A Swiss Cloud-Native Farm

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SEP 02 – 04, 2026

CONTAINER days HAMBURG

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About Me

Recent selfie with Jura (cow #33)

The Farm

Main Site

65 cows, dairy facilities, milk vending machine

Biogas Plant Site

Energy production

Why Cloud-Native?

What's there

- Old proprietary protocols
- Windows-only GUIs, VNC
- Data locked in silos

What I wanted

- Real-time data & alerting
- Mobile-friendly dashboards

"Swiss Farm" (1883) by Eugène Burnand

Oil on canvas, farm in Ecublens near Seppey, Vaud

Let's Turn the Farm Cloud Native

Infrastructure Foundation

Cluster

- 4x HP EliteDesk Mini PCs
- 16GB RAM, 512GiB NVMe each
- Talos Linux

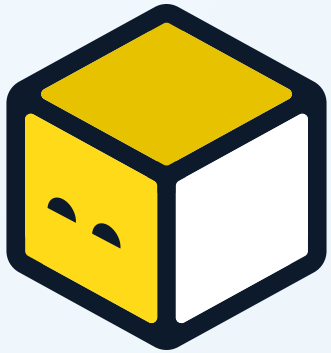
Operating Costs

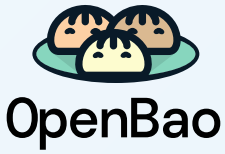
- Power: 60 Wh = 1.4 kWh/day = 137 CHF/year
- Hardware amortization: **350 CHF/year** (=1 node)
- **Total: 487 CHF/year (~40 CHF/month)**

Infrastructure as Code with OpenTofu

Network config managed with **OpenTofu**[1]:

- MikroTik routers (official provider)
- IPAM (phpIPAM)
- Cloudflare DNS
- WireGuard tunnels
- Secrets in OpenBao[2]



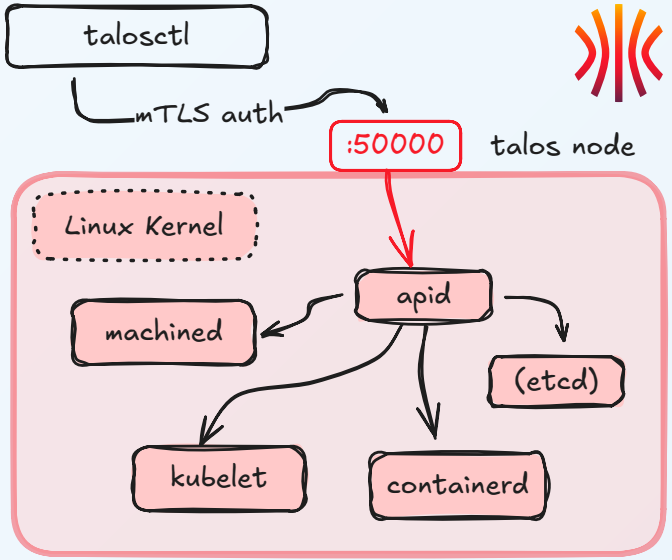


1. https://opentofu.org
2. https://openbao.org

Talos Linux

- < 50 OS binaries, < 80 MB footprint
- Immutable root filesystem, no package manager
- No SSH, no shell — interaction via gRPC API
- Declarative configuration

Managed with **TOPF**[1]

