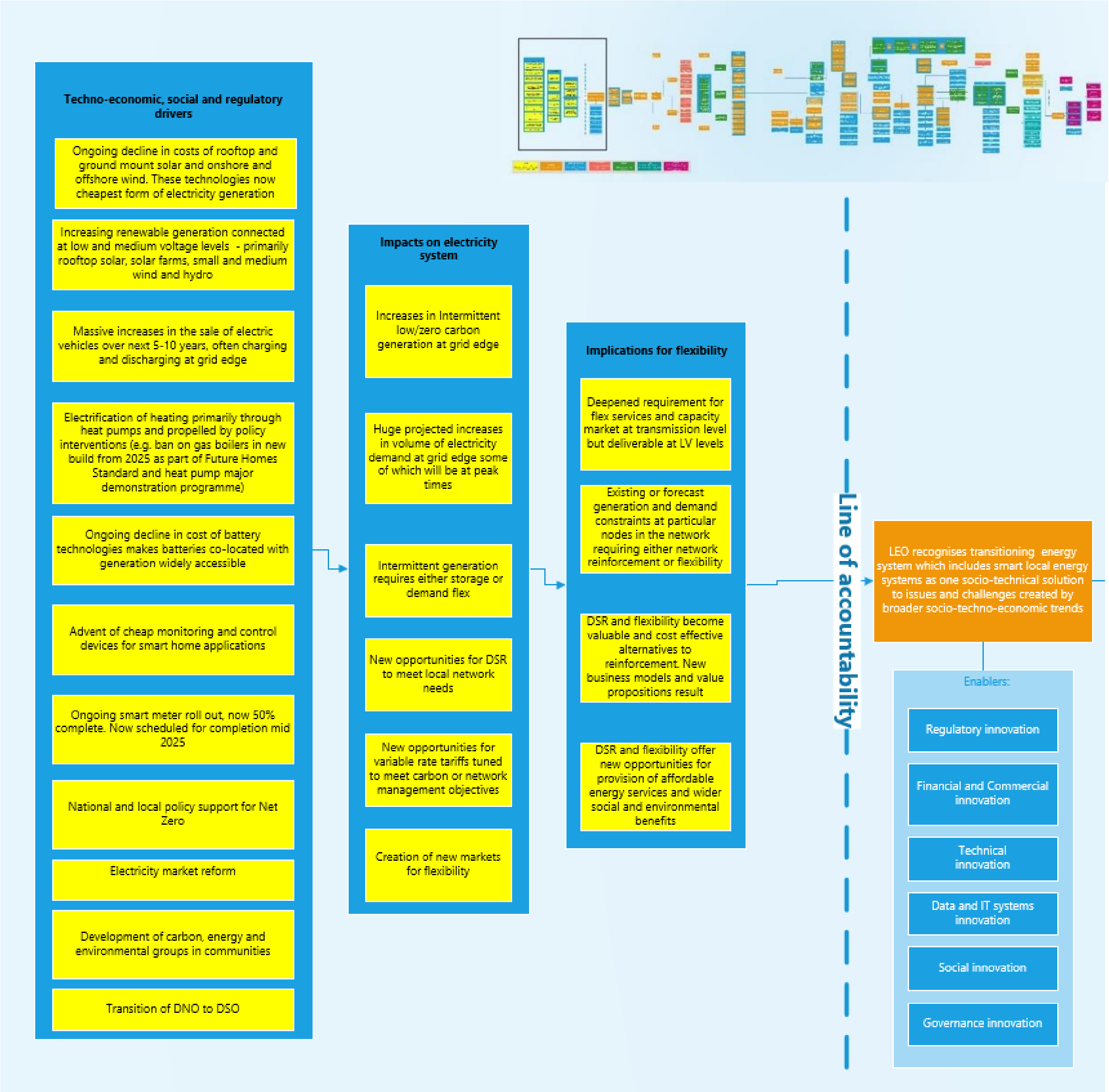
Theory of Change- Project LEO Appendix.

