Pathways to gain recycled P materials into new value chains

Technology for the recovery of mineral P and mapping of market opportunities for reuse of recycled products

Støttet av: Trøndelag fylkeskommune, Innovasjon Norge

The VISION

New value chains for recycled phosphorus to a market willing to pay

Project goals

- Develop technical solutions to recycle mineral P into products with a positive value
- How to create knowledge sharing for faster development of new regulations and clear quality requirements adapted to sustainable recycling of resources (important for recycled products to have good value)
- Green finance for selecting sustainable technology solutions adapted to the EU's taxonomy regulations ⇒ value chain for recycled phosphorus

Project parters

Project owner:

- Ecopro AS: General manager Tore Fløan https://ecopro.no/

Industry partners:

- Yara AS: Director Circular & Specialty Product, YARA Norden, Knut Røed https://www.yara.com/
- Solberg Industry AS: Owners and leader Halfdan Solberg & Business Development Manager Sverre Lorentsen https://www.solbergindustri.no/
- Danish Bank: Bank Manager, Coporate Market Trøndelag, Rolf Einar Pedersen og sustainabilty expert Daniel Brenden https://www.danskebank.no

Branches and clusters:

- Norwegian Water Association – Counsellor Arne Haarr https://norskvann.no/ (representing Norway in European Federation of National Associations of Water Services, EurEau
- NCE aquatech cluster – Project coordinator Morten Andersen https://aquatechcluster.no/
- Civac Circular values cluster – Cluster leader Trond Norum https://civac.no/

R&D partners:

- NIBIO – Project leader and Senior Scientist Trine Eggen https://www.nibio.no
- RISE (Research Institutes of Sweden) – Project leader Elin Kusoffsky og Seksjonsjef Gustav Rogstad https://www.ri.se/sv

Reference group
Actors from sewage sludge branch and food sea industry

Waster water treatment plants

- Tønsbergs renseanlegg
- Oslo kommune renseanlegg
- Bergen kommune renseanlegg
- IVAR

Sea food industry

- Andfjord Salmon
- Multigen

Motivation for recycling P to new value chains (1)

