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Solar-Powered Dewatering in Copper Mining: Design & OPEX Implementation

Background & Challenges: Mine dewatering is essential but energy-intensive. Energy can represent ~15–40% of a mine's operating costs [1], and pumping often relies on diesel generators or grid power with costly backup. In practice, many sites currently use diesel-powered pump skids (self-priming or submersible) to handle rainfall and groundwater [2]. These generators run continuously, consuming large volumes of fuel and requiring frequent service. Transporting diesel to remote pits is logistically complex and expensive. Diesel engines also emit CO_2, NOx and particulates, creating large carbon footprints. (For example, Allied Pumps notes that hybridizing with batteries – described below – is often pursued to avoid "burning excess fuel" in traditional setups [3] [4].) Moreover, unplanned power interruptions can halt pumps and risk flooding. In short, the **current system** leads to **high OPEX, heavy emissions, and complex maintenance** (with many shutdowns for refueling and engine service) [2] [5].

Key Challenges: - **High fuel and power costs:** Continuous generator use drives OPEX.
- **Emissions:** Diesel engines emit CO_2 and pollutants; mining aims to cut carbon.
- **Maintenance and Reliability:** Engines need oil/filter changes, and pumps must be lifted/serviced often. Unreliable grid or breakdowns threaten production.
- **Remote Operation:** Isolated mines lack grid power. Installing lines is costly, so local generation is needed [6].

Proposed Solar Dewatering System: We recommend a **hybrid solar PV pumping solution under an OPEX (PPA/lease) model**. This uses a photovoltaic array to power dewatering pumps, supplemented by intelligent controls, battery storage, and diesel backup to ensure 24/7 operation. Key elements include:

- **High-Efficiency PV Array:** A ground-mounted field of solar modules sized to match daily pumping demand. Modern panels (15–20%+ efficiency) can deliver abundant power on sunny days. Solar PV is now among the cheapest power sources (with recent LCOEs below diesel in many regions [7]).
- **Electric Submersible Pumps with VFD:** Use water-cooled, corrosion-resistant submersible pumps or surface pump skids driven by AC motors and variable-frequency drives (VFDs). VFDs allow soft start, level control and "sleep" mode. For example, Danfoss notes that VFDs enable auto shutoff when the target water level is reached, and restart on rising levels [8] [9]. This avoids throttling or valves, cutting energy waste.
- **Maximum-Power-Point Tracking (MPPT):** The solar inverter (or a dedicated pump controller) will incorporate MPPT to extract maximum power from the array at all times, optimizing pump efficiency. Controllers can switch between solar and backup sources seamlessly.
- **Energy Storage (Batteries):** A battery energy storage system (BESS) buffers solar variability and covers night-time or low-sun periods. As Allied Pumps explains, hybrid systems "combine battery storage with traditional diesel engines," so the diesel generator is idle unless batteries are depleted [4]. Batteries allow pumps to run after dusk or through clouds without immediate diesel use.
- **Diesel/Hybrid Backup:** For ultimate reliability, include a small diesel generator (or grid tie-in, if available) that automatically starts when solar + battery cannot meet demand. In practice, the diesel

only runs to recharge batteries or on unusually high loads. Allied's **GENVAR-BLUE™** generators, for example, throttle the engine to optimal load and store unused energy in batteries [4]. This hybrid approach drastically cuts fuel consumption and emissions: the engine only runs at peak efficiency.
- **Smart Monitoring & Control:** Integrate flow meters, level sensors and a PLC/SCADA system. Allied's case study shows each pond pump with its own flow and level transmitter reporting to the mine SCADA [10]. Remote telemetry (e.g. Allied's NODEM system) provides 24/7 data on water levels, pump status, battery state and fuel [11]. Predictive alerts can be generated (e.g. low fuel or seal wear) so maintenance is done proactively. Automation allows setpoint control: pumps can automatically switch on/off with water levels or schedules, without operator intervention [9] [11].

A hybrid pumping unit (shown) combines a diesel generator, battery bank and pump under solar power management. Advanced controllers allow the diesel to run only when needed, storing surplus solar energy in batteries [5] [4].

Commercial (OPEX/PPA) Model: To avoid upfront CapEx, a third-party vendor would design, build and own the system, charging the mine either a flat monthly fee or per-volume of water pumped (PPA). NREL data indicate mines often use in-house renewable projects, but about 15% of mining renewables today are contracted through external PPAs or leases [12]. Under the contract, the vendor guarantees performance (energy delivered/pumped) and handles all O&M. This aligns with the example of Boliden Garpenberg's service agreement with Sulzer, where the supplier maintained the entire pump fleet [13] [14] (though in that case it was owner-run rather than PPA). In our model, the vendor is fully responsible: **they supply and maintain the PV array, pumps, controls, and backup.** The mine essentially "buys" reliable dewatering service or power from them, eliminating fuel logistics and up-front costs. This leverages proven contracting in mining: for example, Northam Platinum signed an 80 MW solar PPA in 2024 to power its Zondereinde mine, cutting carbon by ~22% [15].