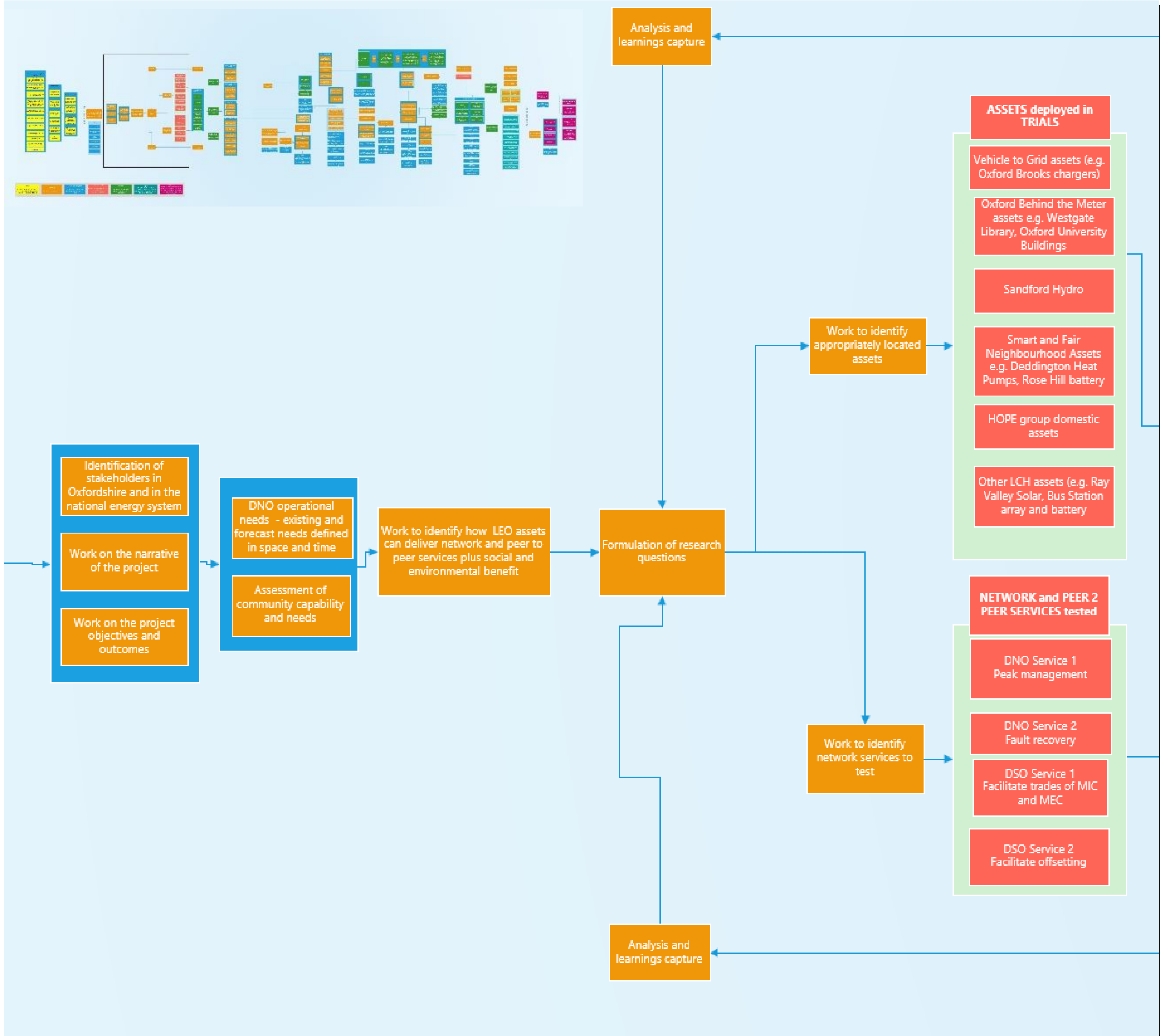


This part of the ToC on the extreme left describes the principle drivers currently transforming the energy system. The first column shows techno-economic, social and regulatory drivers. The second column describes how the drivers are impacting the electricity system in particular and the third column describes what this means in terms of the need for greater flexibility in supply and demand on the transmission and distribution networks. These create the rationale and scope for LEO and are reproduced here:

- Deepened requirement for flex services and capacity market at transmission level but deliverable at LV levels.
- Existing or forecast generation and demand constraints at particular nodes in the network requiring either network reinforcement or flexibility.
- DSR and flexibility become valuable and cost effective alternatives to reinforcement. New business models and value propositions result.
- DSR and flexibility offer new opportunities for provision of affordable energy services and wider social and environmental benefits.

Drivers causing system change and their implications are not within LEO's direct realm of influence and therefore sit to the left of the "line of accountability".

LEO is demonstrating local energy systems that embrace these challenges recognizing that in order to do so there must be enabling innovations in all dimensions of the energy transition. These innovations shown in blue boxes are: innovation in technical factors, data and IT systems, financial and commercial aspects, regulation, governance and social aspects also.

