ENPOS – Energy Positive Farm

Monitoring energy use on farms – measurements, bookkeeping forms

Electricity consumption

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INVESTING IN YOUR FUTURE

CENTRAL BALTIC
INTERREG IV A
PROGRAMME
2007–2013

UNIVERSITY OF HELSINKI

MTT

www.emu.ee
Eesti Maaülikool
EMU Estonian University of Life Sciences

Main topics

- Electric energy
- What to measure
- Where to measure
- How to measure
- Differences between measurement and logging
- Instrumentation
- Measurement evironment

Electric energy

If *W* is work of electric current

U – voltage

I – current strength

t – time of current existance

R – resistance of the circuit

Q – electric charge transported by the current (*Q* = *It*)

then the amount of work in case of direct current (DC) is *W* = *UQ* and from that

$$W = UIt = \frac{U^2 t}{R} = I^2 Rt$$

On the other hand, we know that the power of electric current

$$P = UI = \frac{U^2}{R} = I^2 R.$$

So, the energy consumed by some electric circuit or device in time *t*

$$W = Pt\ .$$

The unit of energy is Joule. The unit of power is Watt. In case of electric energy for large amounts of consumed energy kW·h are used:

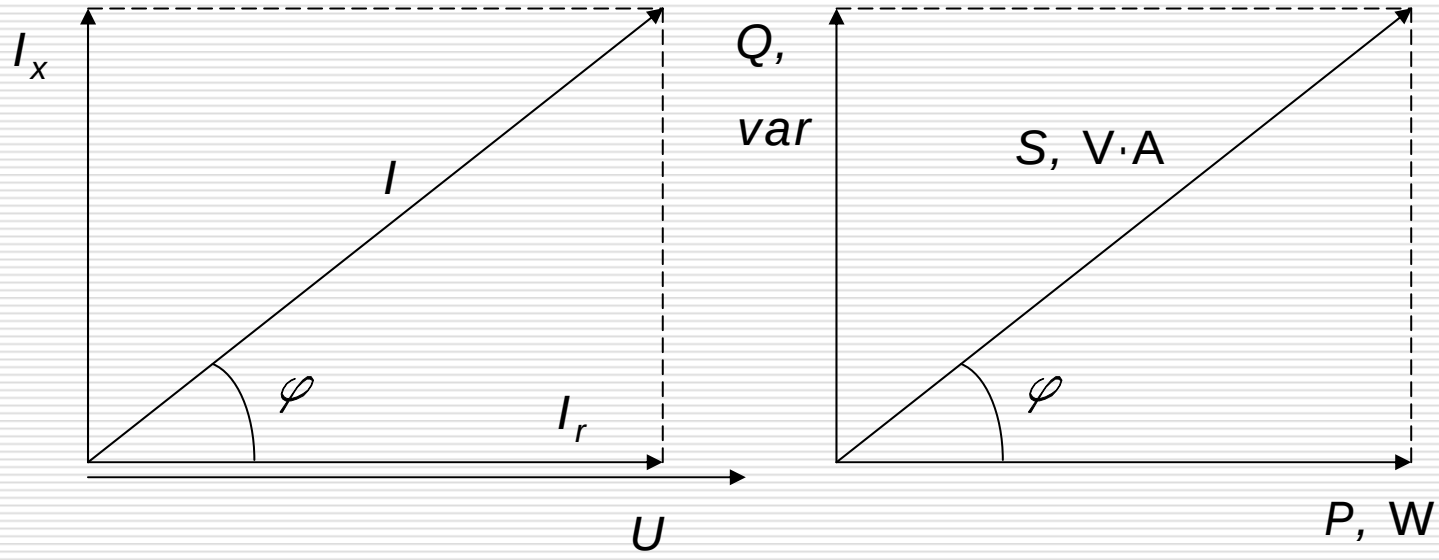
$$1\ \text{kW·h} = 3.6 \cdot 10^6\ \text{J}.$$

In case of alternating current (AC) some electric consumers (mostly electric motors) have inductive or capacitive (reactive) resistances. Because of that the current and voltage have different phases and in this case

Active power $P = UI\cos\varphi$

Reactive power $Q = UI\sin\varphi$

Full power $S = UI$


I_x
I
φ
I_r
U
Q, var
S, V·A
φ
P, W

What to measure

To register energy consumed we can measure:

- In case of 1_{ph} purely active loads: $\boldsymbol{W_1}$ or $\boldsymbol{P}$ and $\boldsymbol{t}$ or $\boldsymbol{U}$, $\boldsymbol{I}$ and $\boldsymbol{t}$ or ON/OFF state if the load is constant.
- In case of 1_{ph} reactive loads: $\boldsymbol{W_1}$ or $\boldsymbol{P}$, $\boldsymbol{t}$ and φ or $\boldsymbol{U}$, $\boldsymbol{I}$, $\boldsymbol{t}$ and φ or ON/OFF state if the load is constant.
- In case of 3_{ph} active loads: $\boldsymbol{W_3}$ or $3\boldsymbol{P}$, $\boldsymbol{t}$ and φ or $\boldsymbol{U}$, $3\boldsymbol{I}$, $\boldsymbol{t}$ and φ or ON/OFF state if the load is constant.
- In case of 3_{ph} reactive loads: $\boldsymbol{W_3}$ or $3\boldsymbol{P}$, $\boldsymbol{t}$ and φ or $\boldsymbol{U}$, $3\boldsymbol{I}$, $\boldsymbol{t}$ and φ or ON/OFF state if the load is constant.

Where to measure

- At the electric energy substation
- Inside the distribution boards
- Near the machines (electric motors, heating or cooling devices) with largest consumption

How to measure

If the measurements are done by loggers, we need

- To distinguish all relevant points in the electric grid to be able to get the electric energy consumption by specific technological process
- To get access to electrical wiring at these points.
- Depending on the equipment available, connect loggers at these points
- To choose the logging interval
- To choose logging period
- To draw a plan with logging points and loggers' numbers
- To check the loggers state during logging period
- To download data to PC or shuttle or to disconnect logger in the end of the logging period

Differences between measurement and logging

Measurement

- Measurement may be done by devices without onboard memory or remote data saving capability – every time we read the value, we get the integrated energy consumption (energy meter)

- Measurement may be done for getting results for specific load estimation at given time for short interval

Differences between measurement and logging

Logging

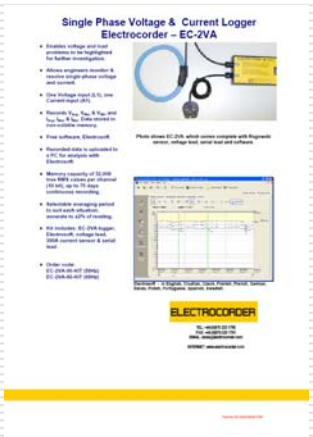
- Measurement is done by devices with onboard memory or remote data saving capability – all values are saved with specific interval (frequency) for long period – days, weeks

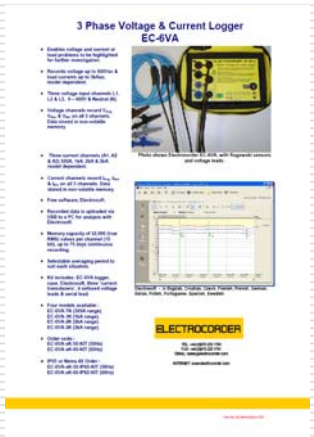
- Measurement may be done by devices without onboard memory or remote data saving capability – energy meters with data recording by hand. Difficult to use for shorter than 24 h logging interval

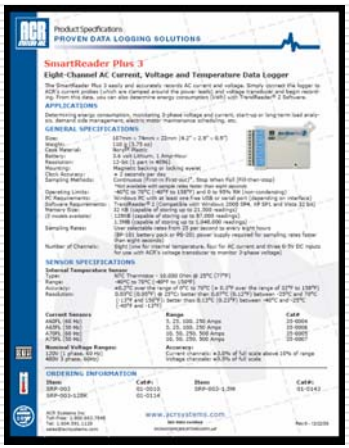
Instrumentation

Most suitable devices are loggers with large memory and built-in power supply.