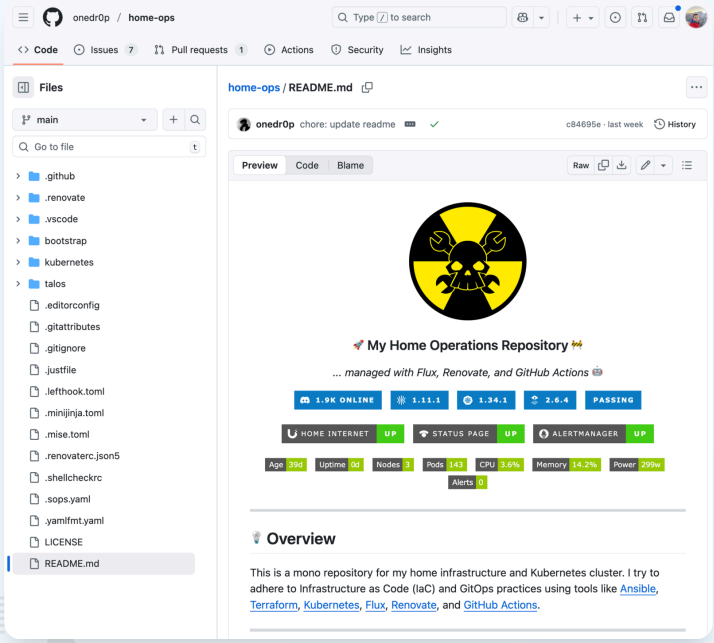


1. https://github.com/postfinance/topf

Configuring the cluster

Inspired by home-ops[1]

- **GitOps**-first approach with FluxCD
- Open-source home lab configurations
- Active Discord & GitHub community



github.com/onedr0p/home-ops

1. https://home-operations.com/

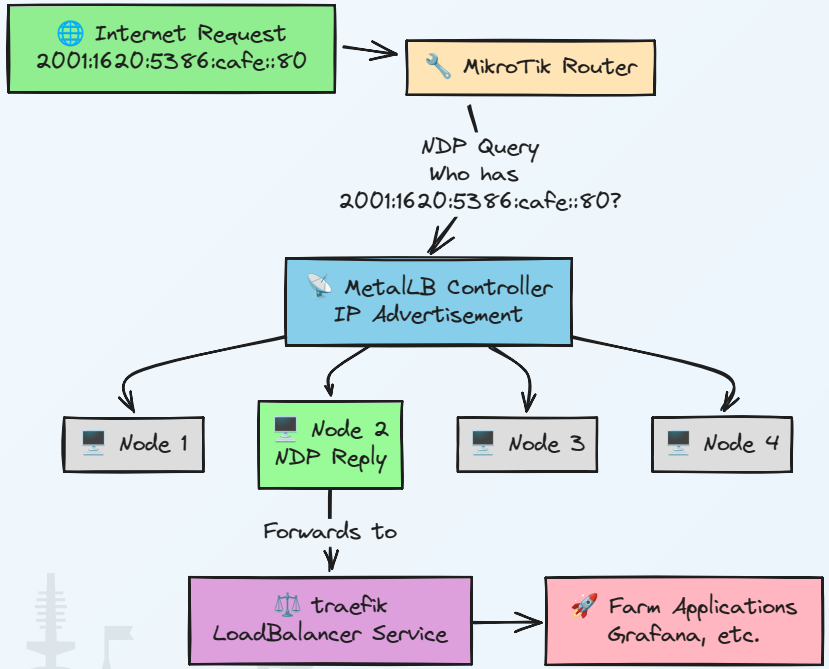
Network Architecture

Dual-stack IPv4 / IPv6

MetalLB exposes the ingress on an IPv6 address via NDP[1] — no NAT needed

For IPv4-only clients:

- Cloudflare proxy in front of the IPv6 address
- Or a small VPS proxying IPv4 → IPv6