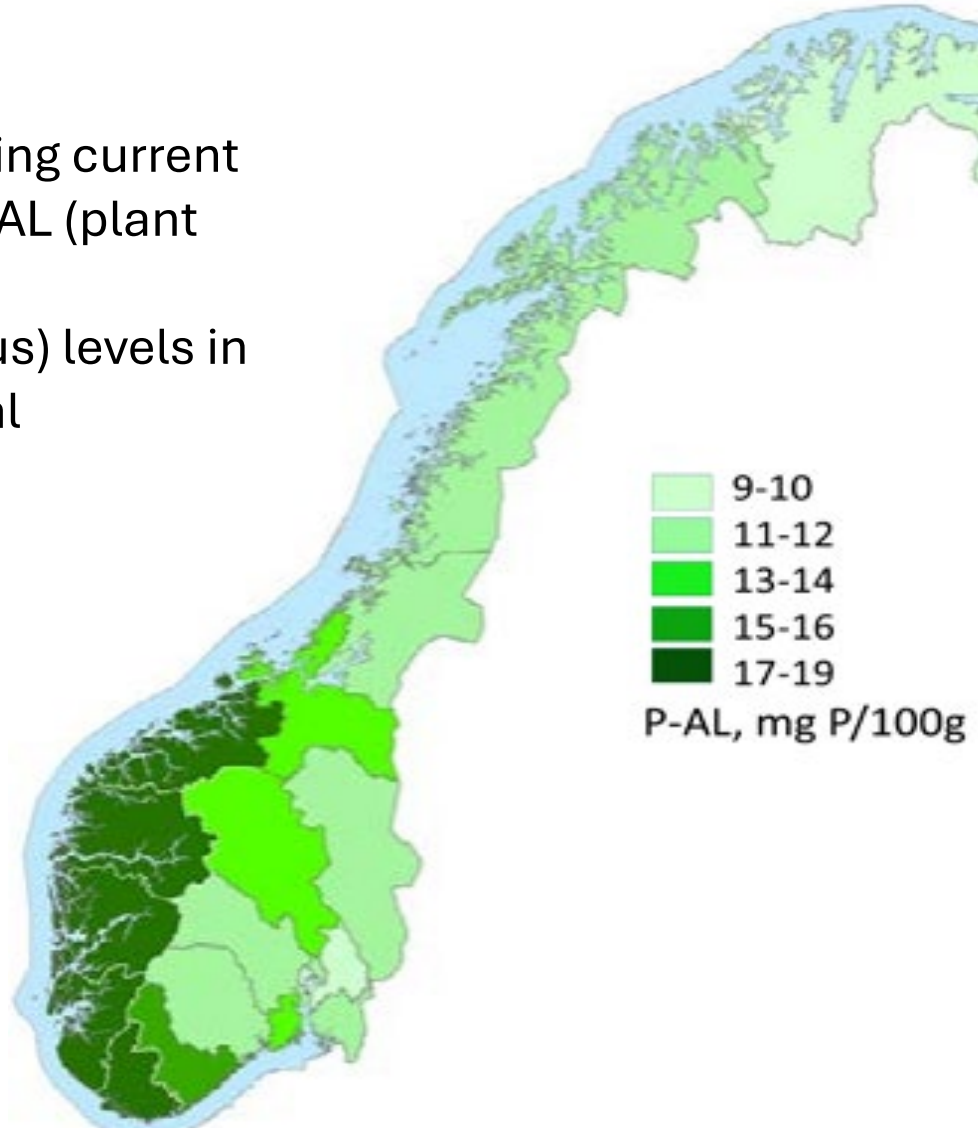
Strighter regulation

- **The EU's Industrial Emission Directive (IED)** and emission limit values according to BAT ⇒ increasing the amounts of sludge that the industries have to handle. The regulation will apply to all forms of industrial discharges, for instance slaughtering and processing industry
- **The EU's Urban Wastewater Treatment Directive** is in the process of being approved ⇒ e.g. more stringent treatment requirements for pollutants, including proposals for maximum limit values (MLVs) for pharmaceuticals ⇒ in general, the proposed directive is a major challenges and costs for handling sewage sludge for Norwegian municipalities
- **Norwegian fertiliser regulations** ⇒ hearing process ⇒ reducing the use of phosphorus in agriculture and including MLVs for four organics contaminants
- **EU Taxonomy regulations**, an important economic carrot for choosing sustainable solutions & green financing - recycling of critical nutrients is important.
- **The EU's Sludge Directive,** possibly revised?

Motivation for recycling P to new value chains (2)

Fertiliser regulation Proposed amount of P applied per da per year

Map showing current average P-AL (plant available phosphorus) levels in agricultural soils



In soil with plant available P

P-AL > 15 ⇒ do not need to add P-fertiliser

Motivation for recycling P to new value chains (3)

