🔧 The complete build guide — parts to live data

Build your own HiveHub.

Everything you need to build a HiveHub for **up to 16 hive scales**: the full parts list with price estimates, the PCBs, wiring notes, firmware flashing with VS Code + PlatformIO, scale calibration and the self-hosted backend. Roughly **€90–120 for a dual-scale build** (plus load cells of your choice), a weekend of soldering-iron-free assembly, and no subscription — ever.

The recommended setup

One board, off-the-shelf modules on pin headers, no SMD soldering.

🧠

Scale Module V0.4 + XIAO ESP32-C6

The central PCB. It carries the **XIAO ESP32-C6** and off-the-shelf modules on headers: **NAU7802** load-cell ADC (2 scales), **MAX17048** battery gauge, **TPS63020** buck-boost, **TP4056** USB-C charger, **DS3231 RTC**, **micro-SD** and **SHT40**.

⚖️

Optional: up to 16 scales

Add the **NAU7802 breakout PCB** with its **TCA9548A** I2C multiplexer and up to **8× NAU7802** modules — 16 scales in total on one HiveHub. (When the mux is used, no NAU7802 is installed on the main PCB — see the wiring notes below.)

☀️

Optional: off-grid power

A LiPo or 18650 pack, a **CN3791** MPPT solar charger and a 6 V panel keep a HiveHub running unattended; the MAX17048 reports the battery state with every measurement.

The guide below walks through the whole build in six steps. Prefer paper? Download every step as a nicely formatted PDF.

Step 1 — Order the parts

The bill of materials for **one HiveHub**. Prices are rough 2026 ballpark figures (AliExpress / Seeed, excl. shipping) — they fluctuate, so treat them as orientation, not a quote. AliExpress links are affiliate links and support the project.

COMPONENT	AMOUNT	EST. PRICE	NOTE
CORE ELECTRONICS — ≈ €47			
Seeed Studio XIAO ESP32-C6 (3-pack)	1 pack	≈ €15	One HiveHub uses one board (≈ €5 each); keep the spares for HiveInside sensors or the next hub.
External antenna for the XIAO ESP32-C6	1	≈ €3	u.FL 2.4 GHz antenna — much better range from inside a plastic box.
NAU7802 load-cell ADC module	1 (up to 8)	≈ €3	One module reads **2 scales**. Dual-scale build: 1 on the main PCB. 3+ scales: up to 8 on the breakout PCB — and **none** on the main PCB.
TCA9548A I2C multiplexer	0–1	≈ €2	0 for a dual-scale build, 1 for 3+ scales (installed on the NAU7802 breakout PCB).
TPS63020 buck-boost module	1	≈ €3	Battery or 5 V input → stable 3.3 V rail.
Micro-SD card slot module	1	≈ €1.50	Local cache and measurement backup.
Micro-SD card	1	≈ €2	256 MB is fine.
SHT40 module	1	≈ €2	Ambient temperature & humidity. Wired modules usually carry 4.7 kΩ I2C pull-ups — see the pull-up note in step 3.
DS3231 RTC module	1	≈ €2	Timekeeping without NTP. **Remove its 4.7 kΩ I2C pull-up resistors** — see the pull-up note in step 3.
USB-C LiPo charger (TP4056)	1	≈ €1.50	Charges the battery over USB-C.
IP65 push button	1	≈ €2	Setup / provisioning button, mounted through the enclosure.
Aluminium U-profile 50×25×3 mm, 400–450 mm	1 per scale	≈ €10	Scale frame — local metal shop or hardware store.