1. Neighbor Discovery Protocol — the IPv6 equivalent of ARP

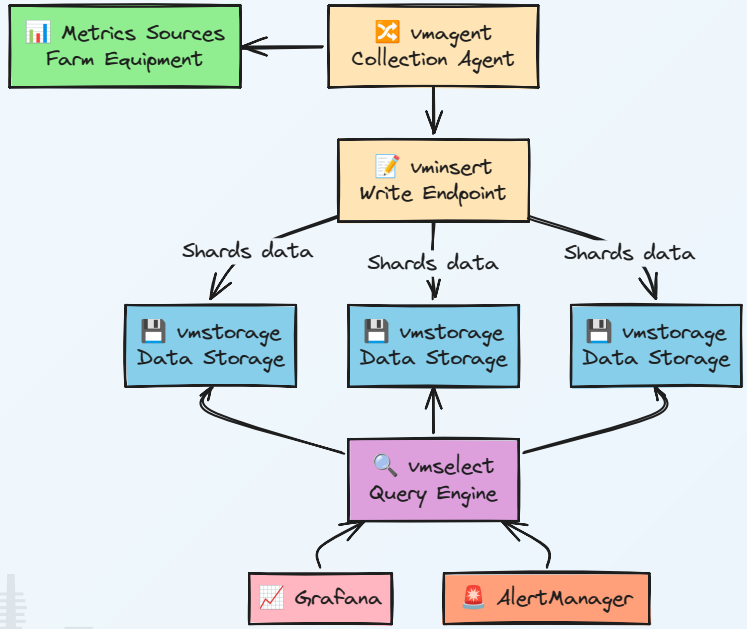
Monitoring Stack

VictoriaMetrics

- **Simple architecture**
- Drop-in Prometheus replacement
- Better resource usage
- Long-term retention

Grafana

- Dashboards + alerting



Use Cases

Milking Data

Real-time collection & analysis

Biogas Plant

Performance metrics & alerts

Electric Fences

Remote control & monitoring

Milk Vending Machine

LiDAR sensor integration

Self-Hosted Apps

Invoicing, PDF archive, SSO

Uptime Monitoring

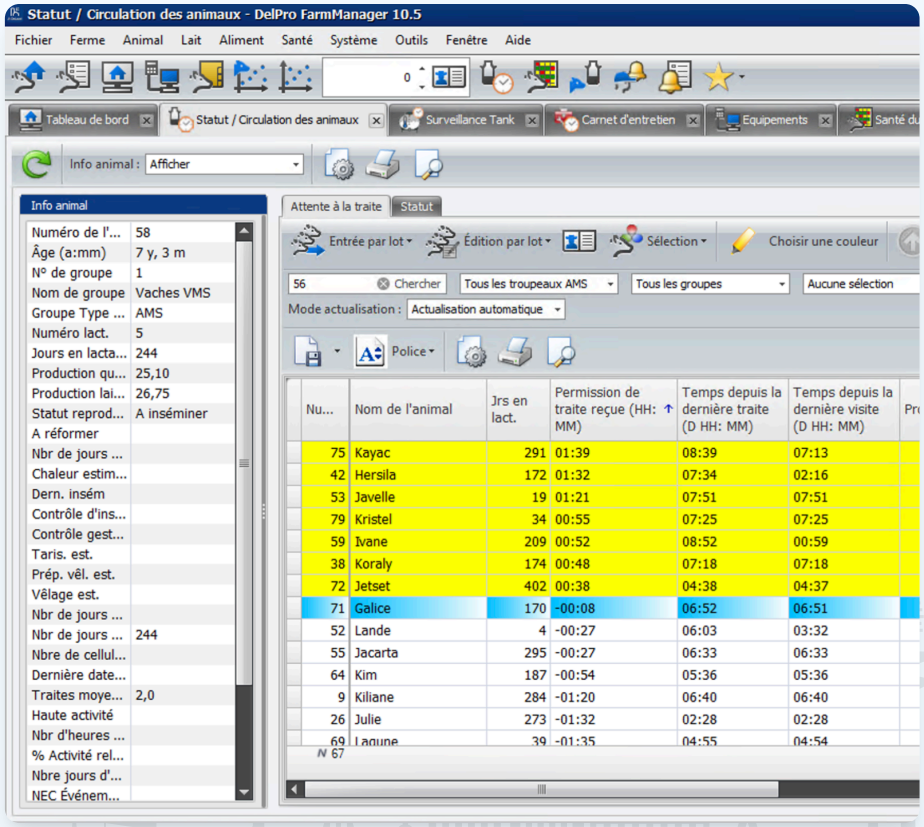
All farm devices, status page

Milking at the Farm

- Holstein cows
- 65 cows, ~2.3 milkings/day
- DeLaval VMS voluntary milking system
- Cows choose when to be milked