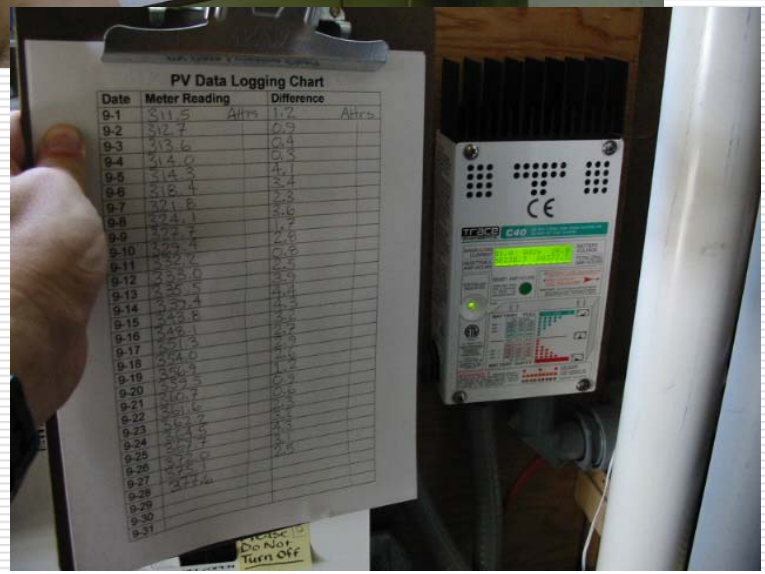
Some exhamples







Manual data logging



CURRENT SENSORS

Deltec Shunts
www.deltecco.com

Shunts (low value resistors)

- Good for AC or DC.
- Relaltively low cost ($20 - $50).
- Direct conversion to voltage (no extra stuff required).
- Must be spliced in series with the circuit.
- No electrical isolation.

Hall Effect (m-field) sensors

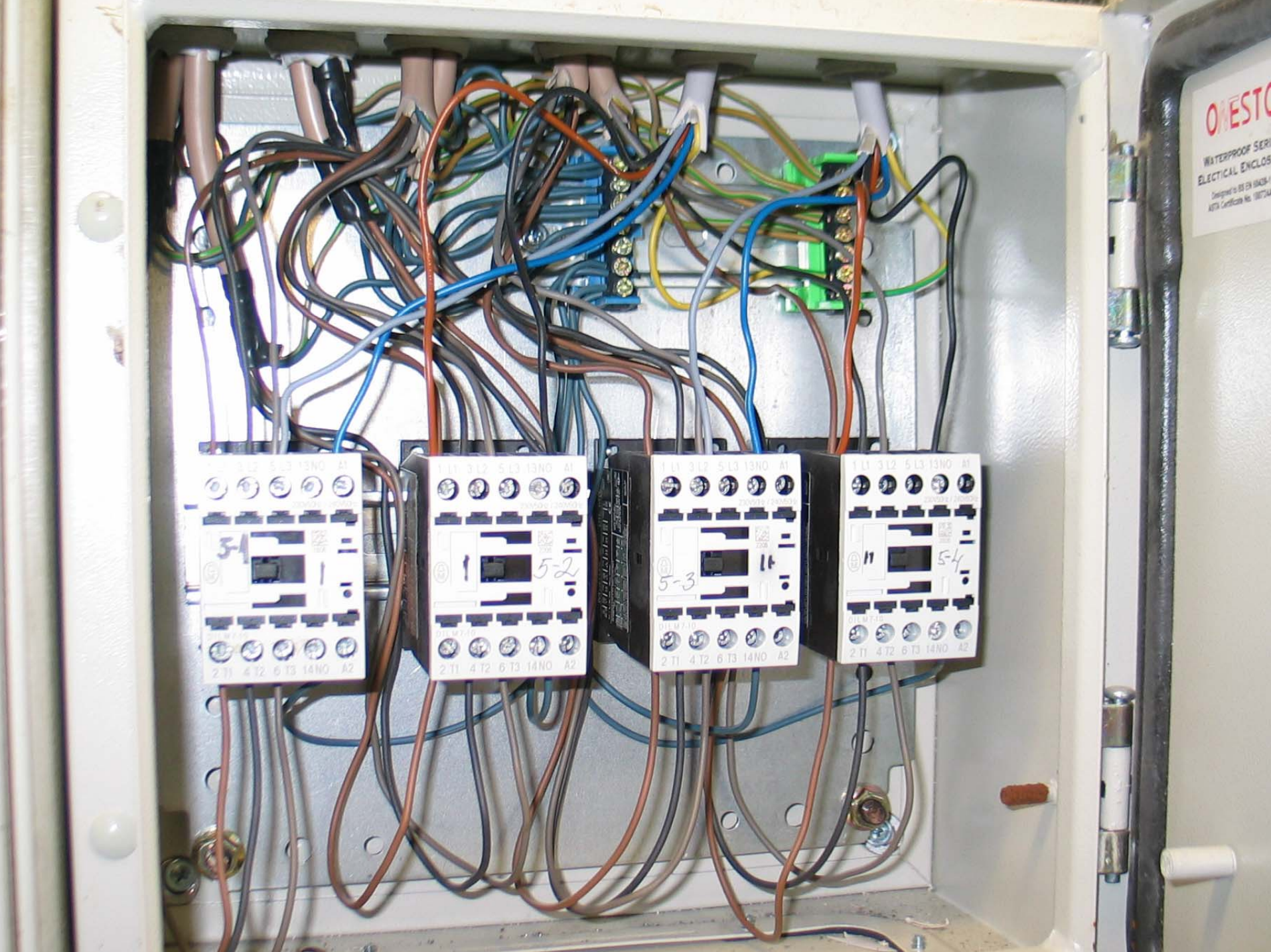
- Good for AC or DC.
- Relatively low cost ($12 to $72).
- Requires regulated power for the sensor.
- Must be threaded over a disconnected wire but no splice is needed.
- Provides electrical isolation.

