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Wellbore Positioning Technical Section

The Industry Steering Committee on
Wellbore Survey Accuracy (ISCWSA)

Redefining Well Intercepts: First Field Deployments of a Next Generation Active Magnetic Ranging While Drilling System

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ERDOSMILLER

GUNNAR
ENERGY SERVICES

Speakers

- David Erdos – Magnetic Ranging Product Line Manager, Partner at Erdos Miller
- Clinton Moss – CEO & Founder at Gunnar Energy Services
- Georgy Rassadkin – Ranging Domain Manager at Gunnar Energy Services

Introductions

- Erdos Miller - develops MWD technology, primarily directional sensors and surface systems
- Gunnar Energy Services – magnetic ranging service and technology provider
- Collaboration started in 2020 with the goal of replacing wireline ranging technology with while drilling ranging technology

Agenda

- Challenges with wireline ranging
- Challenges with while drilling solutions
- System design – sensor selection and noise floor
- Rotating magnet field test results
- Current injection field test results
- Next steps

Challenges with Wireline Ranging

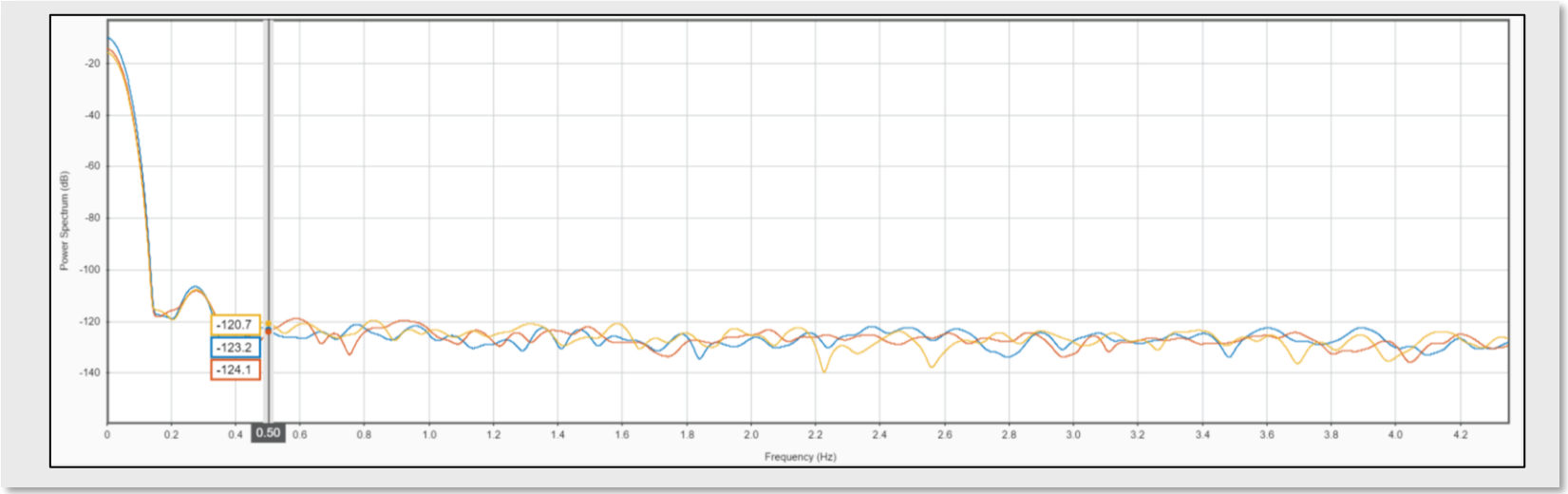
- Open hole wireline ranging runs take time… a lot of time (and $$$)
  - Each round trip ~24-48 hours
- Open hole wireline is risky from a safety perspective
  - Hole stability
  - Risk of getting stuck
  - Well control / swabbing
- Manual review and processing of data

Challenges with While Drilling Solutions

- Limited communication bandwidth available with mud pulse telemetry
  - Solution: compute the ranging results downhole and telemeter the computed result rather than the raw data
- Large number of high-frequency magnetometer samples need to be stored and processed downhole
  - Solution: develop Cortex downhole processing module
- Minimize magnetometer circuit noise floor to maximize range
  - Solution: optimized the magnetometer electronics to achieve a 10x reduction in our magnetometer noise floor
- Ranging signal noise (stick slip with rotating magnet)

