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UNIVERSITY OF APPLIED SCIENCES

BESS BUSINESS MODEL (BM) & ENERGY MARKETS

Presented by:

Adebayo Agbejule, Mikko Pieskä, Joel Songok, and Thomas Vikström.

Presentation Outline

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1. Types of Battery Electric Storages
2. Research Problems
3. BESS Business Model (BM) and Value Proposition (Global)
4. BESS Business Model (BM) and Value Proposition (Finland)
5. Best Practices for Profitable BESS Operations (Finland)
6. Case Study - Day Ahead Arbitrage Optimization

Research Problems

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1. What market(s) offer the best profitability and business case for a BESS?

2. Can you operate with the BESS in several markets at the same time and are there commercial and technical risks with this?

3. What are the main technical aspects you have to consider when you operate your BESS? E-g. short term profit maximization can shorten the lifecycle of the BESS which leads to lowered IRR.

4. What kind of business models exist abroad and in Finland for BESS? What are the best practices to run a successful/profitable business with a BESS?

BATTERY USES

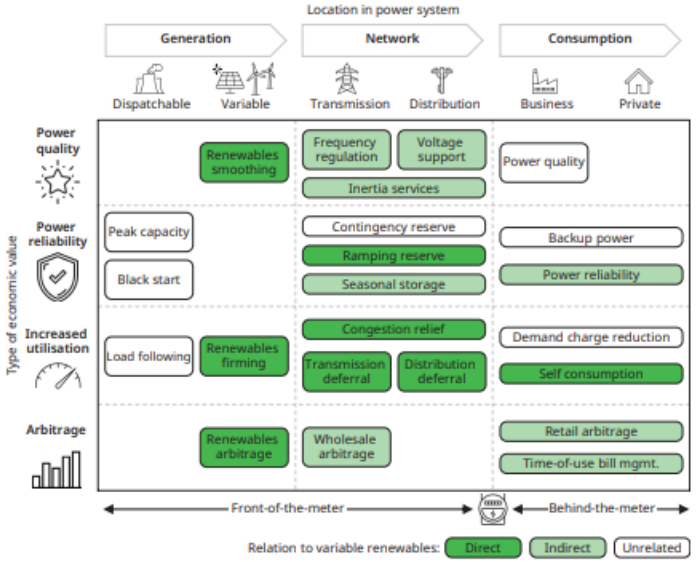

Figure 3.25 Overview of the 23 most common electricity storage applications along the dimensions of location within power system and type of economic value, with colour signifying the relation to variable renewable electricity generation. The selection of 23 applications is based on a review of reports from research institutes, international organizations, industry, and academia.[20,26,61–69] A detailed description of all 23 applications can be found in Table 3.4. Schematic inspired by Battke.[60,70]

From FREE BOOK – Monetizing Energy Storage (Schmidt/Staffell):
https://doi.org/10.1093/oso/9780192888174.001.0001

Available eg: https://www.ely-keskus.fi/documents/10191/60571718/1.Fingrid_Jarno_Sederlund_23.4.2024_uusi.pdf/2ca50e83-eb94-9978-07a1-21f8070ff0b7?t=1745496768690

Types of Battery Electric Storages

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Hybrid Batteries, FTM

“Back-up physical asset”

- Used only in reserve markets (FFR/FCR-D, FCR-N if size is adequate), as markets will be saturated can also be used in DA,ID etc) but **possibility to physically hedge** production trading
- Optimal location with existing production
- “Standard size”, 5MW-container and it´s multiples
- Electric taxation not involved since there is no consumption
- Grid fees: ~20t€/MW investment+ 0,99/0,66 € MWh (charge/discharge)
- Typical investors & companies
- FIN N/A?, see e.g. CAISO

Grid Batteries, FTM

“Part of electric grids”

- Used only in reserve markets (FFR/FCR-D, FCR-N if size is adequate), as markets will be saturated can also be used in DA,ID etc)
- Optimal location by suitable grid connection
- “Standard size”, 5MW-container5MW-container and it´s multiples
- Electric taxation not involved since there is no consumption
- Grid fees: ~20t€/MW investment + 0,99/0,66 € MWh (charge/discharge)
- Typical investors & companies; several, energy companies