DeLaval VMS milking robot

DelPro Farm Manager



Legacy Management Interface

- Traditional Windows-based application
- Limited real-time capabilities

Key Limitations

- No API access for automation
- Limited mobile access

DelPro Data Extraction

Custom Go service: MS SQL → Prometheus format[1]

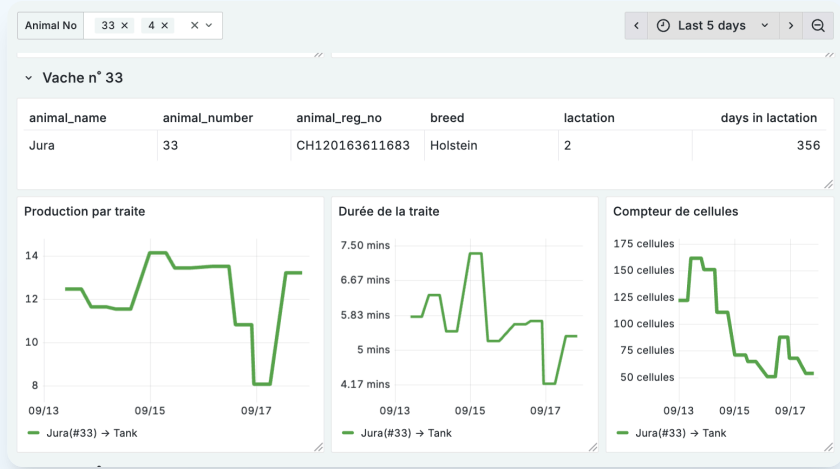
- `/metrics` — live data
- `/historical-metrics` — backfill into VictoriaMetrics

```
delpro_milk_last_somatic_cell{
  animal_number="77",animal_name="Lovely",
  breed="Holstein",destination="Tank",
  lactation="1"} 34
delpro_milk_last_somatic_cell{
  animal_number="78",animal_name="Jessie",
  breed="Holstein",destination="Divert1",
  lactation="3"} 265
delpro_milk_last_yield_liters{
  animal_number="1",animal_name="Jade",
  breed="Holstein",destination="Tank",
  lactation="3"} 14.3
delpro_milk_last_yield_liters{
  animal_number="9",animal_name="Marine",
  breed="Montbéliarde",destination="Tank",
  lactation="1"} 13.2
```

1. https://github.com/clementnuss/delpro-exporter

Grafana Dashboard

Production trends and analytics

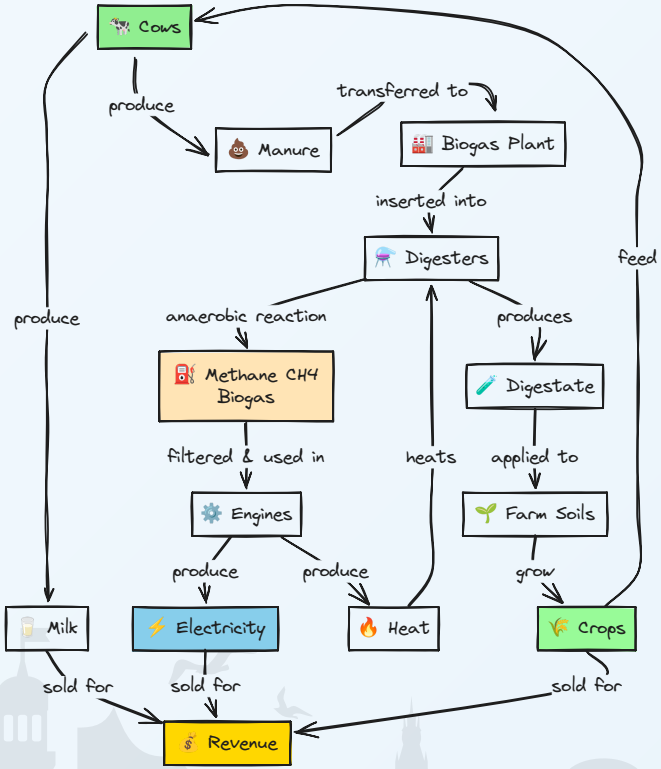


Individual cow stats - Jura (#33)