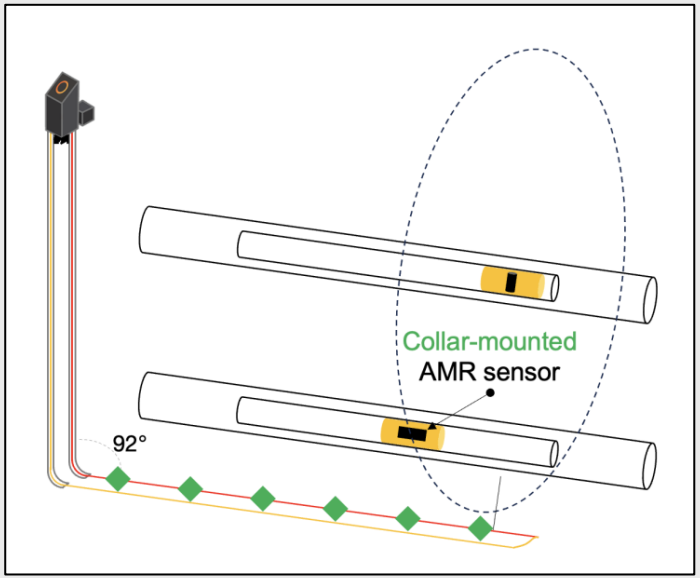
Magnetometer Noise Floor

- Minimizing the magnetometer noise floor is critical to achieving the maximum possible range



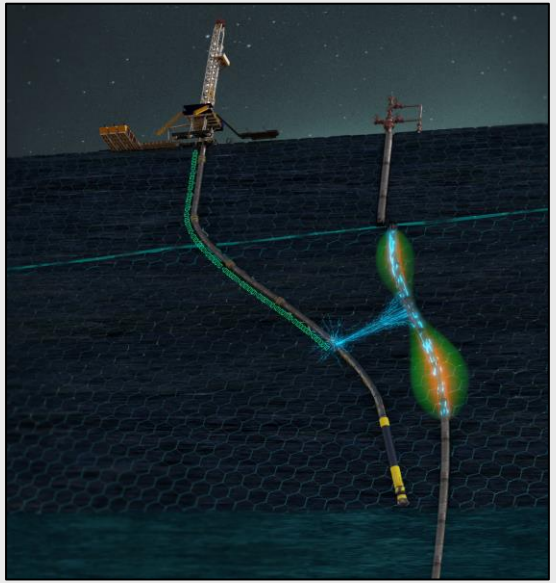
Field Test Results

Rotating Magnet

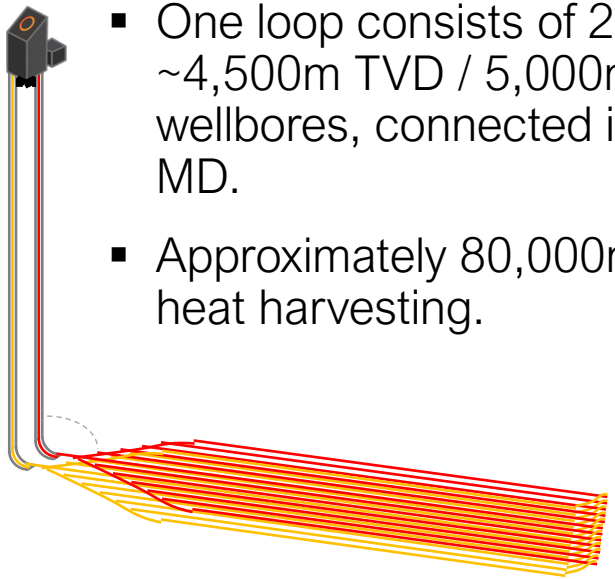


Geothermal project in partnership with Eavor

Access Independent Active Ranging



Rotating Magnet AMR While Drilling



- One loop consists of 2 vertical wells at ~4,500m TVD / 5,000m MD and 24 lateral wellbores, connected in 12 pairs at ~8,000m MD.
- Approximately 80,000m closed lateral loop for heat harvesting.