Grid Batteries, BTM

“Utilizing of existing connections”

- Aggregated use only in reserve markets
- Cost advantage is an existing grid-connection and optimized only in grid direction
- No standard size
- difficult market on domestic usage due size-limits in power
- Electric taxation CAN be avoided by payable petition and separate measurement of consumption, but is not cost-efficient on smallest cases
- Grid fees varies by locations, can be very high
- Service providers/companies : only few, Innovestor and Powera

Grid + Home Batteries, BTM

“Best of both possibilities”

- Used only partly in reserve markets and partly possibility to physically hedge also consumption loads/production in DA
- Optimal location with existing production (solar panels), but can be used only with loads
- Electric taxation applies
- Grid fees: varies by locations and sizes (2-65 €/MWh)
- Typical service providers/companies - ; Elisa, Teravoima, Innovestor, several new companies
- Investor: user

Home Battery

“Easy logic”

- Used only to physically hedge consumption loads and or production in DA
- Optimal location with existing production (solar panels), but can be used only with loads
- Electric taxation applies
- Grid fees: varies by locations and sizes (2-65 €/MWh)
- Typical investors & companies; users

CO-LOCATED FUTURE

INDUSTRY

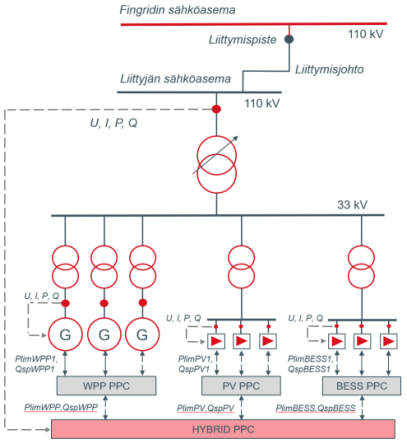
Single-connection

100MW + 50 MW + 20 MW =130 MW

Liite 1 Sovellusesimerkkejä hybridivoimalaitoksista

1 Esimerkki 1

Hybridilaitos: Tuulipuisto DFIG-turbiinein $P_{max_{WPP}}$=100 MW, aurinkovoimalaitos $P_{max_{PV}}$=50 MW ja sähkövarasto $P_{max_{ESS}}$=20 MW. Hybridivoimalaitoksen mitoitustehoksi Pmax liittymispisteessä on liittymissopimuksessa sovittu 130 MW. Voimalaitoksella on 8 km liittymisjohto liittymissopimuksessa määriteltyyn liittymispisteeseensä.



https://www.fingrid.fi/globalassets/dokumentit/fi/palvelut/kulutuksen-ja-tuotannon-liittaminen-kantaverkkoon/ohje---jarjestelmateknisten-vaatimusten-soveltaminen-hybrid-pp-2025.pdf