Pressure on the sale of P-rich residual raw materials in agriculture

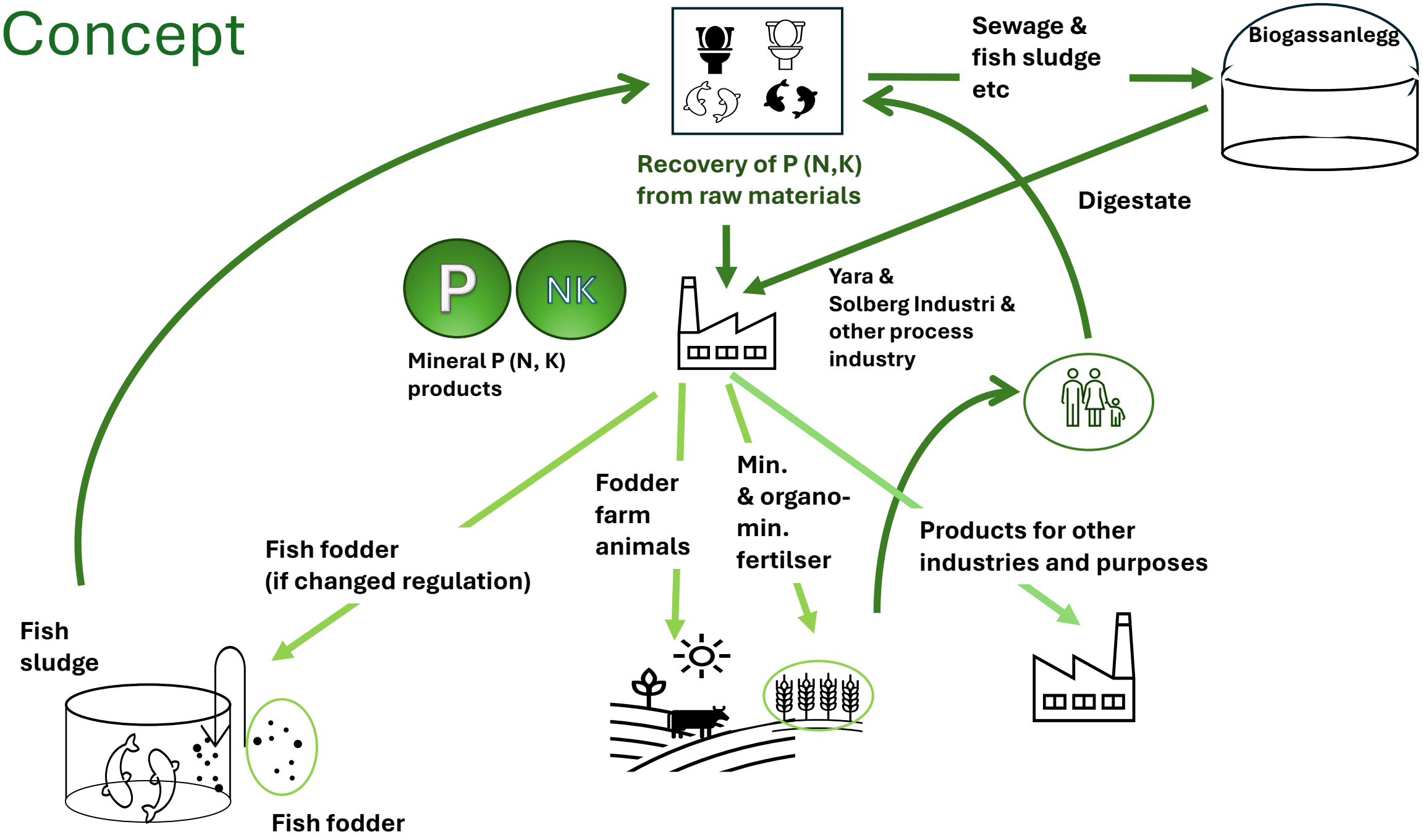
- **Farmers - own fertiliser** ⇒ dependent on using own fertiliser to maintain animal population (spreading area)

- **Non-separated & liquid fraction biowaste** (livestock manure and food waste) from
  - facilities where farmers have an agreement to deliver fertiliser and get back biowaste
  - facilities they do not deliver fertiliser to, but already have agreements with reception (nearby facilities)