HEADERS & HARDWARE — ≈ €17			
PCB standoffs M3 (set)	1 set	≈ €3	
2-pin female header	8	≈ €2	
4-pin female header	8	≈ €2	
6-pin female header	3	≈ €1.50	
7-pin female header	2	≈ €1.50	You may use 6-pin headers for the XIAO ESP32-C6 and leave 5V and D0 unconnected.
2-pin screw terminal	1	≈ €0.50	
4-pin screw terminal	1	≈ €0.50	
2.54 mm male pin header (1×3)	1	≈ €1	The power-source selection jumper.
Wire crimps for SHT40 + scale	1 set	≈ €3	
Cable (sensor + load-cell wiring)	as needed	≈ €5	
LOAD CELLS — PICK ONE OPTION (2 PER SCALE PLATFORM)			
TAL203	2	≈ €10	Cheap, works just fine.
Mavin NA2	2	≈ €30	Best medium-range performance; dimensions identical to the Bosche H30A.
Bosche H30A	2	≈ €90	Best name-brand option.
ENCLOSURE — PICK ONE (150×150 TO 200×200 MM, PLASTIC; BIGGER = EASIER WIRING)			
Very nice box	1	≈ €15	
Standard box	1	≈ €8	
BATTERY — PICK ONE OPTION			

Budget 10,000 mAh LiPo	1	≈ €20	
18650 cells + holder	2–4 + 1	≈ €14	Two cheap 18650 in parallel give roughly 2–4 weeks of runtime.
SCALE CONNECTORS — PICK ONE OPTION			
SP13 5-pin connectors	1 per scale	≈ €2 each	Waterproof, pluggable — recommended.
PG7 cable glands (set)	1 set	≈ €5	Budget alternative — but removing a single scale becomes a hassle when it cannot simply be unplugged.
OPTIONAL — OFF-GRID & EXTRAS			
CN3791 MPPT solar charger, 6 V	1	≈ €4	Needed to charge the LiPo from a solar panel.
Solar panel 6 V / 4.5 W	1	≈ €8	
MAX17048 fuel gauge	1	≈ €2	Battery voltage / state-of-charge with every measurement; module carries 10 kΩ I2C pull-ups.
USB-C passthrough with cover	1	≈ €4	External charging port in the enclosure wall, in case solar fails.
Internal USB-C cable (20 cm, flat)	1	≈ €2	Connects the passthrough to the TP4056.
HolyIot 25015 in-hive BLE sensor	1 per hive	≈ €10	HiveInside and HiveHeart provide more data, but the 25015 is a cheap, ready-to-use (add casing) in-hive sensor.

💰 **What does a build cost?** Core electronics + hardware land around **€65**. A typical dual-scale build with TAL203 load cells, a standard box and two 18650 cells comes to roughly **€90–120**; going off-grid with solar adds about **€15**. Each additional scale afterwards costs about €10–95 depending on your load-cell choice — the electronics are already there.

🟩 **PCBs are ordered separately** (step 2) and are deliberately not in the BOM: their price is almost entirely shipping — 5 boards cost around **€5 + shipping** at the usual fabs.

Step 2 — Order the PCBs

Ready-to-upload fabrication files (Gerbers + drill, zipped) are included in the repository for every board. Upload the zip at any PCB fab (JLCPCB, PCBWay, Aisler, ...), keep the default settings, and order — 5 boards cost around €5 plus shipping.

🟩 Scale Module V0.4 (required)

The central board — carries the XIAO ESP32-C6 and every module from the BOM on pin headers.
pcb-design/scale module/esp32-c6 →

🟨 NAU7802 breakout PCB v0.2 (3+ scales)

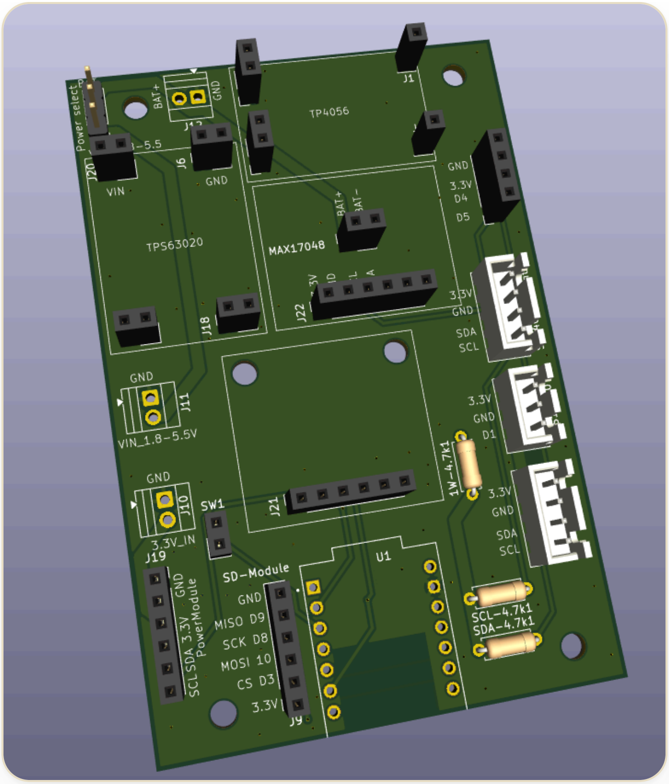
The 16-scale expander: TCA9548A mux + up to 8× NAU7802. Only needed for more than 2 scales; connects to the Scale Module's I2C expansion header.
pcb-design/NAU7802 breakout pcb →

