Stage 1: Status Quo → **Action 1: Generation of Interest** → **Stage 2: Will of investing and cooperation** → **Action 2: Investigation/Data Acquisition on inefficiencies and partners** → **Stage 3: Knowledge of inefficiencies and cooperation opportunities** → **Action 3: Investment analysis and intervention implementation** → **Stage 4: Energy Efficiency Cooperation implemented**

Action 1: Generation of Interest

Economic Perspective

Financial

- ► Companies/Parks lack access to (long-term) financing or lack knowledge thereof
- ► Internal competition for capital prioritizes non-energy related investments
- ► No additional own funds dedicated for energy matters
- ► Energy costs are not a crucial cost factor
- ► Existing structures are costly to change, so there is no interest in doing so
- ► Long payback times are not in line with company guidelines

Social/Managerial Perspective

Individual

- ► Reluctance to change and adapt to potentially different working environments
- ► Lack of time and resources to work on issues other than the core business
- ► Lack of skills and competencies to deal with issues other than the core business
- ► Staff is not motivated to deal with (their department's) energy demand etc.
- ► Responsibility for energy topics is not clearly defined

Mutual

- ► Weak cross-sectoral co-operation, there is no existing network
- ► No prior relation between companies in an industrial park
- ► Cultural barriers towards cooperation that relates to internal production processes
- ► Different management/reporting levels at involved companies are responsible

Organizational

- ► Problems due to split incentives may occur internally and/or externally

- ► Uncertainty and lack of information about internal organization
- ► Absence of energy management systems (ISO 50001, also e.g. ISO 9001 and ISO 14001)

Framework Perspective

Policy

- ► Lack of comprehensive and coherent energy related strategies increase investment risks

Standardisation

- ► Different safety issues (and yearly costs) according to different voltage supply
- ► Energy taxes on individual energy carriers need to be harmonized in a local hybrid system
- ► Registration as an energy supplier is needed if energy (especially electricity) is utilized externally
- ► At the moment it is difficult to have more than one energy supplier, which makes selling infrequent residual/surplus energy difficult for companies

Technical/Engineering Perspective

In the beginning

- ► Long physical distances between enterprises (energy losses)
- ► Low adoption rates as of waiting before other firms have successfully adopted technology or cooperation (reliability, quality, profitability)
- ► Lack of monitoring and measuring of energy consumption within enterprises
- ► Lack of infrastructure (physical space for new technologies, distribution infrastructure for the transportation of waste streams or by-products)

- ► Lack of technical solutions for managing by-products
- ► Outdated infrastructure does not allow efficient solutions
- ► Most of the energy efficiency potentials in the company have already been realized
- ► Hesitant to interfere within reliably running production processes (production disruptions, hidden costs)
- ► Lack of knowledge for designing, developing, constructing, manufacturing, operating and maintaining new technologies or cooperation e.g. first of its kind
- ► Insufficient technology maturity (TRL evaluation)
- ► Integration of energy management systems (microgrid EMS)
- ► Intellectual property protection hampers the dissemination of technology relevant information
- ► Lack of knowledge about technical options, their applicability and reliability
- ► Quantities and attributes of waste streams and by-products are hardly flexible at existing facilities

Information Provision Perspective

In the beginning

- ► Missing informational head of the park, who could initiate cooperation ideas
- ► Lack of interest in the neighbouring company's energy demands/residuals

- ► Lack of knowledge about successful demonstration projects and/or other references
- ► Energy is not a strategic important issue
- ► Lack of access to external competences
- ► Lack of knowledge about possible side-streams, collaborating partners, etc.

Barriers in blue shapes are barriers arising (mainly) from cooperation

Action 2: Investigation/Data Acquisition on inefficiencies and partners

Economic Perspective

Financial

- ► Existing plants are not depreciated today, which hampers the investment in new ones

Market-related

- ► Limited customer acceptance (fear of distorted, unreliable business relations)

- ► Fear of competitive disadvantages through exchange of information, knowledge and data
- ► Costs associated with environmental damage/climate effects are poorly reflected in market prices
- ► No or insufficient consideration of life-cycle costs in market prices

Social/Managerial Perspective

Individual

- ► Lack of skills and competencies to deal with issues other than the core business
- ► Fear of distortions to core business due to occupied (human) resources)
- ► Staff is not motivated to deal with (their departments) energy demand etc.
- ► Responsibility for energy topics is not clearly defined, so data acquistion is difficult

