yes ... it can!



GitHub repository page for **babelbee / openwrt**, forked from `openwrt-mirror/openwrt`.

Mirror of the OpenWRT repository <http://openwrt.org/> — Edit

33,059 commits   3 branches   0 releases   2 contributors

branch: `babelbee_new`   **openwrt / +**

This branch is 30 commits ahead, 1379 commits behind `openwrt-mirror:master`   Pull Request   Compare

Fixed can interfaces

**cp15** authored on Mar 19   latest commit `db36173a2f`

<code>config</code>	config: disable kernel tracing on uml	4 months ago
<code>docs</code>	docs: update remaining references to functions.sh	3 years ago
<code>include</code>	fix typo	4 months ago
<code>package</code>	Add and activated an updated canutils package, which now points to th...	3 months ago
<code>scripts</code>	scripts: fix getver git dir check	4 months ago

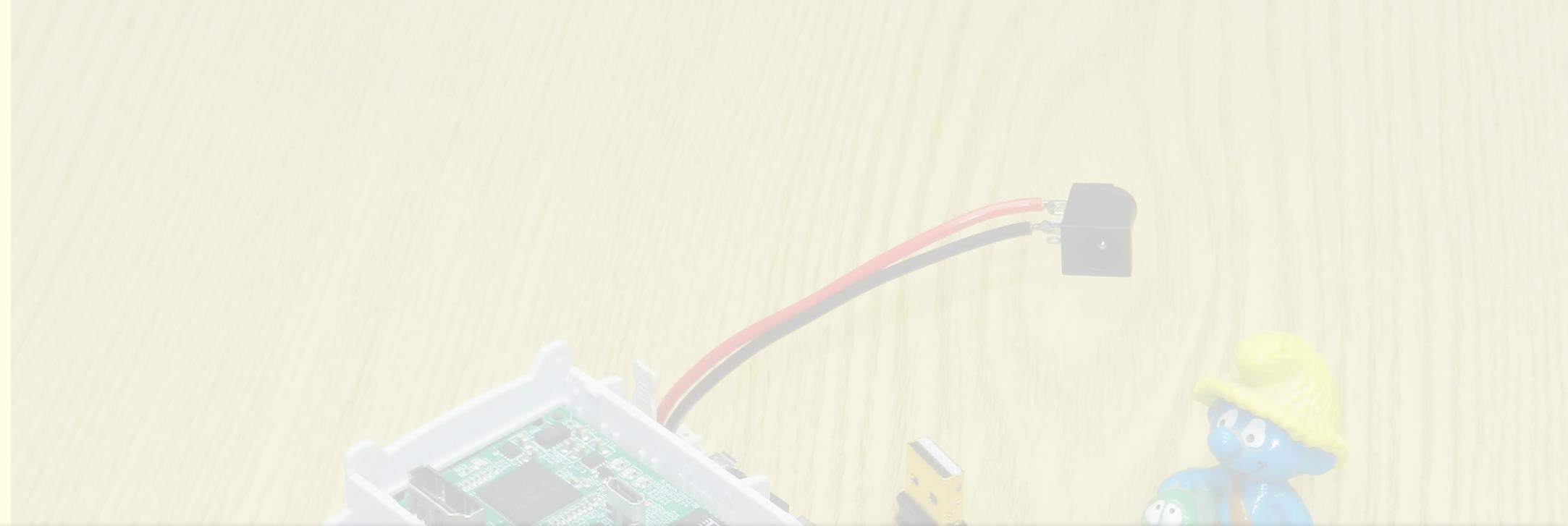
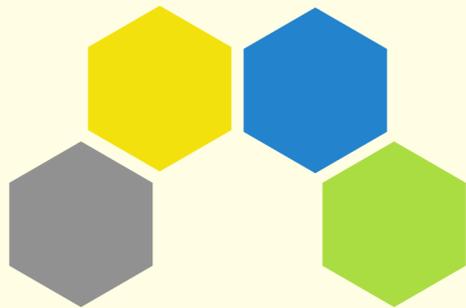
Code   Pull requests (0)   Wiki   Pulse   Graphs   Settings

HTTPS clone URL: `https://github.com/babe`

You can clone with [HTTPS](#), [SSH](#), or [Subversion](#).



Yes ... it will!



# IBR-DTN

A modular and lightweight implementation of the bundle protocol.

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wiki: [WikiStart](#)

[Start Page](#) | [Index](#) | [History](#)

## Welcome to the IBR-DTN Project

This implementation of the bundle protocol [RFC5050](#) is designed for embedded systems like the [RouterBoard 532A](#) or [Ubiquiti RouterStation Pro](#) and can be used as framework for DTN applications.

The module-based architecture with miscellaneous interfaces, makes it possible to change functionalities like routing or storage of bundle just by inheriting a specific class.