Amploc Hall
Effect Sensors
amploc.com
See HP85

Current Transformer

- Good for AC only.
- Relatively low cost ($15 to $75).
- Clamps over the wire. Usually no disconnection or splicing required.
- Provides electrical isolation.

Onset
Clamp-on current transformer
onsetcomp.com


5-1
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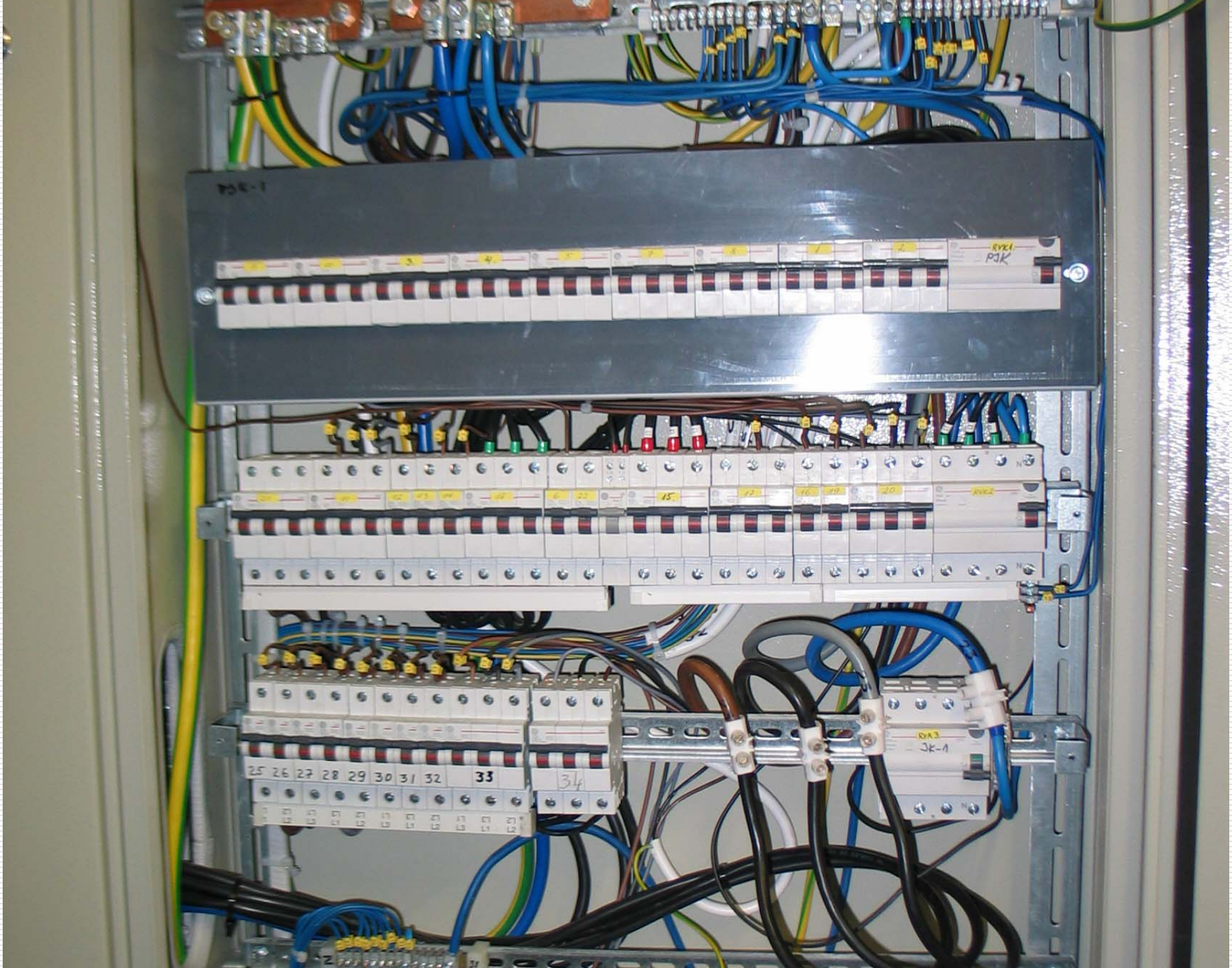