The Biogas Cycle

A complete circular economy on the farm:

- Cows eat crops → produce manure
- Manure produces methane (CH_4)
- Methane fuels engines → electricity + heat
- Residual heat heats the digesters
- … and dries crops
- Digestate fertilizes crops



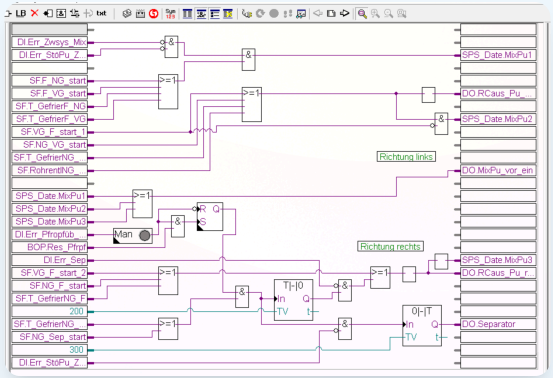
Biogas Plant Operations

Digesters and feed mixer

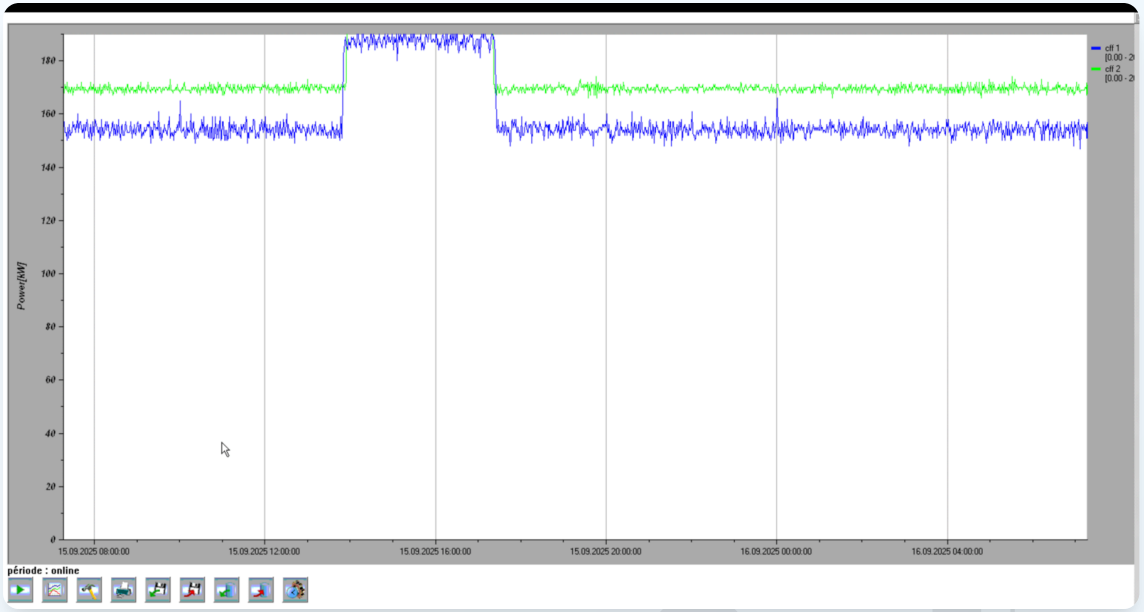
Control systems & monitoring

Engine overview

SAIA PCD Programmable Control Device — the biogas plant's controller



SAIA PCD Controller GUI



Historical Data Visualization

Legacy Control Interface

- Windows-based
- Manual data export only
- Limited remote capabilities (VNC only)