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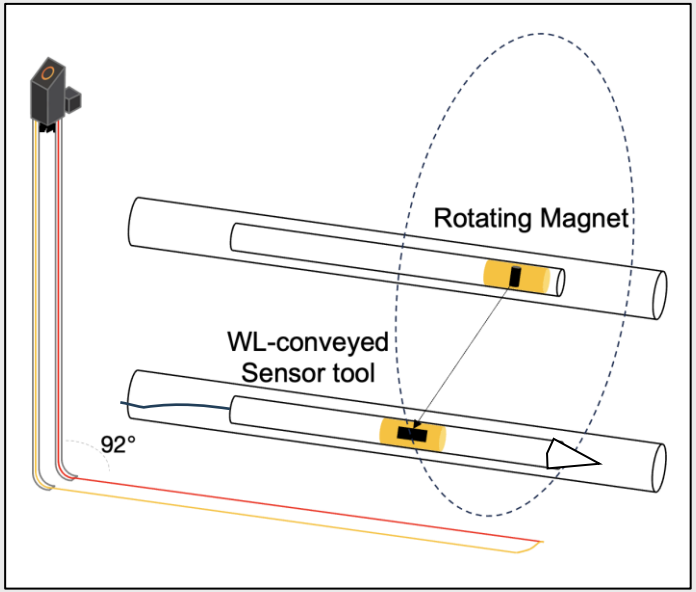
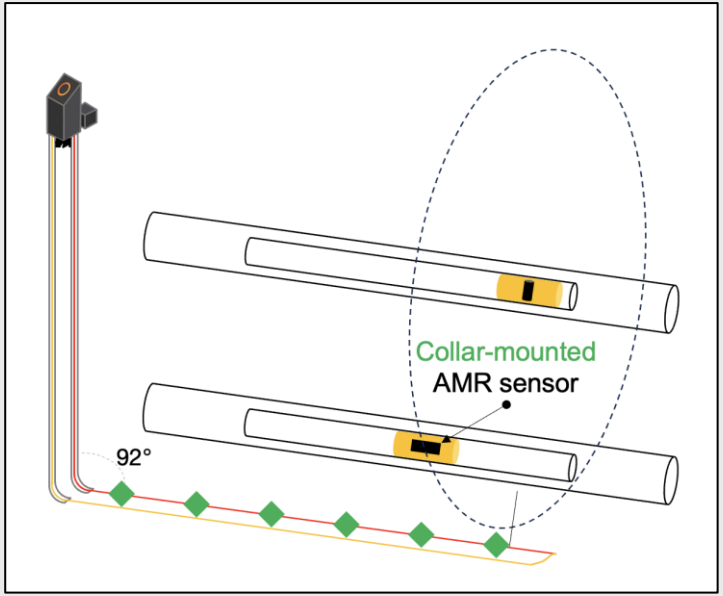
Wireline vs While Drilling