Mutual

- ► Weak cross-sectoral co-operation, cooperation opportunities may be overseen
- ► No prior relation between companies in an industrial park
- ► Different management/reporting levels at involved companies are responsible

Organizational

- ► Problems due to split incentives may occur internally and/or externally
- ► Lack of trust between companies and park manager / or service companies

- ► No possibility or no willingness to make changes to a rented building
- ► Absence of energy management systems (ISO 50001, also e.g. ISO 9001 and ISO 14001)

Framework Perspective

Legislative/Regulatory

- ► Industrial codes and standards are not aligned with proposed solutions
- ► Infrastructure related uncertainties (e.g. regulations for HV and LV networks)
- ► Uncertainties in national legislation
- ► Incoherence between local, regional, national, European legislation creates uncertainty
- ► Legal complexity in the individual Member States
- ► Big data management
- ► No legal claim for building heat pipes over private ground

Standardisation

- ► Prohibition of exchanging electricity between two customers
- ► Lack of standardization about waste heat exchange (e.g. metering and measurement)
- ► Frameworks prohibit technical/economical sound cooperation in the gas & electricity market

Technical/Engineering Perspective

During acquisition

- ► Uncertainty of quality of exchanged energy (temperature level, continuity profile, volumes etc.)
- ► Aligning intermittent energy production (load profiles) between processes
- ► Low adoption rates as of waiting before other firms have successfully adopted technology or cooperation (reliability, quality, profitability)
- ► Lack of feasibility study, life cycle analysis or technological forecasting
- ► Missing link between supply/load profiles of the companies (no appropriate usage of by-products or waste streams possible)
- ► Lack of monitoring and measuring of energy consumption within enterprises
- ► High demands on computer performance and IoT sensors/actuators for data analysis and optimisation algorithms
- ► Cyber security protocols to protect privacy issues for energy exchange are required

- ► Most of the energy efficiency potentials in the company have already been realized
- ► Lack of knowledge about technical options, their applicability and reliability
- ► Lack of knowledge for designing, developing, constructing, manufacturing, operating and maintaining new technologies or cooperation e.g. first of its kind
- ► Quantities and attributes of waste streams and by-products are hardly flexible at existing facilities
- ► Insufficient technology maturity (TRL evaluation)
- ► Inappropriate technologies (as of weather conditions, intermittent source, capacity utilization not economical, incompatible)
- ► Intermittency of some renewable energy sources (unsufficient supply, storage systems or load shifting required to meet demand)
- ► Integration of energy management systems (microgrid EMS)
- ► Intellectual property protection hampers the dissemination of technology relevant information

Information Provision Perspective

During acquisition

- ► Lack of knowledge about possible side-streams, collaborating partners, etc.
- ► Missing informational head of the park
- ► Provision of sensitive business data, e.g. energy data, is needed
- ► Information exchange and communication between relevant persons does not work properly
- ► Lack of knowledge about neighbour company's energy demands/residuals

- ► Lack of knowledge about successful demonstration projects and/or other references
- ► Lack of knowledge about financing, subsidy options
- ► Failure to recognize non-energy benefits of efficiency
- ► Energy is not a strategic important issue
- ► Lack of access to external competences

Action 3: Investment analysis and intervention implementation

Economic Perspective

Financial

- ► Players fear hidden costs of first-of-kind investment projects

- ► Companies/Parks lack access to (long-term) financing or lack knowledge thereof
- ► Internal competition for capital prioritizes non-energy related investments
- ► Long payback times are not in line with company guidelines
- ► Companies/parks face high investment costs
- ► Financial problems due to retroactive changes of renewable energy support schemes, which also create lack of trust among investors
- ► Players lack substantial private (risk) finance
- ► No additional own funds available
- ► Existing plants are not depreciated today, which hampers the investment in new ones
- ► Energy costs are not a crucial cost factor
- ► Existing structures are costly to change
- ► (Monetarized) economic, organizational and technical risks, including risk uncertainties

Market-related

- ► Fear of technological lock-in effects or obsolescence due to expected technological progress
- ► Limited customer acceptance (fear of distorted, unreliable business relations)

- ► Costs associated with environmental damage/climate effects are poorly reflected in market prices
- ► No or insufficient consideration of life-cycle costs in market prices
- ► Uncertainty about energy/resource price developments
- ► Availability of risk insurance insufficiently offered on market