DOMESTIC

DAY-AHEAD ARBITRAGE

kW shift value (energy) for consumer (with VAT) - total	1h €/a	2h €/a	3h €/a	4h €/a	5h €/a	6h €/a	7h €/a	8h €/a
2021	36,35 €	69,00 €	98,32 €	124,91 €	148,71 €	169,51 €	186,89 €	201,02 €
2022	90,29 €	170,99 €	243,94 €	310,60 €	369,76 €	419,33 €	459,05 €	489,14 €
2023	32,63 €	60,71 €	85,73 €	107,74 €	127,07 €	143,63 €	157,60 €	168,89 €
2024	36,84 €	68,27 €	94,67 €	118,17 €	138,34 €	155,48 €	169,15 €	179,92 €
2025	9,08 €	16,89 €	23,81 €	29,97 €	35,46 €	40,25 €	44,28 €	47,48 €
		value 1h to 2h	value 2h to 3h					
differences wiht bigger capacity		90 %	42 %	27 %	19 %	14 %	10 %	8 %
		89 %	43 %	27 %	19 %	13 %	9 %	7 %
		86 %	41 %	26 %	18 %	13 %	10 %	7 %
		85 %	39 %	25 %	17 %	12 %	9 %	6 %
		86 %	41 %	26 %	18 %	14 %	10 %	7 %
2021 Q1	5,30 €	9,79 €	13,78 €	17,28 €	20,26 €	22,77 €	24,82 €	26,46 €
2021 Q2	5,95 €	11,21 €	15,91 €	20,25 €	24,16 €	27,57 €	30,27 €	32,40 €
2021 Q3	7,36 €	14,04 €	20,06 €	25,61 €	30,59 €	34,87 €	38,32 €	40,90 €
2021 Q4	17,74 €	33,95 €	48,57 €	61,77 €	73,70 €	84,30 €	93,48 €	101,25 €
2022 Q1	15,09 €	28,39 €	40,03 €	50,04 €	58,61 €	65,86 €	71,56 €	76,08 €
2022 Q2	19,99 €	38,13 €	54,37 €	68,93 €	81,82 €	92,50 €	100,66 €	106,28 €
2022 Q3	36,43 €	69,45 €	99,60 €	127,89 €	153,28 €	174,37 €	191,54 €	204,53 €
2022 Q4	18,79 €	35,02 €	49,94 €	63,74 €	76,05 €	86,60 €	95,29 €	102,25 €
2023 Q1	8,43 €	15,92 €	22,52 €	28,44 €	33,72 €	38,38 €	42,23 €	45,30 €
2023 Q2	5,25 €	9,69 €	13,45 €	16,71 €	19,28 €	21,28 €	22,88 €	24,12 €
2023 Q3	8,74 €	16,11 €	22,71 €	28,18 €	32,88 €	36,83 €	40,10 €	42,66 €
2023 Q4	10,21 €	19,01 €	27,05 €	34,41 €	41,19 €	47,14 €	52,40 €	56,81 €
2024 Q1	9,72 €	17,98 €	25,29 €	31,91 €	37,55 €	42,44 €	46,26 €	49,20 €
2024 Q2	9,57 €	17,46 €	23,67 €	29,11 €	33,81 €	37,60 €	40,74 €	43,29 €
2024 Q3	7,37 €	13,68 €	18,77 €	23,29 €	27,09 €	30,26 €	32,75 €	34,73 €
2024 Q4	10,18 €	19,15 €	26,94 €	33,86 €	39,89 €	45,17 €	49,40 €	52,70 €
2025 Q1* (ongoing)	9,08 €	16,89 €	23,81 €	29,97 €	35,46 €	40,25 €	44,28 €	47,48 €

BESS BM and Value Proposition (Global)

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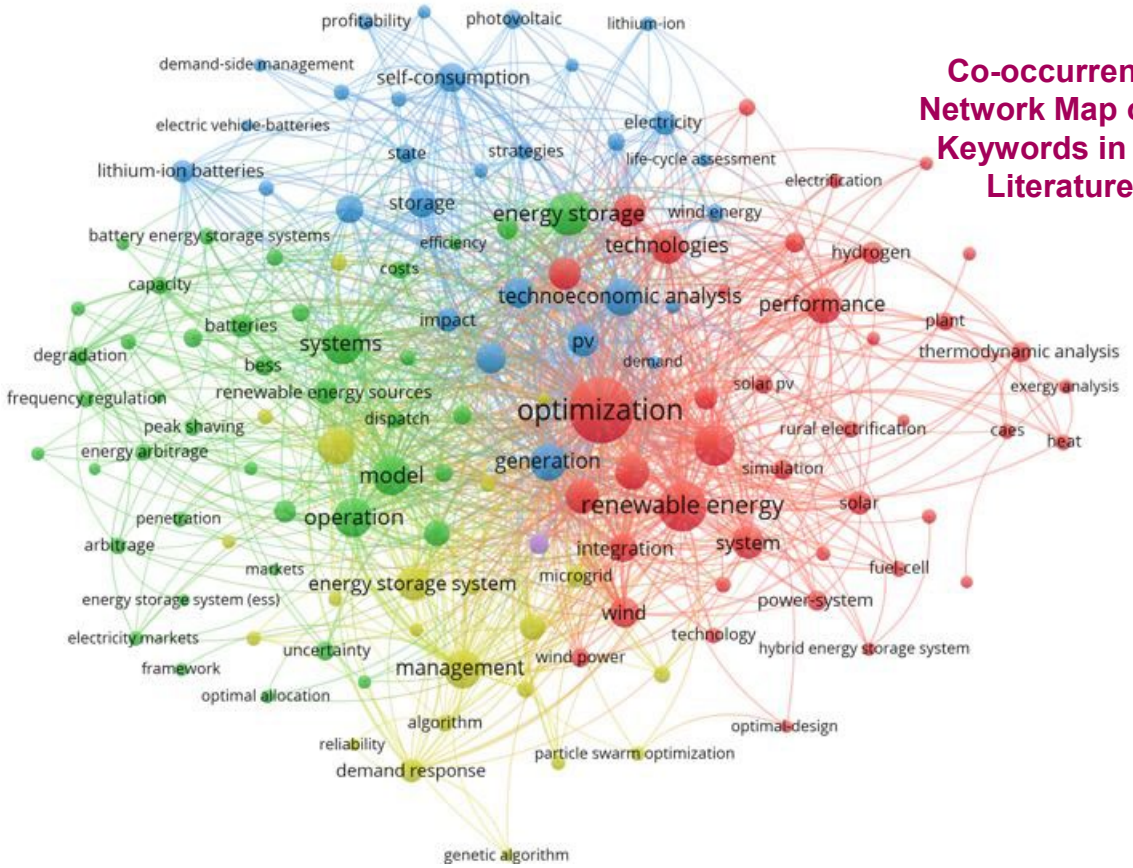
Timespan 2007:2025	**Sources** 158
Documents 788	**Annual Growth Rate** 26.52 %
Authors 3228	**Authors of single-authored docs** 20
International Co-Authorship 29.7 %	**Co-Authors per Doc** 4.61