Wireline Ranging

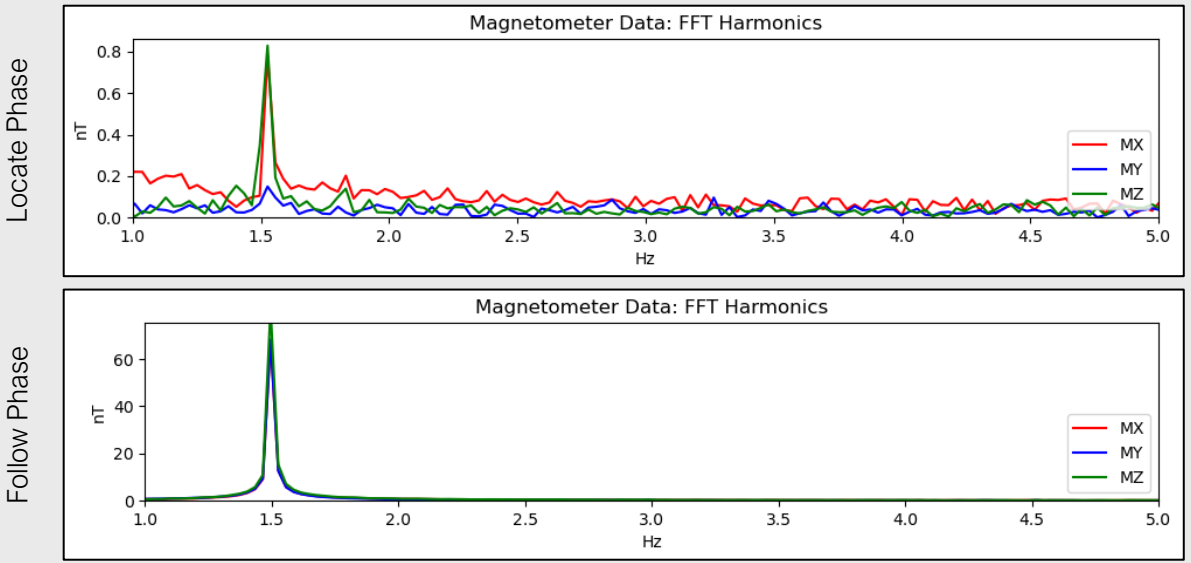


Ranging While Drilling

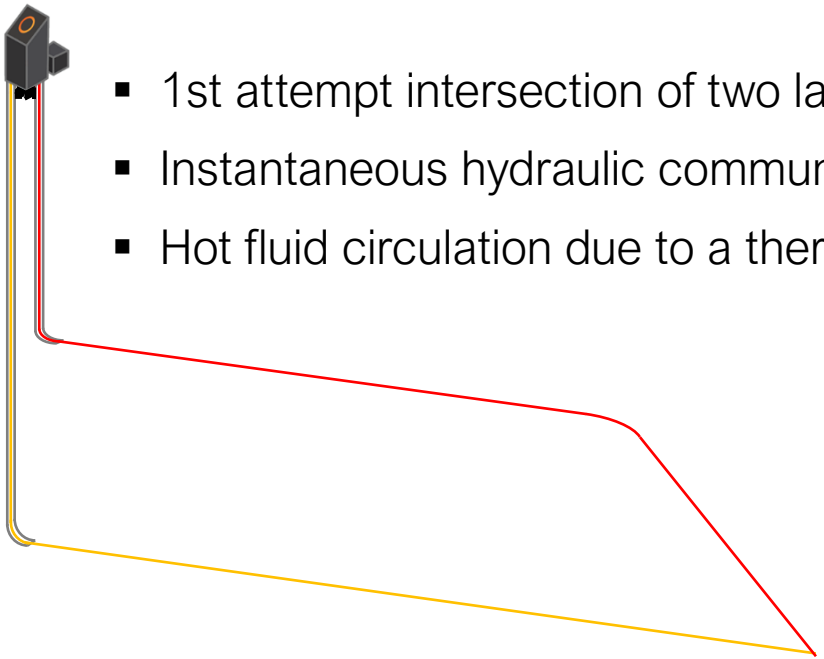


Rotating Magnet Ranging While Drilling – Field Data

RM Ranging While Drilling: Raw memory log data showing ranging signal in the frequency domain