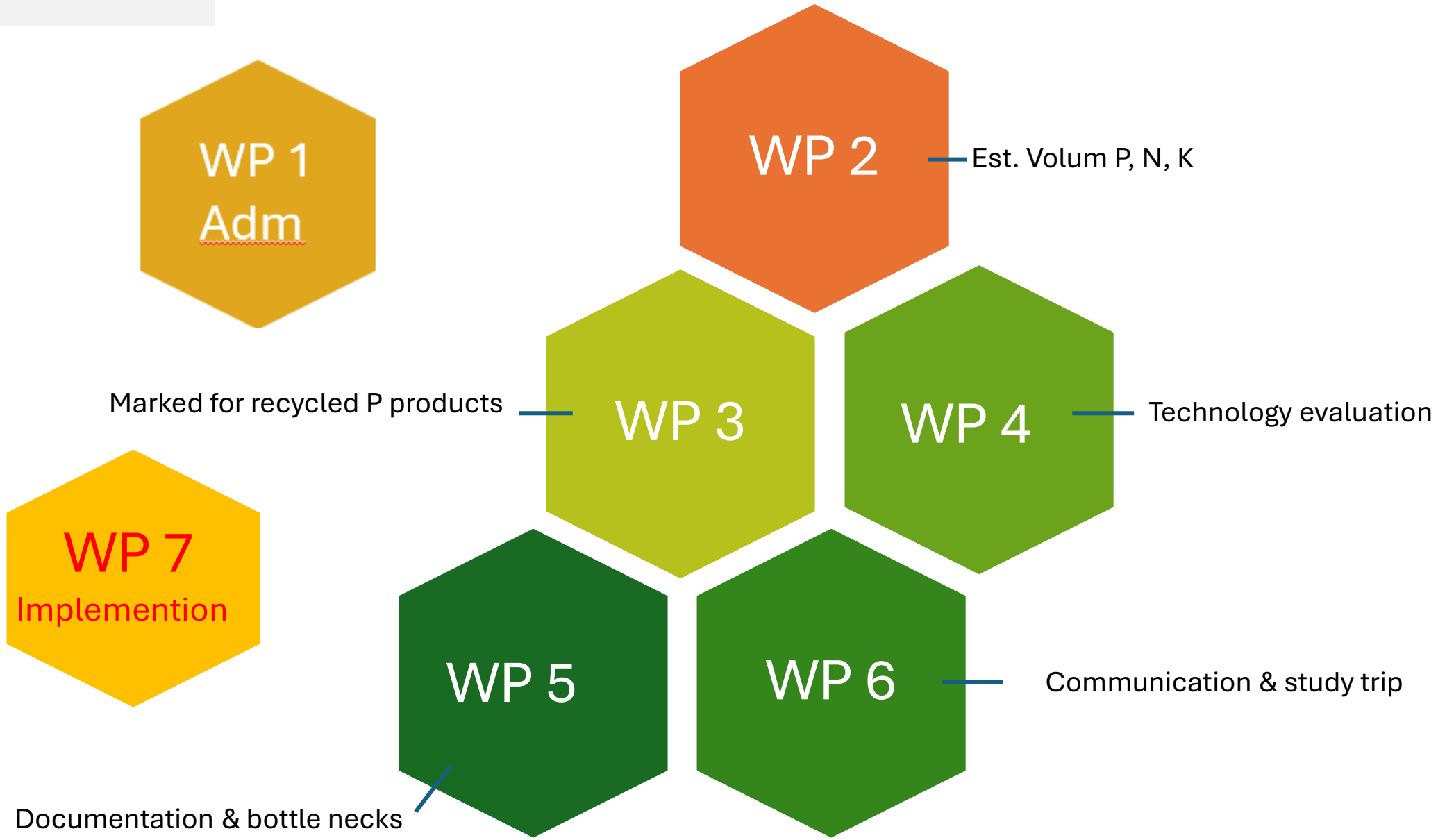
- **Dewatered sewage sludge - and biowaste with sewage sludge**
  - have restrictions on use (vegetables, meadows) and are mainly used for grain
  - is transported from fertiliser-rich areas in Western Norway to Eastern Norway

- **Compost** from food waste, fertiliser, biowaste with different substrates, etc. Everything else comes in addition

Concept


Sewage &
fish sludge
etc
Biogassanlegg
Recovery of P (N,K)
from raw materials
Digestate
P
NK
Mineral P (N, K)
products
Yara &
Solberg Industri &
other process
industry
Fodder
farm
animals
Min.
& organo-
min.
fertilser
Products for other
industries and purposes
Fish fodder
(if changed regulation)
Fish
sludge
Fish fodder