Implementation Steps

1. **Site Assessment:** Survey the mine's dewatering requirements (flow rate and head) and solar resource. Model the daily water volume to be pumped and hours of sunlight. Identify locations for PV arrays (flat area or trackers) and pump installations (e.g., top of pit or pond rim).
2. **System Design:** Engineer the pump and PV system. Choose an energy-efficient pump (submersible or surface) sized for the required lift. Specify an inverter or pump controller with MPPT. Calculate PV array size to meet average demand plus buffer (e.g. 20% oversizing). Decide battery capacity for desired autonomy. Design mounting (fixed or tracker) for panels. Include wiring, switchgear and an automatic transfer scheme to trigger diesel/generator or battery when solar is low.
3. **Contracting:** Issue RFP to vendors experienced in solar pumping. The tender should specify performance (e.g. minimum daily volume pumped), availability guarantees, and ownership (PPA or lease structure). Negotiate terms like power price or fee structure. Ensure vendor will provide long-term O&M under contract.
4. **Procurement & Construction:** The vendor procures high-efficiency PV modules, inverters/controllers, batteries, pumps, genset, and other hardware. Construction proceeds with civil work for PV supports, pump mounting, and cabling. If possible, factory-test the pump-pump-controller system (as Allied did with AS2417 certification) to verify integration [16].
5. **Installation:** Install the PV field, battery container, pump wells, and electrical connections. Integrate the system into the mine's SCADA and local controls. Mount sensors (flow meters, level switches) and configure the telemetry link.

6. **Commissioning:** Perform full system tests: check PV output, pump operation under various conditions, failover to battery/genset, and remote monitoring. Allied's project was "fully commissioned on site" after factory testing [16]. Conduct these tests in the field, adjusting MPPT setpoints and safety interlocks.
7. **Operations & Maintenance:** Handover control to the vendor's O&M team. The vendor remotely monitors performance (via the telemetry dashboard) and schedules maintenance. Routine tasks include cleaning panels, inspecting pump/motor, and servicing the diesel engine at extended intervals. The mine focuses on receiving pumped water, while the vendor guarantees uptime.

Efficiency, Benefits and Use Cases

- **Energy and Cost Efficiency:** Solar dewatering eliminates fuel costs (solar "fuel" is free) and can dramatically cut energy OPEX. Studies show that solar pumps emit 95–97% less greenhouse gas per kWh than grid or diesel pumps [17]. Without needing fuel trucks, mines save on logistics and labor. Electric pump systems also have lower maintenance: no oil/filter changes, no engine wear from light-load "glazing" [4]. As Danfoss notes, electric skids quickly pay back higher initial cost through these savings [18].
- **Reliability:** Abundant sunshine offers very reliable daytime power. In many areas the solar resource is predictable; connectivity to unreliable grids is bypassed. During sun hours the pump can run 100% on PV. At night or during extended cloud cover, stored battery energy (and if needed the diesel backup) covers the load, ensuring **24/7 pumping**. The risk of an unplanned outage is greatly reduced compared to generator-only operation. In fact, remote rural users find solar pumps far more reliable than erratic grids [19].
- **Environmental Impact:** By displacing diesel, the system cuts carbon and pollutants immediately. For example, Allied reports that hybrid solutions "consume significantly less fuel" and thus output much less CO_2 and NOx [5]. Over time, the mine earns carbon credits and meets ESG targets.
- **Use Cases:** Solar dewatering is analogous to the very successful use of solar pumps in other water-limited settings. For instance, solar irrigation pumps have boomed in agriculture: India grew from ~5,000 solar pumps in 2012 to ~170,000 today as costs fell [20]. Mines, though pumping contaminated water, have similar needs. In Spain, a remote slate mine deployed a solar pump for environmental water control, avoiding a costly grid link [6]. Technology vendors now offer PV-diesel hybrid pump trailers (e.g. Allied's GENVAR-BLUE) designed for mining dewatering [21]. On a larger scale, mining giants are embracing solar: Northam's 80 MW PPA at Zondereinde is projected to cut the mine's carbon intensity by ~22% [15], illustrating how solar integrates into mining power.

Conclusion: Implementing solar-powered dewatering under an OPEX model will cut fuel and power costs, reduce emissions, and simplify operations. By engaging a specialist vendor via PPA/lease, the mine gains reliable, around-the-clock pumping with no upfront CapEx. The system leverages proven technology (PV modules, high-efficiency pumps, VFDs, batteries) and smart controls. Real-world cases show solar pumps can serve remote water needs cleanly [6] [17]. With thorough design and staging, the mine can transition to this eco-friendly dewatering solution that aligns with both economic and sustainability goals.

Sources: Recent studies and industry sources on solar pumping and mining dewatering [1] [2] [5] [4] [22] [6] [8] [9] [12] [23] [15].

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