Successful Intercept

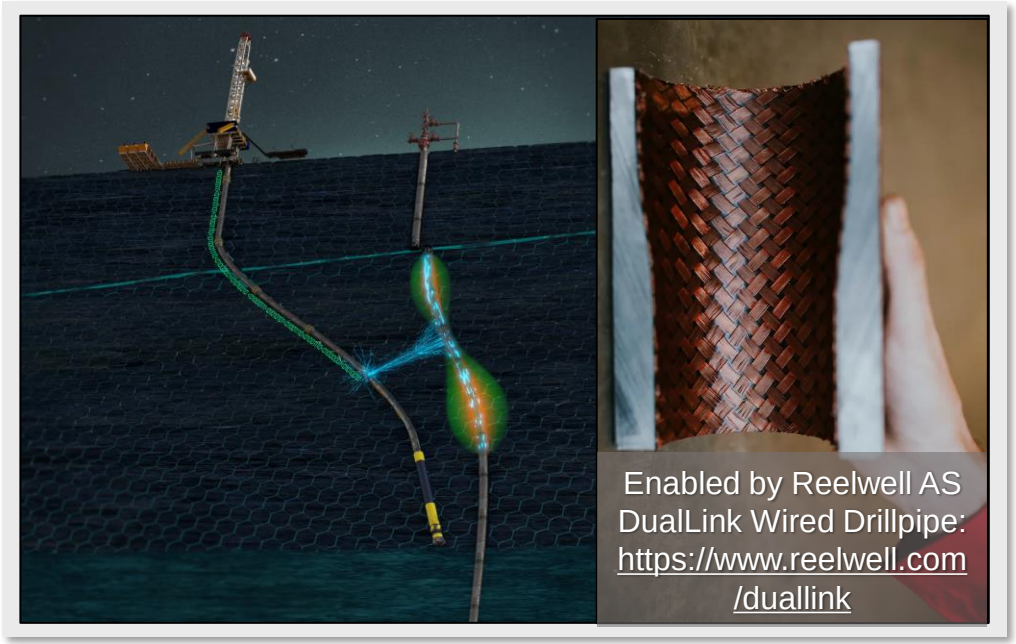


- 1st attempt intersection of two lateral wells at 7,805m MD
- Instantaneous hydraulic communication between two wells
- Hot fluid circulation due to a thermosyphon effect

Steam from the outlet well →

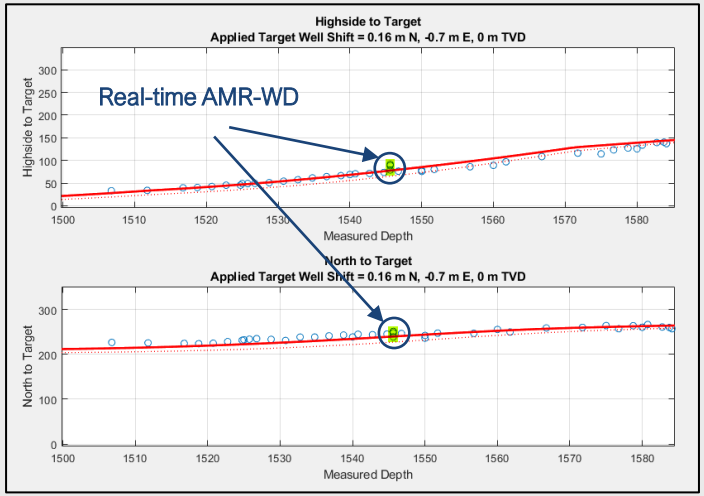
All-in-one Access-Independent AMR/PMR/Gyro While Drilling System

- Depth of investigation (range) of wireline AMR systems is limited by power injected into the formation
- Wired pipe enables:
  - 20x increase in power delivery
  - Elimination of wireline runs and BHA trips
  - Modelled depth of investigation (range) is up to 100–150m
  - Expected to work in salt
  - Patent # US 11,781,421 B2
  - First field deployment completed in Q1 2025 (Western Australia land)

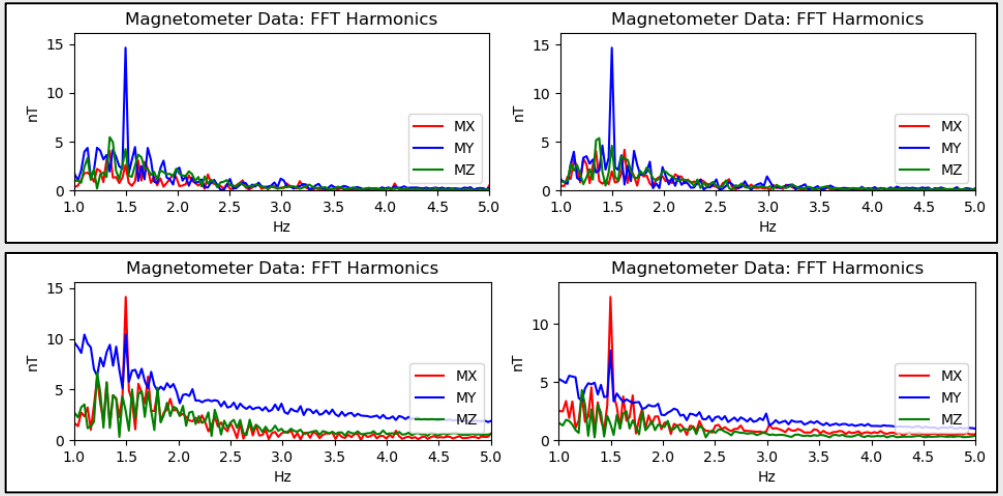


Access-Independent AMR While Drilling – Field Data

Real-time AMR While Drilling results
overlaying wireline AMR



AMR While Drilling: Raw memory log data
showing ranging signal in the frequency domain*