SAIA EtherSBus Protocol

SAIA PCD Communication

- Proprietary EtherSBus protocol
- Serial or Ethernet (UDP, port 5050)

Existing Python Library

- `digimat-saia` implements EtherSBus

```python
# SAIA EtherSBus communication
from digimat_saia import SAIANode

# Create local node and declare remote server
node = SAIANode(253)
server = node.servers.declare('192.168.1.100')

# Read biogas parameters from remote PCD
gas_flow = server.registers[1000].float32
temperature = server.registers[1001].float32
power_output = server.registers[1002].float32
pump_running = server.flags[10].value
```

Problem: I don’t want to implement a Prometheus exporter in Python again.

gRPC Bridge & Go Exporter

gRPC Service (Python)

- Wraps `digimat-saia`
- ConnectRPC framework (CNCF sandbox)
- Reads/writes registers & flags

Prometheus Exporter (Go)

- Polls the gRPC service periodically
- Uses `VictoriaMetrics/metrics` library

```
biogaz_poids_balance_kg 13467
biogaz_pression_stockage_gaz_mbar 0.8393750190734863
biogaz_puissance_ccf1_echelonnee 190
biogaz_puissance_ccf2_echelonnee 200
biogaz_reservoir_separateur_vide 1
biogaz_retour_auto_brasseur_fermenteur1_inf 1
biogaz_retour_auto_brasseur_fermenteur1_sup 1
```

Both open source: saia-grpc-service[1], saia-pcd-exporter[2]

1. https://github.com/clementnuss/saia-grpc-service
2. https://github.com/clementnuss/saia-pcd-exporter

Biogas Plant Dashboard

Real-time biogas plant monitoring and analytics

Electric Fence Control

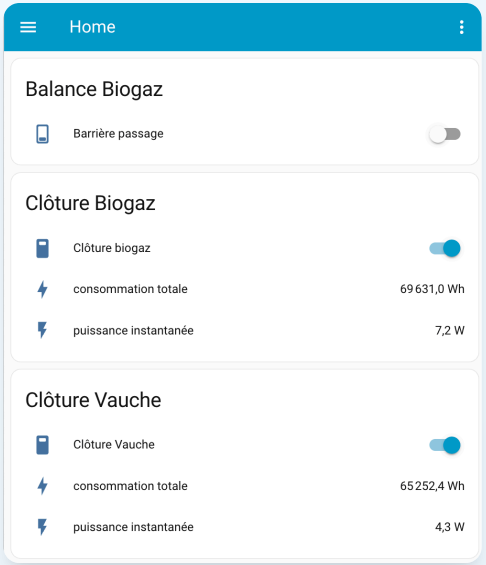
Remote Fence Management

- Shelly relays for power control
- Kubernetes-hosted MQTT server
- Home Assistant integration

Use Cases

- Repairs / emergency fence shutdown

Shelly 1PM Gen3 MQTT relay



Home Assistant fence control

Shelly → MQTT ← Home Assistant

Milk Vending Machine

Measuring Milk Levels

- No level sensor in the tank
- LiDAR measures the milk surface
- Alerts when the machine is empty

Tank Geometry: 1cm height = 1 liter

$$1L = 10^{-3}m^3 = \pi \cdot r^2 \cdot 10^{-2}m$$

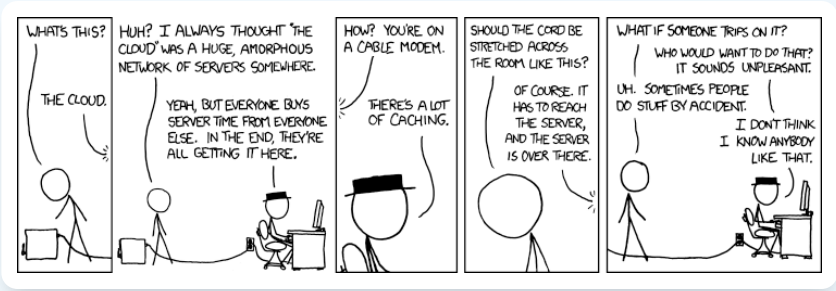
$$r = \sqrt{\frac{10^{-1}}{\pi}} = 0.178m = 17.8cm$$

