PROJECT ACRONYM: ZeEUS
PROJECT FULL TITLE: ZERO EMISSION URBAN BUS SYSTEM
GRANT AGREEMENT NUMBER: 605485
The ZeEUS project demonstrated electric and hybrid bus operations in ten European cities in a project which was co-funded by the European Commission 7th Framework Programme. Each city went through the process of designing routes, specifying and procuring vehicles and equipment, installing charging infrastructure, training staff and operating the buses. This report provides a decision support tree based on analysis of best practice and a process evaluation in nine of the cities. It indicates factors to be taken into consideration at different stages in preparing for electric bus operation. The information is based on experiences in Barcelona, Bonn, Cagliari, Eindhoven, London, Münster, Plzen, Stockholm and Warsaw among city authorities, bus operators, transport authorities, bus manufacturers, charging infrastructure providers and energy suppliers.

Key words
- Electric buses
- Process evaluation
- Decision-making
- Planning operations
- Operating e-buses
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ACRONYMS

**SOC**: State of Charge
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1. EXECUTIVE SUMMARY

1.1 BACKGROUND TO ZEEUS

Zero Emissions Urban Bus Systems (ZeEUS) is a European Commission co-funded project under the FP7 research framework. The aim of ZeEUS is to demonstrate the potential for e-buses (electric buses) in an urban public transport environment in ten cities across Europe. A range of pure electric and hybrid vehicle technologies were trialled across the consortium, along with a number of different charging technologies and techniques.

The cities were faced with a range of challenges. These included operational challenges of setting up and running new bus services based on technologies with which they had little or no experience. At the same time there were organisational challenges associated with the new working arrangements involved in e-bus operations. In some cases this meant building new relationships between bus operators and transport authorities and the suppliers of charging equipment, electricity and e-buses.

1.2 DECISION SUPPORT TREE

When introducing new technologies, previous experience shows that although technical issues will be important to bus operators and others involved in planning and delivering services, there are many other issues affecting deployment. These may include financial concerns, political priorities, local regulations, operational or contractual requirements and lack of skills and experience.

This report summarises the findings from analysis of best practice and process evaluation in the experience of ZeEUS demonstrations in nine cities (Barcelona, Bonn, Cagliari, Eindhoven, London, Münster, Plzen, Stockholm and Warsaw). The findings are presented in the form of a decision support tree. This identifies seven stages in the decision making process for implementing an electric bus operation and in each stage, identifies the key points to consider. For each of the points to consider it identifies the main factors contributing positively and negatively (if they are not the opposite of a positive factor).

The decision making stages covered are:

1. Decision in principle
2. Understanding requirements and issues
3. Decision to proceed
4. Planning services and preparing for operation
5. Specification
6. Procurement
7. Preparing for implementation.

Further information on the points summarised in the decision support tree is available in the ZeEUS deliverables D51.4 Process Evaluation and D53.8 Good Practice and Lessons Learned.
2. INTRODUCTION

2.1 BACKGROUND TO ZEEUS

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### 2.3 PARTNERS' CONTRIBUTION

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3. STAGE 1: DECISION IN PRINCIPLE

Decision in principle

Points to consider
- Is there local support for e-buses?
- Are there resources available to procure e-buses?
- Is there local practitioner support for e-buses?
- Is bus procurement required to meet specific environmental standards?
- Are there sensitive areas where e-buses could be used to introduce public transport?

Contributory factors
- Local authority/ bus operator has policies/ targets for improved air quality/ reduced noise
- Support for innovation in local authority and bus operators
- Public support for cleaner transport
- EU/ national funding/subsidy
- Planned budget
- Unspent budget
- Motivated key individuals in local authority/ bus operators/ energy supplier
- Tendering criteria favour e-buses
- Expectation of future environmental standards for buses
- Contractual agreements for electric mobility
- Historic sites
- Pedestrian areas
- Tourist attractions
4. STAGE 2: UNDERSTANDING REQUIREMENTS AND ISSUES

- Understanding requirements and issues
  - Does the city have positive experience of alternative fuel public transport?
  - Does the bus operator have experience of e-buses in other cities?
  - Does the city have experience of electric trolleybuses?
  - Does the energy supplier have experience of installing and operating vehicle charging infrastructure?
  - Is there an opportunity for collaboration with other cities?

- Points to consider
  - Skills available/transferable for planning, implementing and operating services
  - Established working relationships between engineering and operational teams
  - Planning, implementation and operational experience
  - Research, consultation, information sharing
  - Understanding risks

- Contributory factors
  - Planning, implementation and operational experience
  - Understanding risks
  - Planning, implementation and operational experience
  - Understanding risks
  - Planning, implementation and operational experience
  - Understanding risks
5. STAGE 3: DECISION TO PROCEED

Decision to proceed

Points to consider

- Is there a requirement to demonstrate a financial case for investment in e-buses?
- If no financial case is required, what needs to be recorded to support the decision to proceed?
- What regulatory requirements are there that may affect the service plans and specifications?
- Are there unregulated aspects which need to be considered and approved?