*Readings from the AMR-WD gradient probe are shown in pairs to illustrate sensor array data

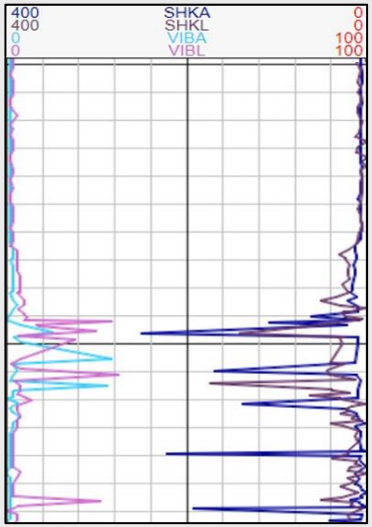
Access-Independent AMR While Drilling – Australia Operations

Gunnar and Erdos Miller crew and equipment at the intercept well site in Australia

Gravity, Magnetic, and Continuous Gyro toolfaces are used simultaneously to track the vertical target well in close proximity and maintain intercept alignment

Access-Independent AMR While Drilling – Intercept

High shock/vibe while milling



Metal shavings in the returns

Metal buildup on string magnets

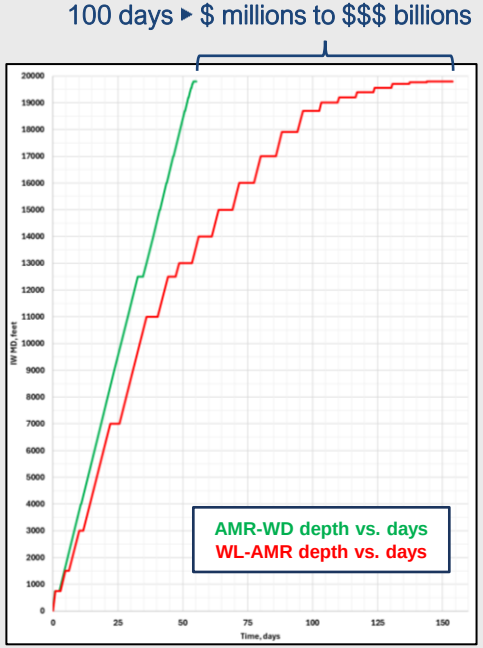
Mill wear profile

AMR-WD Summary of Results

- Successful first field deployment of the Access-Independent Gradient AMR While Drilling system
- Target intercepted in record time
  - 60m SHL offset between target and intercept wells
  - 2000m TVD at the intercept
  - Only 5 wireline AMR runs were performed, with the 5th run to confirm contact before milling
  - Just 8 days between the first and last ranging runs
- Successful abandonment approved by the regulator
- Significant time and cost savings for the client: abandonment completed below AFE

Our Mission: Zero Wireline Runs

- **Complete elimination of wireline ranging runs**
  - No BHA/pipe trips
    - No exposed open hole risk
    - Safer and faster
- **Example:** 3x faster intercept
  - 20,000ft intercept MD
  - Wireline AMR
    - 20 wireline AMR runs
    - 155 days to intercept
  - AMR While Drilling:
    - 55 days to intercept
    - $ Tens of millions saved on Complex P&A
    - $$$ Billions saved on Major Blowout with daily fines



What is our Goal?

- Goal: The complete elimination of wireline runs for ranging
- As single shot went to MWD, so must wireline ranging go to Ranging While Drilling
- Why? For the stakeholders:
  - Regulators
  - Operating companies
  - The public and the environment (the consideration of upmost importance!)

Next Steps

- Algorithm and system improvements to further reduce magnetometer noise downhole
- Wired pipe field test – the ultimate implementation will enable injection and communication via the wired pipe
- Preparing option to deploy without wired pipe – downhole current injection from batteries or turbine

Question?