Social/Managerial Perspective

Individual

- ► Fear of distortions to core business
- ► Uncertainty of effects on local population, communities where park/company is located
- ► Success driven managers with short-term contracts need fast success

Mutual

- ► Different management/reporting levels at involved companies are responsible
- ► Fears of security of supply in case switching of suppliers is limited

Organizational

- ► Problems due to split incentives may occur internally and/or externally
- ► Lack of trust between companies and park manager / or service companies
- ► Companies are direct market competitors
- ► Fear of negative effects on workplace safety

- ► Uncertainty and lack of information about internal organization
- ► Changes to managerial structures may become necessary, reduces acceptance of decision makers
- ► Incentive structures in companies guiding objectives of decision makers reduce acceptance
- ► No possibility or no willingness to make changes to a rented building/ lessor does not allow implementation

Framework Perspective

Legislative/ Regulatory/Policy

- ► Industrial codes and standards are not aligned with proposed solutions
- ► Infrastructure related uncertainties (e.g. regulations for HV and LV networks)
- ► District heating operator is not legally obliged to allow and remunerate a feed in into his network
- ► Uncertainties in national legislation
- ► Incoherence between local, regional, national, European legislation creates uncertainty
- ► Tax structures (such as depreciation periods)
- ► Legal complexity in the individual Member States
- ► Big data management
- ► Regulation is counter-productive to some technologies/measures

- ► Lack of comprehensive and coherent energy related strategies increase investment risks
- ► Ineffective market based support instruments
- ► Lack of appropriate incentives
- ► Application for subsidies is too complicated

Standardisation

- ► Different safety issues (and yearly costs) according to different voltage supply
- ► Prohibition of exchanging electricity between two customers
- ► Lack of standardization about waste heat exchange (e.g. metering and measurement)
- ► Energy taxes on individual energy carriers need to be harmonized in a local hybrid system
- ► Registration as an energy supplier is needed if energy (especially electricity) is utilized externally
- ► At the moment it is difficult to have more than one energy supplier, which makes selling infrequent residual/surplus energy difficult for companies
- ► Frameworks prohibit technical/economical sound cooperation in the gas & electricity market

Technical/Engineering Perspective

Realisation

- ► Uncertainty of quality of exchanged energy (temperature level, continuity profile, volumes etc.)
- ► Aligning intermittent energy production (load profiles) between processes
- ► Crossing private ground of neighbours with e.g. heat pipes
- ► Low adoption rates as of waiting before other firms have successfully adopted technology or cooperation (reliability, quality, profitability)
- ► Lack of feasibility study, life cycle analysis or technological forecasting
- ► Advanced communication infrastructure needed (bi-directional flow of energy and information like for smart grids, microgrids and prosumers)
- ► Lack of monitoring and measuring of energy consumption within enterprises
- ► High demands on computer performance and IoT sensors/actuators for data analysis and optimisation algorithms
- ► Cyber security protocols to protect privacy issues for energy exchange are required
- ► Lack of infrastructure (physical space for new technologies and distribution infrastructure for the transportation of waste streams or by-products is required)
- ► Long physical distances between enterprises (energy losses)
- ► Lack of technical solutions for managing by-products
- ► Missing link between supply/load profiles of the companies (no appropriate usage of by-products or waste streams possible)
- ► Building or reconstructing facilities to enable energy cooperation may imply the requirement of other measures to comply with the current "best available technologies" (BAT) standards.

- ► Outdated infrastructure does not allow efficient solutions
- ► Quantities and attributes of waste streams and by-products are hardly flexible at existing facilities
- ► Insufficient technology maturity (TRL evaluation)
- ► Intermittency of some renewable energy sources (unsufficient supply, storage systems or load shifting required to meet demand)
- ► Integration of energy management systems (microgrid EMS)
- ► Hesitant to interfere within reliably running production processes (production disruptions, hidden costs)

Information Provision Perspective

Realisation

- ► Provision of sensitive business data, e.g. energy data, is needed
- ► Information exchange and communication between relevant persons does not work properly
- ► Uncertainty about organizational issues of energy cooperation (e.g. who runs the new/ joint plant)

- ► Lack of knowledge about financing, subsidy options
- ► Uncertainty about quantification of effects
- ► Failure to recognize non-energy benefits of efficiency