📂 All boards & fabrication files

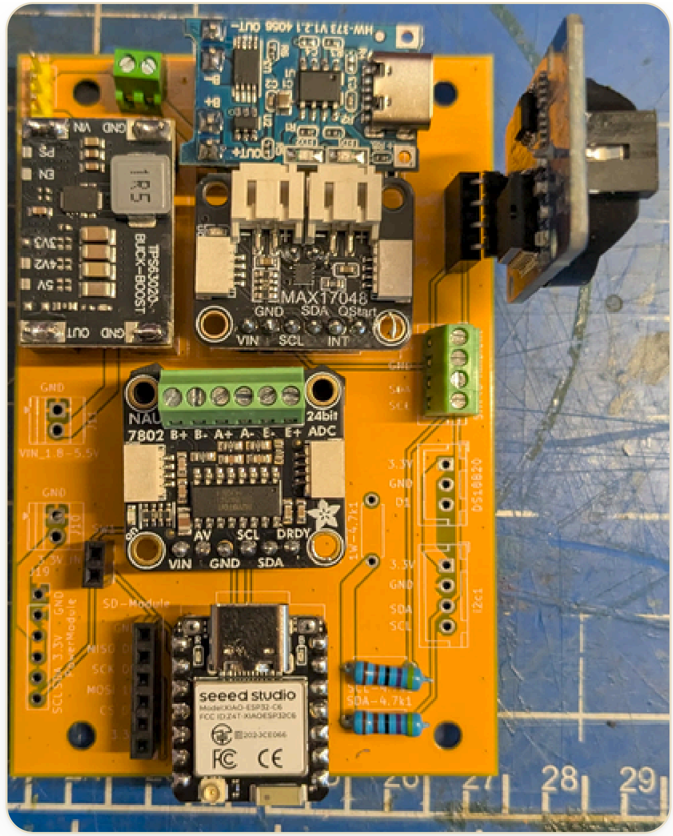
KiCad projects and `fabrication/` outputs for every board, plus assembly notes.
pcb-design/README.md →

Step 3 — Assemble & wire

With the Scale Module PCB the wiring is mostly done for you: solder the female headers onto the board, plug the modules in, connect load cells and battery to the screw terminals — done. That is why there is **no full hand-wiring diagram**: the PCB *is* the wiring diagram. The collapsed pin list at the bottom covers the rare fully-hand-wired build.



Scale Module V0.4 — module placement. Every footprint is labelled on the silkscreen.



An assembled V0.4 board. More photos live in pcb-design/ in the repository.

⚡ The power jumper

The 1×3 pin header on the Scale Module selects the power source. Set the jumper to the **top position when powered from a battery** (through the TPS63020 buck-boost) and to the **bottom position when powered from a 5 V power supply**. Never bridge all three pins.

🔀 Mux rule — where the NAU7802 goes

The NAU7802 has a fixed I2C address, so two of them can never share one bus. **Dual-scale build:** one NAU7802 on the main PCB, no mux. **3–16 scales:** all NAU7802 modules (up to 8) go on the NAU7802 breakout PCB behind its TCA9548A mux — and **no NAU7802 may be installed on the main PCB**, or every read would collide with the muxed chips.