Contributory factors

- Anticipated benefits (monetised if possible) compared with lifecycle costs
- Limited information for monetisation of benefits for air quality and noise
- Limited data on battery life and battery disposal costs causes uncertainty about lifecycle costs
- Availability of funding
- Support in relevant organisations
- Evidence of positive experience
- Vehicle/battery/charging connection
- Charging equipment
6. **STAGE 4: PLANNING SERVICES AND PREPARING FOR OPERATION**

![Diagram showing planning services and preparing for operation]

**Stage 4 Points to consider**

- Which organisation should be represented on the management board for planning and monitoring?
- Is there a motivated senior person with responsibility for bus operations available to load the management board?
- Are all organisations willing to commit to regular meetings during planning and operation?
- Do route selection and route planning take account of all factors affecting optimisation of electricity use?
- Does route selection maximise opportunity for gaining public support?
- Is planning permission required for charging points?

**Contributory factors**

- Local authority/transport authority
- Bus operators
- Charging equipment supplier
- Energy supplier
- Bus manufacturer
- Civil works department
- Effective coordination of the technically challenging planning and delivery of a bus programme
- From the outset, meetings include all organisations involved in delivery of the e-bus programme
- Meetings held monthly or more often as rate of progress requires
- Length and topography of route, number of stops, traffic conditions
- Availability, ownership and configuration of suitable sites for charging (on-street and off route)
- Frequency of service and time available for charging at end of route or on route
- Seasonal temperatures may affect feasible length of route and intervals between charging
- Current and future passenger loading to maximise return on investment in charging infrastructure
- Sensitive areas where diesel buses are unable to operate
- Sensitive areas where diesel buses are in use
- Early discussions with city planners to understand process
- Sufficient time is allowed in the programme to avoid delaying implementation
- Sites which are sensitive or close to dwelling and attract public opposition
7. STAGE 5: SPECIFICATION

**Stage 5**

**Points to consider**

- Do the vehicle and battery specifications take account of all factors affecting optimisation of electricity use?
- Does the charging infrastructure specification take account of all factors affecting optimisation of electricity use?
- Does the proposed location of charging infrastructure maximise chances of smooth implementation?
- Is planning permission required for charging points?

**Contributory factors**

- Length and topology of route, number of stops
- Availability, ownership and configuration of suitable sites for charging (depot and en-route)
- Features and performance of charging system
- Frequency of service and time available for charging at end of route or en route
- Current and future passenger loading
- Requirements for air conditioning and heating
- Simulation of the impact of key parameters on energy use
- Interoperability with any existing e-buses and charging systems
- Interoperability with any existing e-buses and charging stations
- Features and performance of batteries
- Charging infrastructure required by batteries
- Availability, ownership and configuration of suitable sites for charging (depot and en-route)
- Limitations of local electricity grid
- Location of electricity substations
- Site surveys to accurately record utilities and structures help with site selection and save time and resources in the construction phase
- Charging infrastructure installed on land owned by local authority or bus operator
- Early discussions with city planners to understand process
- Sufficient time for approval to avoid delay to implementation
8. STAGE 6: PROCUREMENT

Stage 6: Procurement

Points to consider:
- Is it possible for bus and charger procurement to be coordinated by one organisation?
- If there is a requirement for a tendering process to procure the buses:
- If there is no requirement for tendering to procure the buses:
- Does the bus manufacturer have experience of building e-buses?
- Does the public transport operator control the vehicles and the engineer?

Contributory factors:
- Simpler and more streamlined process
- Improved match between buses and charging system
- Sufficient time is allowed in the programme for fair and effective tendering
- Specification designed to allow for competitive tendering
- Terms and conditions take account of the uncertainties of e-bus operation, including response times for faults
- Penalty clauses balance risk between bus manufacturer and client in case of performance issues
- Weighting in tender evaluation to balance technical specification, performance and costs
- Lack of standards for performance measures relevant to e-bus operations makes comparisons difficult
- Sufficient time is allowed in the programme for an effective selection process
- Warranty terms take account of the uncertainties involved in bus operation
- Selection process balances technical specification, performance and costs
- Lack of standards for performance measures relevant to e-bus operations makes comparisons difficult
- Reduced risk
- Improved reliability
- Option to develop bespoke solutions not currently on the market
9. STAGE 7: PREPARING FOR IMPLEMENTATION

Stage 7

Points to consider

Preparinfor
implementation

Contribution factors

Does the programme include contingency for construction delays? Unforeseen issues with utilities & underground structures

Does the programme include time to integrate e-buses into fleet? E-buses unable to run as planned without full charging infrastructure

Do the delivery organisations have experts to deliver an effective service? Schedules take account of demand for power and charging requirements

Is there a plan for regular retraining of all staff during operations? Contingency planning and back-up vehicles

Is there a plan for optimising charging during operations? Time is allowed for training and staff preparation

Training/recruitment in high voltage equipment and risk assessment for operation and maintenance

Training/recruitment of e-bus schedulers

Driver behaviour training to optimise performance; on-board training

Awareness and familiarisation training for all staff

Training fire service

Reinforce good practice

Monitoring battery SOc to avoid buses becoming stranded

Buses in service prioritised at charging points

Management of full overnight charging of all e-buses

Planned bus maintenance

Planned maintenance of charging equipment

Prioritisation of e-bus routes for snow clearance