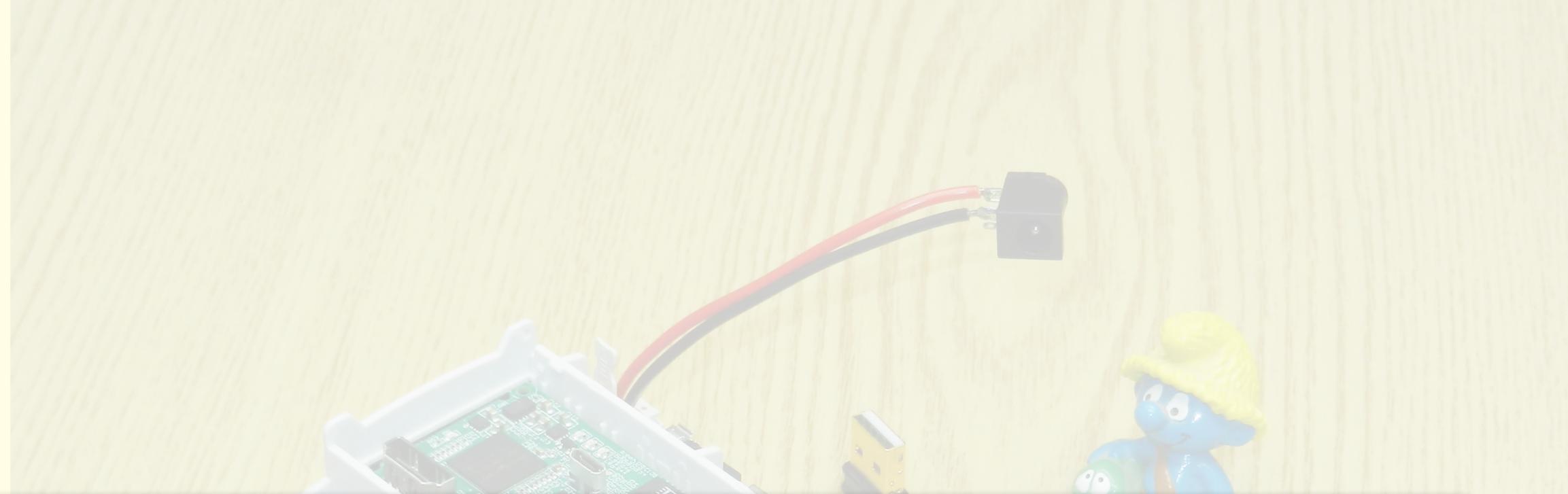
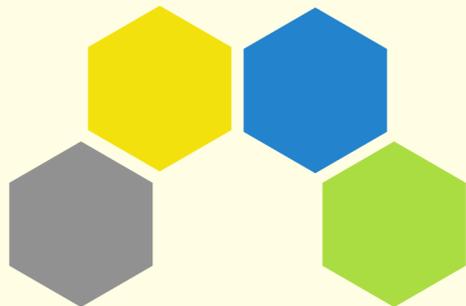
<b>Table of Contents</b>
<a href="#">Software</a>
<a href="#">Runs on ...</a>
<a href="#">Features</a>
<a href="#">Public Node</a>
<a href="#">Starting Points</a>

### Software

- [ChangeLog](#)
- [Download](#)
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- [Documentation](#)
- [Bug report instructions](#)
- [Google+ Profile](#)
- [FAQ](#)



Yes ... it will!



EnergyBus

Standard for Connecting Electric Components of Light Electric Vehicles

[News & Events](#) | [Basics](#) | [Benefits](#) | [Technical Committees](#) | [Organization](#) | [Membership](#) | [Further Info](#)

[www.energybus.org](http://www.energybus.org) -> [Basics](#) -> What is EnergyBus

#### What is EnergyBus

[Why EnergyBus](#)

[Function](#)

[Applications](#)

[Vision-Reality-Future](#)

[History](#)

[Booklet](#)

#### What is EnergyBus

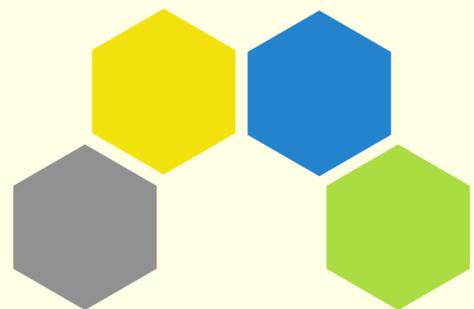
EnergyBus is an open standard for all electrical components of Light-Electric-Vehicles (LEVs). It aims to improve compatibility and safety of LEVs and consists of a cutting-edge connector family and the respective communication protocol. EBS will be available to all EnergyBus members in spring 2011.







**Yes ... you can!**



**Crowdfunding** starting soon...



**Babelbee**



**Open  
Source**

**Electric  
Power**

**Monitor-  
ing**

**Manage-  
ment**

# Babelbee

[www.babelbee.org](http://www.babelbee.org)



# Babelbee

[www.babelbee.org](http://www.babelbee.org)