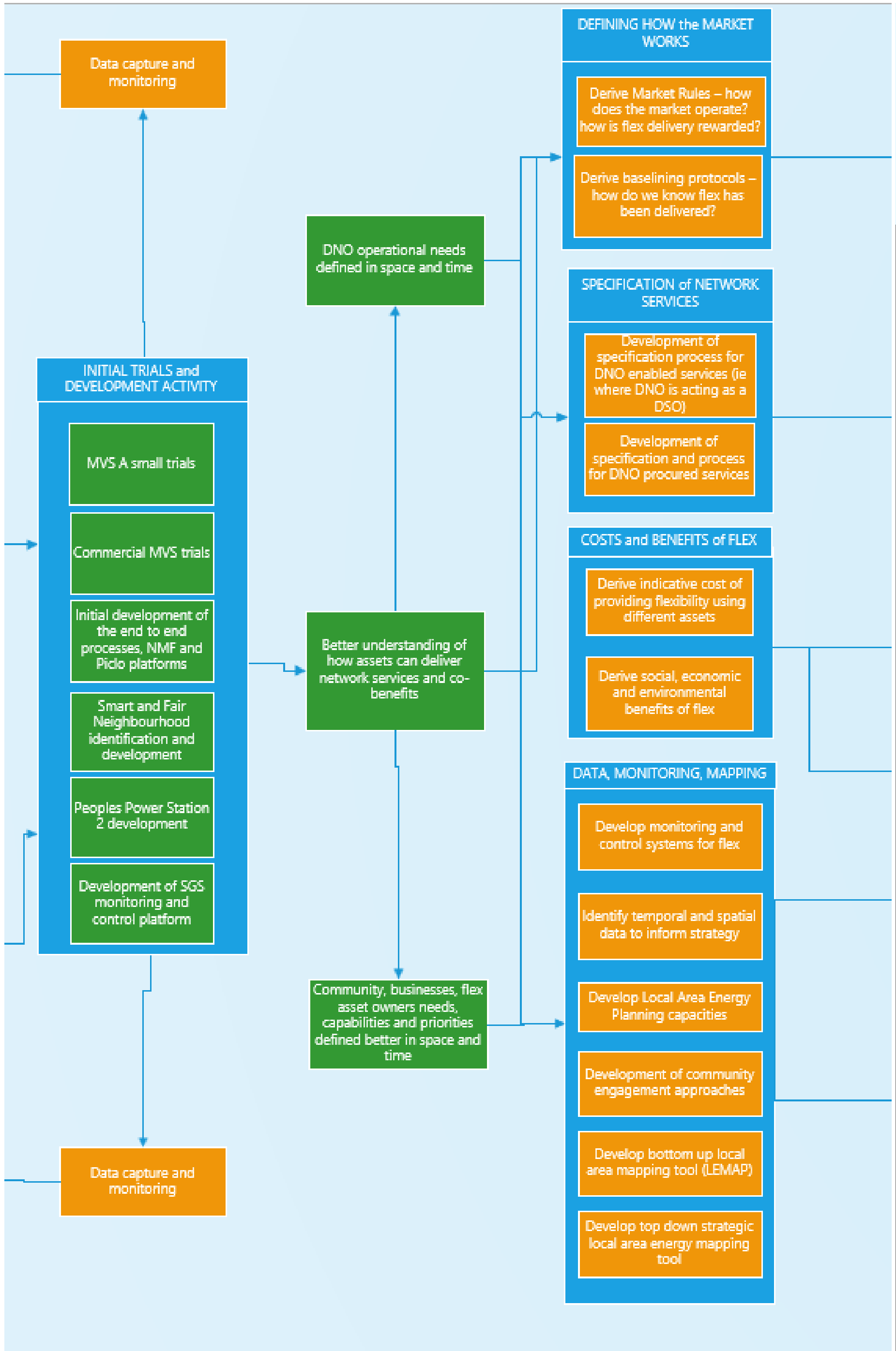


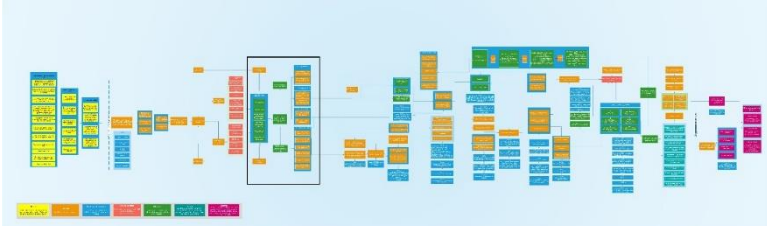
Recognising that smart local energy systems are key to a successful and equitable energy transition, the early part of the LEO began by identifying its key objectives and anticipated outcomes and how these could be weaved into a narrative. Other critical early work was in defining DNO network management needs (spatial and temporal) and also developing methods for assessment of community capability and needs.

Both workstreams lead to thinking about which specific assets owned or potentially controlled by LEO partners could be deployed to create network services. This lead to the formulation of the first iteration of research questions which allowed identification of:

A) the assets required to test those questions (shown in red boxes).
B) the specific DNO services to be tested. These include DNO procured services and Peer to Peer services which are facilitated by DNO systems (also shown in red boxes).

The approach of this programme of work was as light touch as possible, borrowing from agile techniques used in software development: a so called Minimum Viable System (MVS) approach was used to test the ideas, capture learnings from the test and then feed learnings back into the design of the next round of tests. These feedback loops are shown in the "analysis and learnings capture" pathways – leading to further refinement of the research questions.