Co-occurrence Network Map of all Keywords in the Literature

BESS BM and Value Proposition (Global)

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Second-Life & EV Integration

"Battery reuse, Lower BESS capital cost, added value to EV lifecycle, & Vehicle to Grid"

Reusing EV batteries for stationary storage. Vehicle-to-grid (V2G): EVs as grid-connected storage.

Grid Services & Market Participation

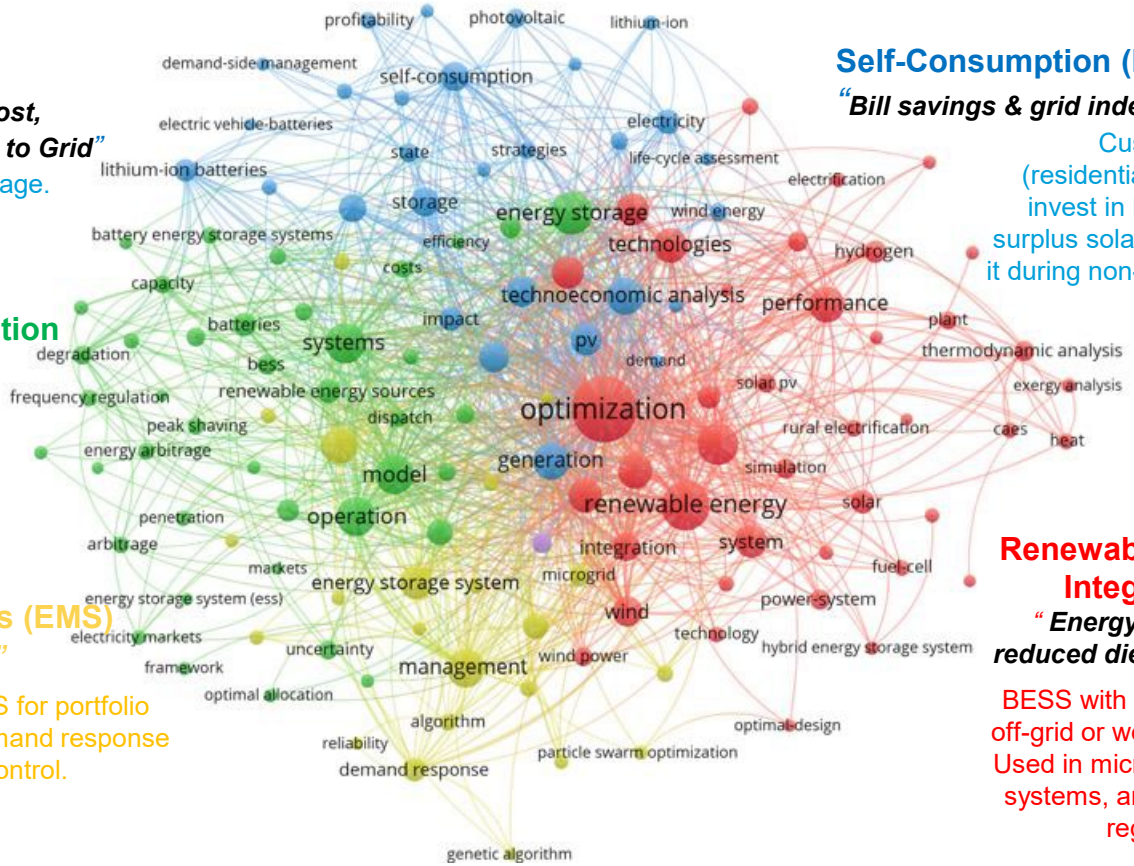
"Market revenue & Ancillary services"