I2C pull-ups — avoid bus brownouts

Most I2C modules ship with their own pull-up resistors, and they add up in parallel: NAU7802, MAX17048 and mux modules generally carry **10 kΩ** pull-ups, while RTC modules and wired SHT40 breakouts often carry **4.7 kΩ**. Too many in parallel pull the bus so hard that the lines can no longer be driven low reliably — the bus "browns out" and devices drop off. **Remove the 4.7 kΩ resistors from the RTC module and do not populate additional pull-ups on the PCB.** The remaining module pull-ups are plenty.

Scales & sensors

Bolt two load cells per platform onto the aluminium U-profile and wire them to the NAU7802 screw terminals (E+, E−, A+, A−). Route the DS18B20 probe and the SP13 scale connectors through the enclosure wall, mount the SHT40 outside the box (shielded from rain and sun), install the IP65 button, and insert the RTC coin cell before closing up. Keep load-cell wiring away from the switching regulator.

Hand-wiring reference — which pin connects to what (only needed without the PCB)

The PCB is the recommended way to build a HiveHub — this list exists for repairs, breadboard experiments and fully hand-wired builds. All XIAO ESP32-C6 pins are the 11 front-header pins (D0–D10).

Power path

FROM	TO	NOTES
Solar panel (optional)	CN3791 MPPT input	6 V panel; CN3791 output goes to the battery
USB-C (external or passthrough)	TP4056 input	Charges the same battery
Battery + / −	TPS63020 VIN / GND	LiPo or 18650 pack
TPS63020 VOUT (set to 3.3 V)	XIAO 3V3 pin + all module VCC pins	One regulated 3.3 V rail for everything
Battery +	MAX17048 BAT/CELL	Fuel-gauge sense connection (optional)
Alternative: regulated 5 V PSU	XIAO 5V pin	Grid-powered builds — skip battery, charger and buck-boost
All grounds	Common GND	Every module, the button and the load-cell shields share one ground

Signals (XIAO ESP32-C6)

SIGNAL	XIAO PIN	GPIO	CONNECTS TO
I2C SDA	D4	22	NAU7802 (0x2A) *or* TCA9548A (0x70), DS3231 RTC (0x68), SHT40 (0x44), MAX17048 (0x36), BeeCounter (0x30/0x31)
I2C SCL	D5	23	Same devices — shared bus clock
DS18B20 1-Wire	D1	1	All in-hive temperature probes in parallel; one 4.7 kΩ pull-up to 3.3 V for the whole bus

SD CS	D3	21	SD module chip select
SD SCK	D8	19	SD module clock
SD MISO	D9	20	SD module data out
SD MOSI	D10	18	SD module data in
Setup button	D2	2	Button to GND (internal pull-up)
(free)	D0	0	Unused
Load cells	—	—	Each platform's cells → one NAU7802 channel (E+, E−, A+, A−); one NAU7802 = 2 channels = 2 scales
TCA9548A downstream (3+ scales)	—	—	SD0–SD7 / SC0–SC7 → one NAU7802's SDA/SCL per mux channel

Full details, addresses and the legacy 30-pin ESP32 map: docs/wiring.md.

Step 4 — Flash the firmware (VS Code + PlatformIO)

Condensed but complete — from a blank machine to a flashed board in about 15 minutes (most of it download time).

1

Install the tools

Install VS Code, open its **Extensions** panel (Ctrl/Cmd+Shift+X), search for **“PlatformIO IDE”** and install it. Wait until PlatformIO finishes its first-time setup (status bar stops spinning), then restart VS Code.

2

Get the code & open the project

```
git clone https://github.com/MacNite/HiveHub.git
```

In VS Code: **File → Open Folder…** and select the `HiveHub/firmware` folder (the folder that contains `platformio.ini` — not the repository root). PlatformIO will detect the project and install the toolchain and libraries automatically on the first build.

3

Optional: pre-seed a config

You can flash completely unconfigured and do everything on the device's provisioning portal later (step 6). To pre-seed Wi-Fi, backend and hives instead, generate a `secrets.h` with the device config tool and save it as `firmware/include/secrets.h` (it is gitignored — never commit it).