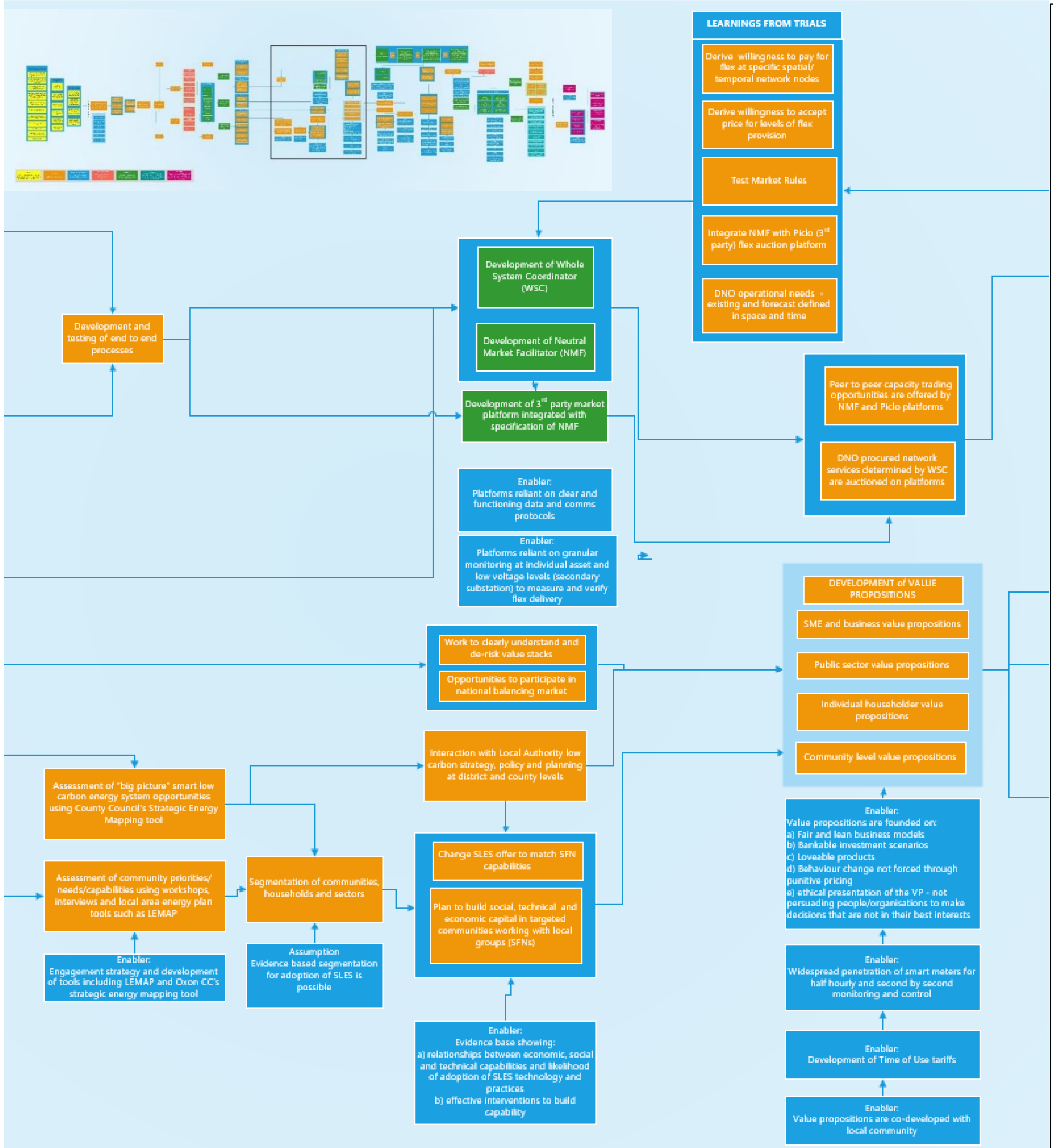




The column of green boxes to signify a set of milestones itemize the initial trials and development activity in the “MVS” and “MVS plus” part of the project. These were:

1. MVS A small trials – tests of the flex potential of assets described in the red boxes in the previous panel: domestic batteries, vehicle to grid aggregation, Sandford hydroelectric, Westgate library HVAC (control of the chillers)
2. Commercial MVS trials – this involved testing of the “Market Stimulation Packages”. These were developed as different routes to bring an asset to the flex market depending on appetite for risk. There was also a very limited amount of funding to get buildings flex ready – e.g. by paying for building management system upgrades
3. SSEN and Origami’s initial development of the end to end process for taking an asset through the process of bidding flex into the market, delivering the flex event and then verifying and settling it.
4. Smart and Fair Neighbourhoods were identified (6 at the time) as exemplar Smart Local Energy systems each with a different technological focus and business model. Governance / management processes established for their development.
5. Peoples Power Station IT platform began to be developed. This monitors energy performance of assets and could ultimately be used to control them. It is mainly targeted at small grid edge assets
6. Development of SGS control and monitoring platform. This platform is already available as a commercial product and was deployed on the larger low carbon assets including Sandford Hydro and Ray Valley Solar