BESS operators provide services to the grid or participate in electricity markets.

Energy Management Systems (EMS)

"Load shifting & energy efficiency"

BESS in energy optimization or EMS for portfolio energy management. Common in demand response aggregation and micro grid control.



Self-Consumption (PV + BESS)

"Bill savings & grid independence"

Customers (residential/commercial) invest in BESS to store surplus solar energy and use it during non-generation hours

Renewable/Off-grid Integration

" Energy access & reduced diesel reliance"

BESS with renewables in off-grid or weak-grid areas. Used in micro grids, hybrid systems, and developing regions

BESS BM and Value Proposition (Finland)

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13 RESEARCH ARTICLES FROM FINLAND

Ancillary Services Markets
(Sihvonen et al., 2025)

- BESS provides ancillary services like fast frequency response.
- These services offer income opportunities.
- Batteries support power systems during the energy transition.
- High costs and regulatory limits challenge economic feasibility.

Local Energy Communities
(Firoozi et al., 2020)

- BESS in LECs can join the mFRR market.
- Participation enables access to manual frequency restoration reserve services.
- Optimized scheduling improves efficiency.
- Control parameters influence real-time profitability. Flexible energy resources enhance community benefits.

Hybrid Renewable PP w/ BESS
(Seppälä & Syri, 2025)

- BESS is used in hybrid wind-PV power plants.
- Enables shifting production to more profitable hours (Nordic electricity market).
- Profitability is limited under current conditions.
- More viable in high-price bidding zones.
- Challenges include profit cannibalization and high capital costs.

Office Building Energy Communities (Lepistö et al., 2024)

- Commercial buildings with BESS and EV charging systems can participate in energy and reserve markets. Profits can be shared among stakeholders (owner, tenant, operator) using cooperative schemes like the Shapley value..

Energy Arbitrage Frequency Services Synergies
(Pusceddu et al., 2021)

- BESS enables energy arbitrage and fast frequency response.
- Combining both services can boost profitability.
- Innovative state-of-charge management is key.
- Capitalizing peak price windows increases returns. Operating profits can rise by up to 25%

Residential PV + BESS Systems
(Meriläinen et al., 2023)

- Cost-effective deployment of residential BESS becomes viable under high electricity price scenarios, especially when integrated with solar PV and intelligent control algorithms. Profitability improves when using real-time price forecasting and smart dimensioning

Best Practices for Profitable BESS Operations (Finland)

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- **Stacking Revenue Streams**: Combine services like frequency response, arbitrage, and peak shaving to enhance income (*Pusceddu et al. and Firoozi et al.*).
- **Participating in Ancillary Services Markets**: Focus on high-value services like FCR-D, FCR-N, and mFRR where batteries can deliver strong performance (*Sihvonen et al. and Firoozi et al.*).
- **Utilizing Smart Forecasting and Control**: Implement intelligent control algorithms and load forecasting to optimize battery dispatch and increase returns (*Meriläinen et al. and Koskela et al.).*
- **Forming Energy Communities**: Collaborate in local or commercial communities to share investment and operational benefits (*Lepistö et al.*).
- **Location and Sizing Optimization**: Ensure battery capacity and site selection align with market price volatility and grid conditions (*Seppälä & Syri*).