4

Build & upload

Connect the XIAO ESP32-C6 via USB-C. In the PlatformIO toolbar (bottom status bar), pick the **`xiao_esp32c6`** environment, then hit **Upload** (→ arrow). Or from a terminal:

```
cd HiveHub/firmware
pio run -e xiao_esp32c6 --target upload
pio device monitor   # serial log, 115200 baud
```

If the upload cannot find the port: hold the XIAO's **BOOT** button while plugging in USB, then retry. On Linux add yourself to the `dialout` group.

5

Verify

The serial monitor should show the boot banner, the antenna selection, the I2C devices it found and the first measurement cycle. Sensors you have not connected are simply reported as not present — nothing crashes.

Step 5 — Run the backend

The backend is a FastAPI + PostgreSQL stack shipped as a Docker Compose file. It runs on anything that runs Docker — a home server, NAS, Raspberry Pi ≥ 4 or a small VPS.

1

Prerequisites

A host with Docker + the compose plugin installed, and — for devices in the field — a domain with **HTTPS** (the firmware verifies TLS; a reverse proxy with a Let's Encrypt certificate is the simplest setup).

2

Configure

```
git clone https://github.com/MacNite/HiveHub.git
cd HiveHub/docker
cp .env.example .env
```

Edit `.env` and set at least:

- `API_KEY` — master/admin key (`openssl rand -hex 32`)
- `POSTGRES_PASSWORD` — database password
- `HIVEPAL_SERVICE_API_KEY` / `HIVEPAL_JWT_SECRET` — only if you use HivePal
- `PUBLIC_BASE_URL` — your public HTTPS URL (used for OTA download links)
- `ENABLE_LOCAL_DASHBOARD=true` — for the built-in login-free dashboard
- volume paths for the database and firmware directories

3

Start it

```
docker compose up -d
docker compose logs -f api   # watch the first start
```

The API listens on port `31115`. It auto-creates the database schema on first start — no manual migrations needed. Check `http://<host>:31115/health` and the interactive docs at `/docs`.

4

Expose it with HTTPS

Put a reverse proxy (Caddy, nginx, Traefik, NPM) in front of port 31115 with a valid certificate and point `API_BASE_URL` on the device at `https://your-domain.example`. NTP (UDP 123) must be reachable from the device's network so it can validate the certificate.

Detailed guides: docker-install.md · truenas-install.md

5

Watch the data

Built-in dashboard (no account): open `http://<host>:31115/dashboard` — charts, device config, OTA and calibration (demo). **HivePal:** claim the device by its claim code for accounts, sharing and mobile access.

Step 6 — Configure & calibrate

Everything after flashing happens on the device's own Wi-Fi provisioning portal — no reflashing, no app required.

1

Open the provisioning portal

Short-press the setup button. The device opens the `HiveHub-Setup-XXXX` Wi-Fi access point — connect to it and the portal appears (or open `http://192.168.4.1`). Set Wi-Fi credentials, the backend URL and API key, then add your hives: the portal auto-detects every NAU7802 channel and DS18B20 probe and lets you pair BLE in-hive sensors per hive. Settings persist on the device and survive OTA updates.

2 Calibrate each scale (tare + known weight)

1. In the portal, open **Scale calibration** — every configured channel shows its live reading.
2. With the platform **empty**, press **Tare (zero)**.
3. Place a **known weight** (a 10–20 kg dumbbell plate or a canister of water you weighed on a kitchen scale works well — the heavier, the more accurate), type its mass in kg and press **Set weight**.
4. Verify: remove the weight (reading returns to ~0.00 kg), put it back (reading shows the known mass). Each change is saved to the device immediately and reported to the backend on the next upload.

Calibrate *after* final mechanical assembly — bolting the frame onto the hive stand changes the zero point. Re-tare at the start of the season. Remote recalibration later works from the dashboard/HivePal without a site visit (calibration mode).

3 Done — first data

Reboot out of the portal (“Save and reboot”). The device connects to your Wi-Fi, uploads its first measurement with its claim code, and shows up in the dashboard. From here on it wakes on its interval, measures, uploads and deep-sleeps.

⬇️ **Download all steps as PDF** 🧭 **Hardware helper**

⚙️ **Device config tool** 💬 **Stuck? Open an issue**