Following work with these assets the project was able to develop a number of workstreams identified in the yellow boxes. These were: a) Defining how the market works including working up rules for how the flex market should operate, benchmarking protocols etc. b) Specification of network services - both DNO procured (e.g. Sustain Peak Management) and DNO enabled (the peer to peer services such as MIC/MEC trading) c) Costs and benefits of flex. Identifying and beginning to quantify transaction costs and capital costs. Also work to better understand social, economic and environmental benefits of flex. d) Data, Monitoring and Mapping. This workstream brought together numerous data related activities: monitoring protocols, local and strategic mapping of energy resources and capabilities and local area energy planning approaches. Activities (a) to (c) primarily feed the development of the local flex market and flex capability of the assets whilst activities in (d) help understanding of the capabilities and resources at the grid edge – i.e. amongst communities and users of the energy system.



Activities aiming to:

- Define how the market works,
- Specify network services,
- Derive economic, social and environmental benefits of flex

are used to help develop the DNO systems that:

a) analyse the spatial and temporal management needs of the network (the "Whole System Coordinator"(WSC))

b) structure the operation of the flex market and the associated platform which hosts the end to end process of market participation (the Neutral Market Facilitator (NMF).

In this part of the project, project partner, Piclo also developed a "third party" platform that interacts with the NMF and creates an alternative space for registering assets and participating in auctions. Key to the success of NMF and Piclo platforms is secure high quality monitoring data to measure and verify flex delivery.

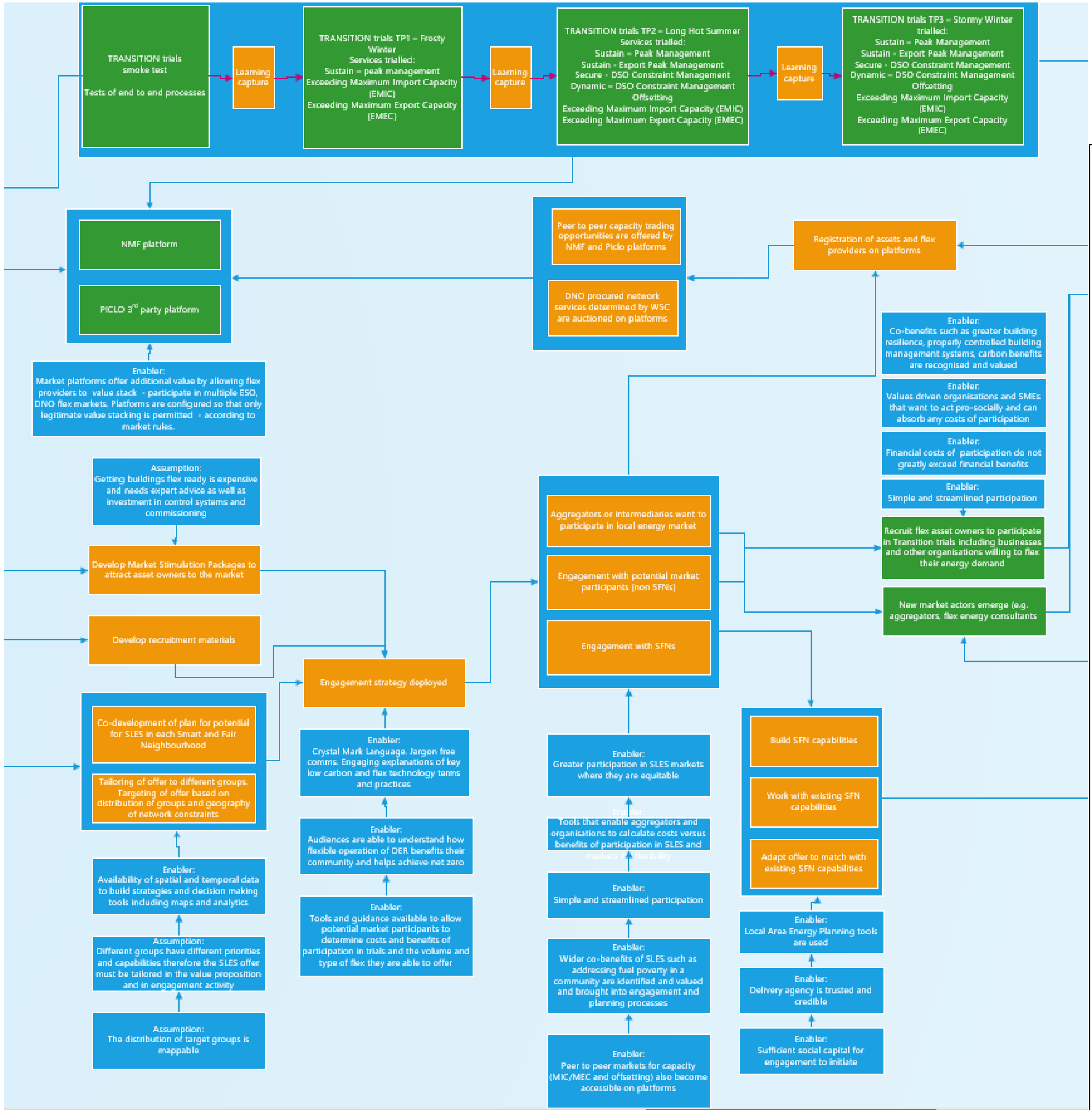
Activities aiming to:

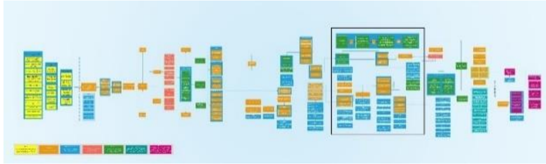
- Derive economic, social and environmental benefits of flex,
- Gather, analyse and present data on grid edge capabilities and resources

are used to:

a) Build support for, and connections with, local government policy, strategy and planning.
b) Co-design local area energy plans and plan Low Carbon Hub's trial Smart Local Energy Systems (SLES), aka "Smart and Fair Neighbourhoods".
c) Develop the value propositions for flex market participation amongst SMEs, Households and the public sector.

Key enablers are: a) a sound evidence base showing the linkages between social, economic and technical capability and ability to participate in SLES. b) fair, loveable and ethical business models c) widespread penetration of smart meters c) availability of supportive tariff structures such as ToU tariffs and d) processes that encourage trust in the value propositions and community ownership over them such as co-design of local energy plans.





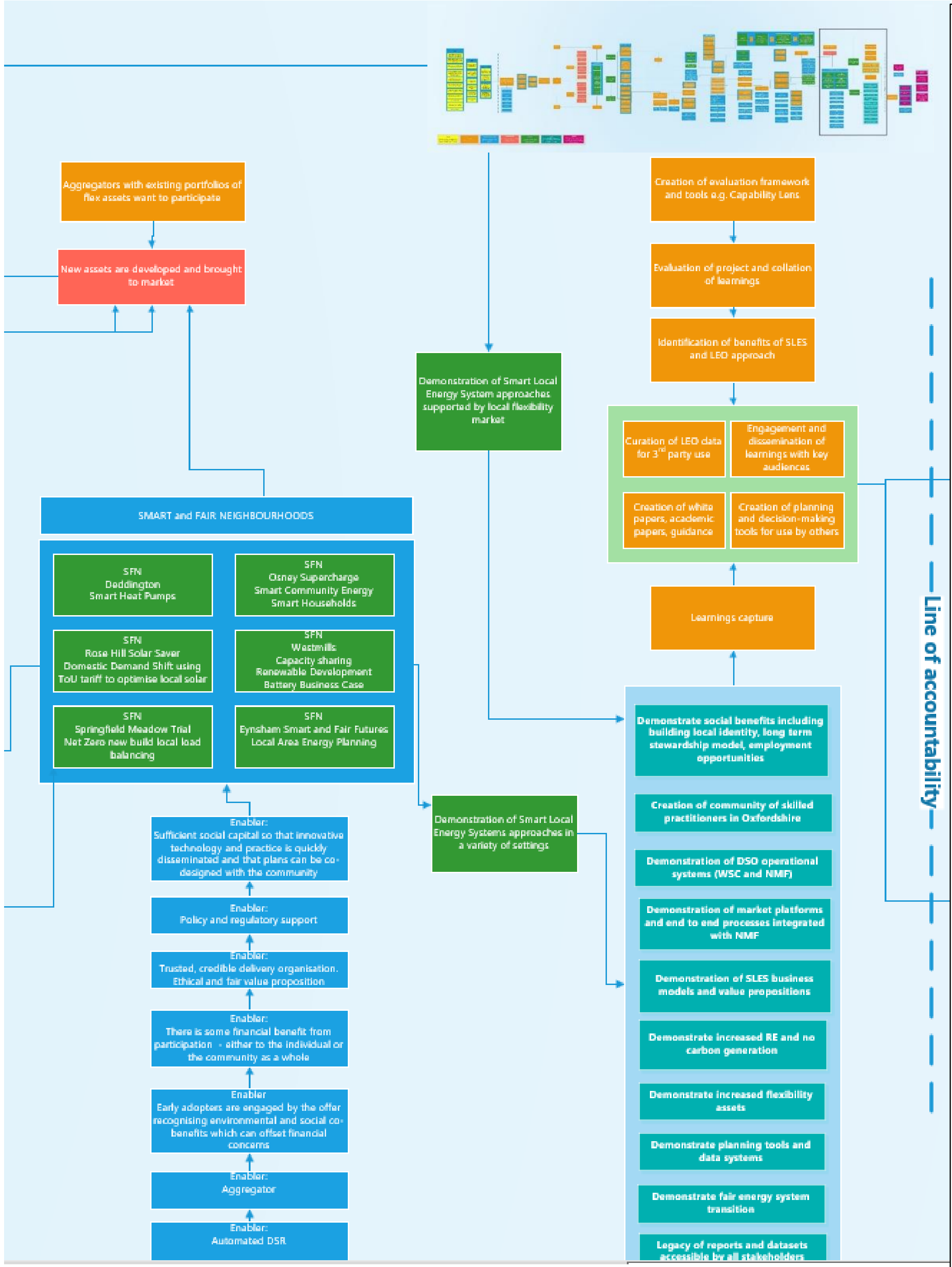
This part of the Theory of Change positions the various TRANSITION trials. These were organized in 4 Trial Periods (TPs):