Case Study-Day Ahead Arbitrage Optimization

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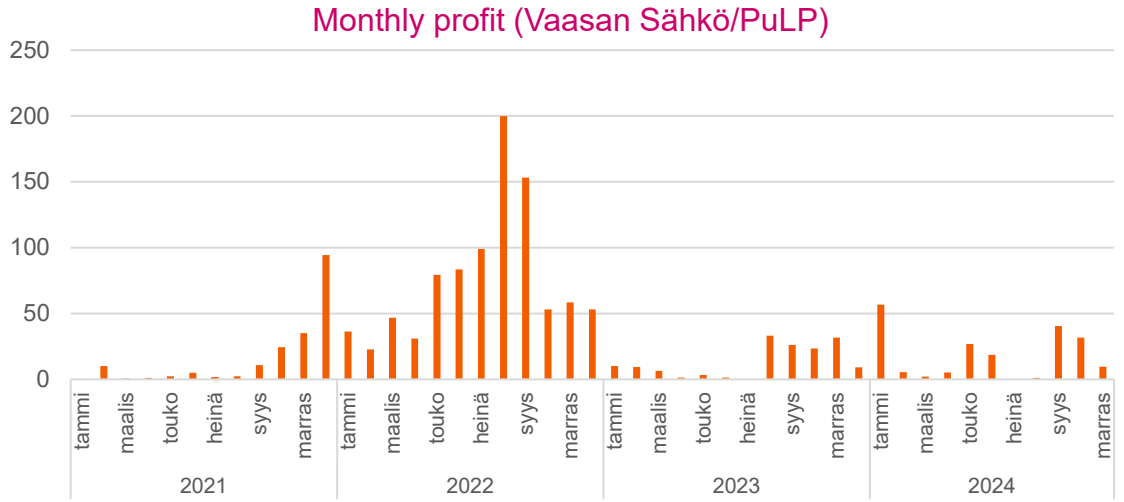
Optimization Methods

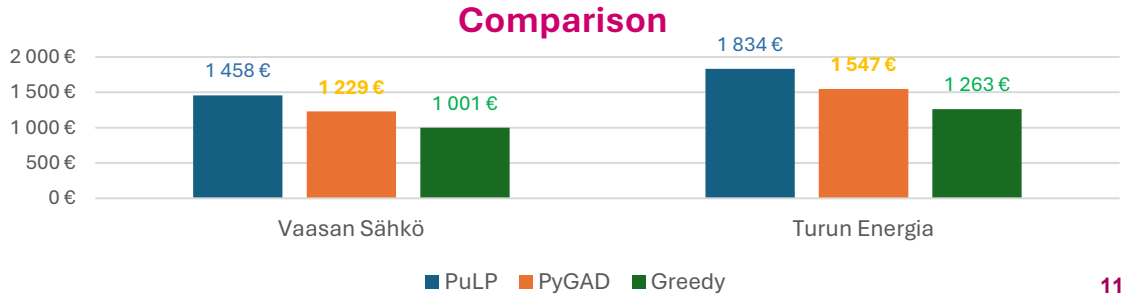
- Greedy – hand crafted, searching for buy/sell-pairs during the day
- Genetic Algorithms Library – mimicking evolution in nature using a fitness function
- Linear Programming Library – using similar fitness function as above

→The algorithms are only optimizing for a single day at a time (00:00-23:59)

Parameters

- 30 kWh battery
- Charging/discharging with 20 % power, keeping SOC 20% – 90%
- Using grid fees in calculation
- VAT 0%
- Efficiency loss 2%, degradation rate 2%/1000 cycles





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THANK YOU

Q&A

Conclusion

- BESS can operate in multiple markets.
- Lack of information project financing of BESS
- Exploring different optimizations models

VAASAN AMMATTIKORKEAKOULU
UNIVERSITY OF APPLIED SCIENCES

Work Package Leader:

Adebayo Agbejule

Email: ade@vamk.fi