Milk vending machine monitoring dashboard

Self-Hosted Services

A nice side-effect of running k8s: self-hosting regular apps is easy

- **InvoiceNinja**[1] — invoicing: silage work, hay sales, crop drying
- **Paperless-ngx**[2] — PDF archival & document management
- **PocketID**[3] — OIDC SSO for all of the above



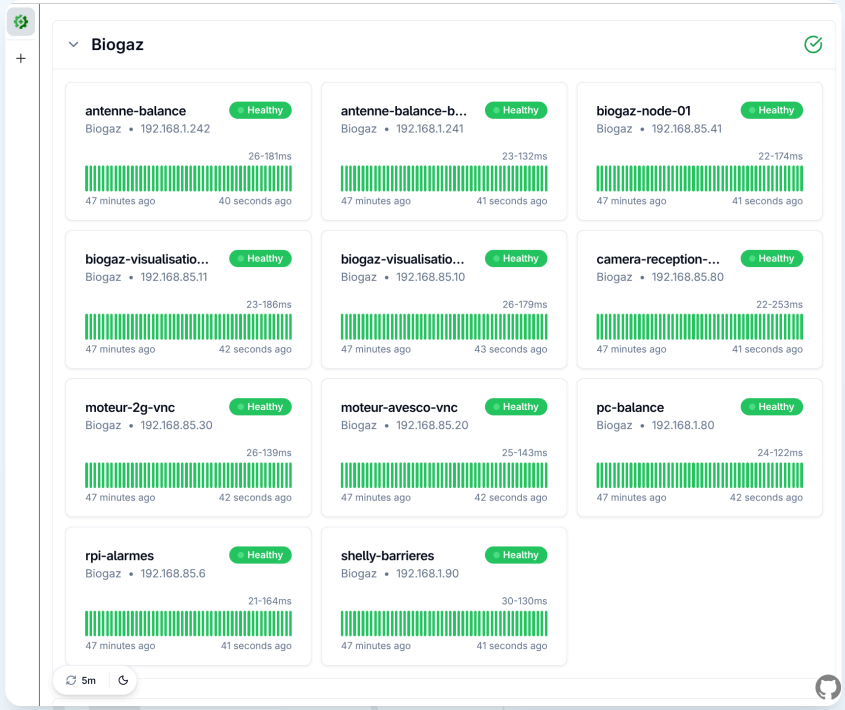
xkcd 908 — "The Cloud"

1. https://invoiceninja.com/
2. https://docs.paperless-ngx.io/
3. https://github.com/pocket-id/pocket-id

Uptime Monitoring with Gatus

Gatus[1] monitors all farm devices:

- Routers, antennas, peripherals
- HTTP, TCP, ICMP checks
- Status page + alerts



1. https://github.com/TwiN/gatus

Live Demo

Real Farm Data

- Current milk production
- Biogas plant performance
- Electric fence status

Security Considerations

- One IT guy
- Managing electric fences
- Remotely controlling livestock barriers
- What could possibly go wrong?

Jurassic Park[1]

1. https://www.jurassicsystems.com/

Lessons Learned

What Worked

- On-premises cost savings
- Talos Linux stability
- GitOps workflow

Challenges

- Legacy system integration
- Reverse engineering

Thank You!

Questions?

Cloud-native principles work everywhere, even on Swiss farms!

The farm that started it all

clement.n8r.ch

From Kubernetes to Cows -
Happy to discuss both!