1. "Smoke tests" – desk based tests of end to end processes
2. TP1 - "Frosty winter" – tests of the service, "Sustain Peak Management" and Exceeding Maximum Import and Export Capacity (EMIC/EMEC) peer to peer services.
3. TP2 – "Long Hot Summer" – additional tests of Secure and Dynamic Constraint management, Sustain Export Peak Management and Offsetting.
4. TP3 – "Stormy Winter" - further tests of TP2 services in a Winter setting.

Learnings from these trials fed back into further development of the Basic Market Rules, design of Piclo and NMF market platforms and analysis of flex market economics (monetized willingness to pay for flex and to deliver it) and a much deeper understanding of the capabilities of assets of different types to deliver flexibility of different types.

Value proposition work led to development of engagement strategy and various communications activities with LEO audiences, including particularly: a) householders living in Smart and Fair Neighbourhoods. b) large organisations capable of delivering flex using their buildings and equipment. c) aggregators.

The aim was to bring more assets and participants to the nascent flex market to create greater competition and liquidity – and explore how compelling the value proposition was to real world actors. Multiple enablers for successful engagement were identified including that the offer was perceived as being fair and ethical and that building operators had the tools and knowledge to robustly assess how much flex they possessed and how much it would cost to deliver it.



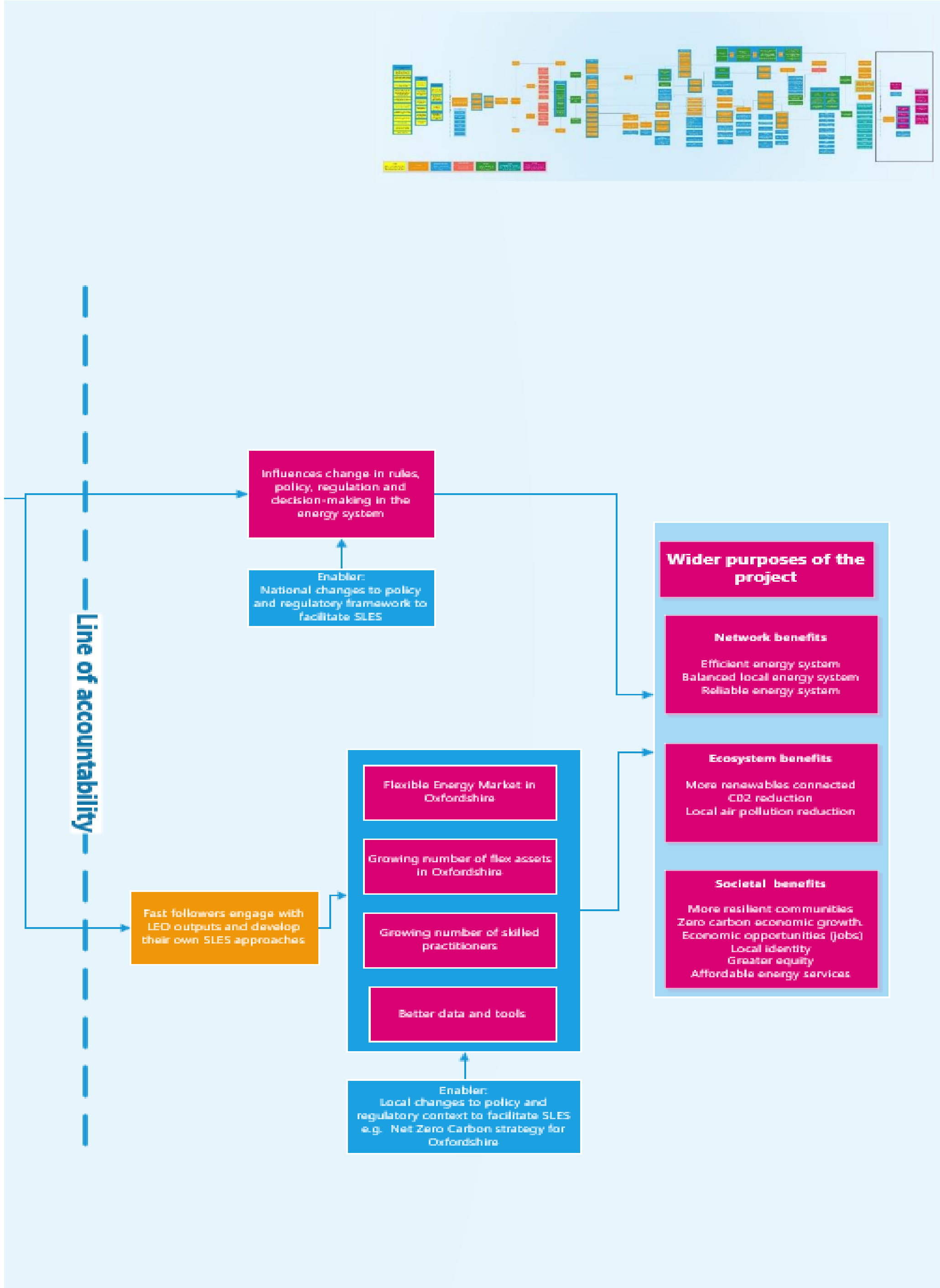
This part of the ToC identifies the 6 Smart and Fair Neighbourhoods developed out of earlier activities and processes. The six SFNs were:

1. Deddington and Duns Tew where LCH aimed to install and, potentially control, smart heat pumps.
2. Rose Hill Solar Saver where residents received an offer to load shift in response to a ToU tariff which would indirectly result in greater consumption of locally generated solar including from panels on residents own roof.
3. Springfield Meadow where there is a need for local load balancing in a new development to ensure DER's can connect.
4. Osney Supercharge where LCH are exploring local load balancing behind a single connection point to the network. DER's installed are a mix of rooftop solar, batteries, local generation from Osney Hydro , electric vehicle charge points, heat pumps and efficiency measures.
5. Westmills windfarm where LCH is exploring capacity sharing with the local community and the economics of a big battery connected to the windfarm
6. Eynsham Smart and Fair Futures where the development of a local area energy plan is under investigation

Multiple enablers for successful SFN's are identified in the blue boxes. These include: sufficient technical, economic and, critically, social "capability" embedded within the SFN communities for the project approaches to work with. Also policy and regulatory support and that the delivery agent is trusted with an ethical and fair value proposition. It is hoped that the ability of certain of these SFNs to participate in local markets for flex will be tested in LEO. Together with the Transition Trials, the SFNs will demonstrate:

- How Smart Local Energy Systems can be enabled and supported by a local flex market
- How SLES can be facilitated using a variety of technologies, planning tools, and types of stakeholder.

The turquoise boxes show the detail of what LEO hopes to demonstrate. Other key activities shown here (in Orange) are the evaluation of these demonstrations and other learnings capture to create a project legacy of reports, guidance, curated data and tools. To structure the learnings capture part of the project a number of frameworks and approaches were developed. These included the creation of an evaluation framework which drew heavily on the Capability Lens developed by the Centre for Sustainable Energy, a code of practice for ethical engagement, a strategy for communications and engagement and a programme of learnings capture which included regular interviews with project partners, writing of ad-hoc reports on specific topics as necessary and annual synthesis reports.



In this final panel the key desired Outcomes of the project are identified. Also listed are the key purposes of the project. Outcomes are defined as the changes to the local and national energy system that LEO wishes to influence or facilitate and should serve the project's wider purpose. As Outcomes rather than Outputs they are to the right of the "line of accountability" i.e. their delivery is beyond the scope and resources of LEO alone. LEO's ToC recognises the following Outcomes:

- Influencing changes in rules, policy, regulation and decision-making in the energy system. This is enabled where there is already a supportive policy and regulatory framework in place.
- Creating the basis for a sustainable flexibility market in Oxfordshire.
- Boosting the number of flex assets in Oxfordshire.
- Growing the number of skilled practitioners: knowledged in the various aspects of creating Smart Local Energy Systems including technical skills related to enabling and delivering flex, planning skills, community engagement and project management skills and financial and business skills.
- A legacy of better specified and helpful data and tools for data curation, analysis and presentation.

Enabling these Outcomes in Oxfordshire will involve changes to the local and national policy, planning and regulatory context and will require other stakeholders, particularly "fast followers" to engage with LEO learnings, adapting approaches and LEO tools for their own context. Strategy documents such as the Net Zero Carbon strategy for Oxfordshire and the ZCOP initiative are supportive of LEO's role in influencing change in the energy system. Outcomes deliver the wider purposes of the project which are a demonstration of how a SLES supported by a local market for flexibility can deliver:

- Network benefits: an efficient, resilient and balanced local energy system which is more cost effective to maintain and operate.
- Ecosystem benefits: with more low carbon energy resources connected at low voltage levels for the network installed in tandem with energy efficiency measures to drive down carbon emissions.
- Societal benefits: greater local sustainable economic activity promoted by the local energy system, creation green jobs, building a greater sense of place, local identity and community spirit, homes and businesses which perform better and are more comfortable places to live and work, more opportunities for local communities and households to act on climate change and build stronger, more resilient neighbourhoods.