RVK1
RVK2
RVK3
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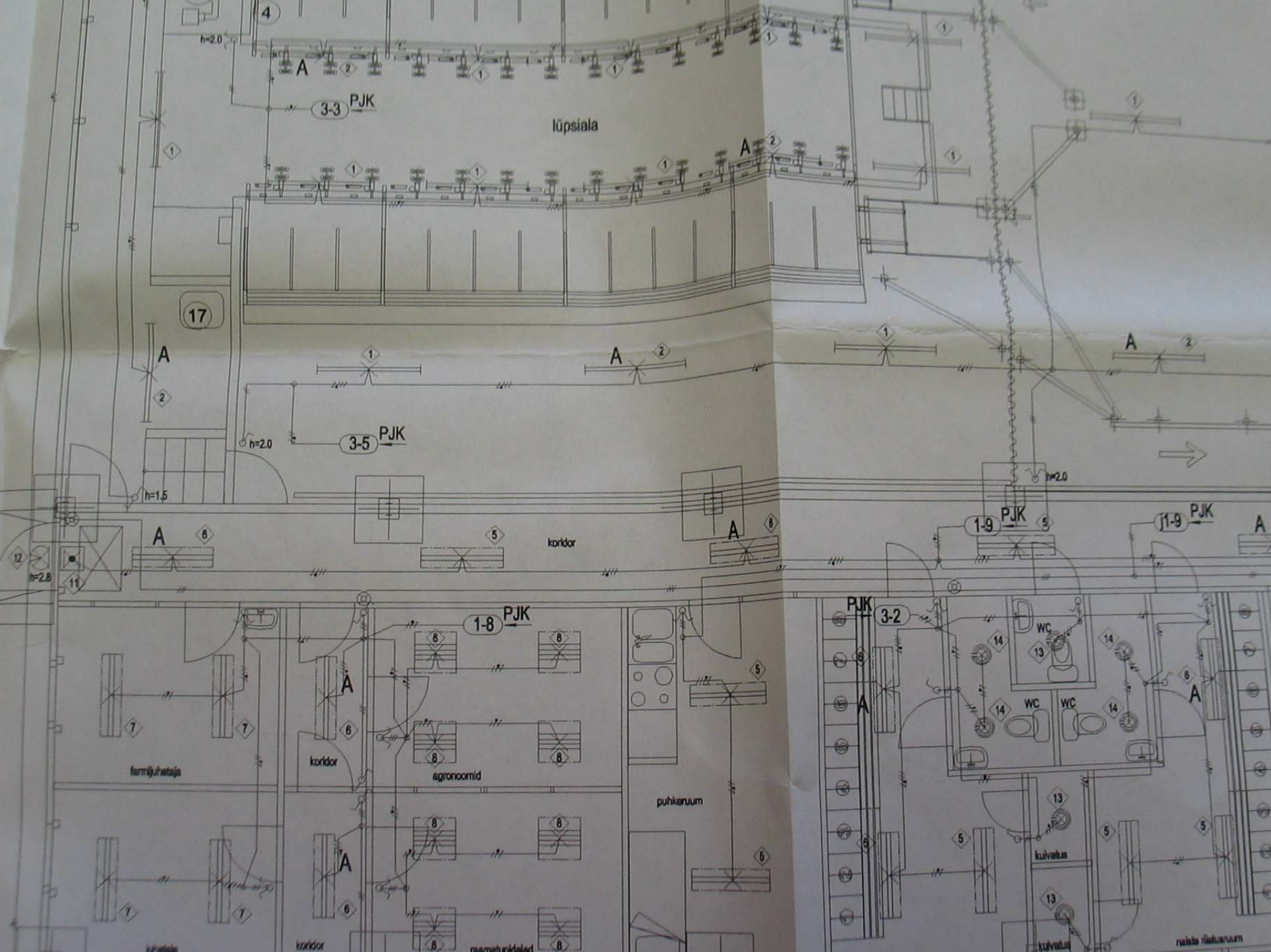
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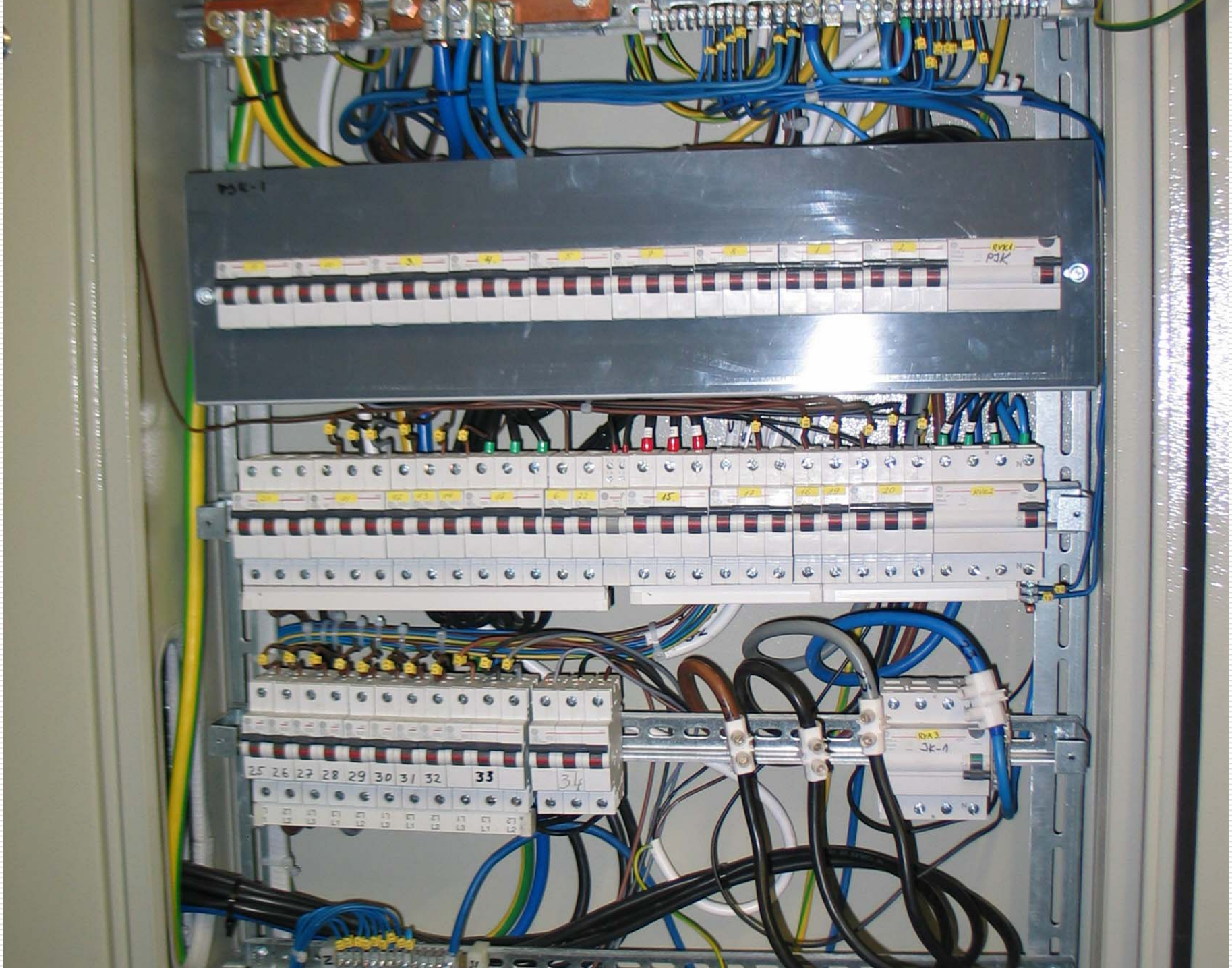
RVK1
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VÄLJAS


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TRAFO

This material has been produced in ENPOS project. ENPOS is acronym for ***Energy Positive Farm***.

The project partners are
• University of Helsinki, department of Agricultural Sciences – Agrotechnology
• MTT Agrifood Research Finland - Agricultural Engineering
• Estonian University of Life Sciences

Project home page is at http://enpos.weebly.com/

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