Work packets



WP1 - Project management

Resp.	Main executors	Act. #	Description of activity	Task #	Task description	Output	Active partners
Ecopro/ NIBIO	NIBIO/ Ecopro	1.1	Administration	1.1.1	Contract Ecopro and financial partners	Signed contracts and consortium.	NIBIO/ Ecopro
				1.1.2	Consortium agreement	Signed consortium agreements.	NIBIO/ Ecopro
	NIBIO/ Ecopro	1.2	Project organisation	1.2.1	Organisations/structure	Established steering-, reference- and project groups, plan for cooperation	NIBIO/ Ecopro/RISE
				1.2.2	Working platforms		NIBIO / RISE + all
	NIBIO/ Ecopro	1.3	Project coordinating/leader	1.3.1	Project leading according to project plan		NIBIO/ Ecopro/ RISE

- Establishing project
- Project leading
- Coordinating activites

WP 2: Identify volumes of P (N, K) – recovery potential

Resp.	Main executors	Act. #	Description of activity	Task #	Task description	Output	Active partners
NIBIO	Norwegian Water Association/ NCE aquatech cluster	2.1	Mapping volumes & material flow P (N,K)	2.1.1	Collect data & information about volumes	Volume of secondary raw materials based on sewage sludge, primary with help from Norwegian Water Association, and fish sludge and other relevant resources from aquaculture industry. Knowledge about P (N,K) concentration in material flows of selected raw materials and processes	Norwegian Water Association/NCE aquatech cluster /Ecopro/NIBIO
	RISE	2.2	Prelim. theoretical recov. pot. PNK	2.1.2	Literature review-based est. recovery pot. P (N,K) - est. Recov. Pot.	Preliminary estimate of recovery potential.	RISE

Delivery:

- Estimate of volume of raw materials based on sewage sludge (contribution from Norwegian Water Association) and of raw materials from the seafood industry (contribution from NCE aquatech cluster).
- Knowledge of P, N, K levels in selected raw materials and processes
- Preliminary estimate of the recycling potential of P, N, K

Status:

- **Act. 2.1: Finalised overview of sewage sludge volumes and of seafood industry volumes**
- Act. 2.2. In progress

WP 3: Product, market and willingness to pay

Resp.	Main executors	Act. #	Description of activity	Task #	Task description	Output	Active partners
NIBIO	RISE/NIBIO/Yara/ Solberg	3.1	Realistic mineral & organo-mineral PNK products	3.1.1	Eval. Recov. Pot. Based on existing marked products	Make a list of mineral P (N, K) products for agriculture and chemical industry	Yara/Solberg/ NIBIO
				3.1.2	Identify product agriculture marked is interesting	From the list in 3.1.1, choose products that are most realistic, based on existing sales numbers (demand)	Yara/Solberg/ NIBIO
				3.1.3	Identify product other industry marked is interesting	From the list in 3.1.1, choose most realistic product based on demand	Yara/Solberg
	YARA/ Solberg/NIBIO	3.2	Pot. customers/segments of selected products	3.2.1	Mineral products - Yara/Solberg Industry	Identify relevant customer segments for mineral, organo-mineral P products	Yara/Solberg
	YARA/ Solberg/NIBIO/ RISE	3.3	Evaluate/judge market value for selected product	3.3.1	Evaluate/judge market value for selected product	List of selected realistic mineral P products & organo-mineral P products including approximate market value for further evaluation	Yara/Solberg/ NIBIO

Delivery:

- Prioritise end products with market potential in agriculture and the chemical industry
- Identify customer segments for different products and estimated market value

Status:

- **Act. 3.1:** **Finalised**
- Act. 3.2. & 3.3 Completed first assessment

WP 4: Techniques and device operations

Resp.	Main executors	Act. #	Description of activity	Task #	Task description	Output	Active partners
RISE	RISE/YARA/ Solberg	4.1	Technology-tracks for selected products	4.1.1	Estab. Overview of techn. Processes/tracts for prod. selected products	Gross list of realistic technology-tracks/processes for further evaluation	RISE
				4.1.2	Identify known R&D and Demo. Efforts	Leads for RISE to follow	Yara/Norwegian Water Association/NCE aquatech cluster
				4.1.3	Quality check list of technol.	Feedback on gross list	Yara/Solberg
	RISE/YARA/ Solberg	4.2	Suppliers for technology-tracks (>TRL 6)	4.2.1	Estab. contact developers Tech. Tracts/processes	List of contact to developers of net-listed relevant technology-tracks/processes	RISE
				4.2.2	Contact with developers	Contact leads for RISE to follow + ensuring developer that there is a real industry interest	Yara/Norwegian Water Association/NCE aquatech cluster
	RISE/YARA/ Solberg	4.3	Specify the unit operations needed for each technology-tracks	4.3.1	Detail possible tech. processes relat. diff. Operat. Parameters.	Sequenced block diagram of main unit operations for each relevant technology-track/process including, if possible, example mass/energy balance.	RISE
	RISE/YARA/ Solberg	4.4	Eval. prod. quality from technology-tracks	4.4.1	Together with developers - estim. Prod. Quality & quantity	Estimate of possible product quality and yield for their relevant combination of secondary raw materials and technology-track/process - to be used to fine tune outputs from WP3.	Yara/Solberg
				4.4.2	Tech. judgements & calcul. facilitate estimations of product quality and yield	Technical advice and calculations for product quality and yields estimation	RISE
	YARA/DB	4.5	Eval. EU taxonomy technology-tracks	4.5.1	EU Taxonomy regulations with relevance	Description of potential effects of the EU Taxonomy regulations on evaluated combinations of secondary raw materials and technology-track/process.	DB

Delivery:

- Lists of technologies and end products. Information about suppliers of the most relevant technologies.
- Create flowcharts with the most important operational processes in different technology tracks. First estimate and then calculate product quantity and quality for relevant combinations of technology tracks.
- Evaluate EU taxonomy regulations against selected technology tracks/processes

Status:

- Act. 4.1. In progress

WP 5: Characterisation, data sharing, regulation, bottle necks – new recovery estimate

Resp.	Main executors	Act. #	Description of activity	Task #	Task description	Output	Active partners
RISE	Yara/Solberg Industri/Norsk Vann, NCE, NIBIO	5.1	Charact. of secondary raw materials	5.1.1	Organising analysis characterisation	Characterisation of secondary raw materials will be use for evaluation in WP 3 and 4	NIBIO/YARA/ Solberg
	NIBIO, Norsk Vann, NCE	5.2	Identify unwanted substances	5.2.1	Review unwanted substances literature + dialog	Summarise unwanted substances **of risk related to regulation** and limit values for selected secondary raw materials. To be coordinated with VKM work.	NIBIO, Norsk Vann, NCE quatech cluster + extern + authority (Mattilsynet, Miljødirektoratet, andre? + VKM)
				5.2.2	Decide analysis to perform	Decide which contaminants to analyse for (and which lab.) and for which secondary raw materials.	
	NIBIO/Norwegian Water Association/NCE aquatech cluster	5.3	Analyse selected raw materials for selected contaminants	5.3.1	Organising analysis contamination	Content of selected unwanted compounds (concentrations and frequency) in selected secondary raw materials of special interest in the project.	NIBIO, Norsk Vann, NCE + Miljødirektoratet
				5.3.2	Data interpretation	Information for use in activity 4, particularly in 4.5.1	NIBIO/Norwegian Water Association/NCE aquatech cluster (VKM, Miljødirektoratets, Mattilsynet)
	NIBIO	5.4	Organisation for sharing data & information	5.4.1	Data & knowledge sharing authority/industry/R&D	Suggest a system for sharing data and information.	NIBIO, Norsk Vann, NCE + eksterne + forvaltning (Mattilsynet, Miljødirektoratet, andre? + VKM)
	RISE+all	5.5	Charact. possible obstacles	5.5.1	Obstacles list	Identify obstacles which have to overcome/handled to succeed.	NIBIO (RISE) (together with all)
	RISE+all	5.6	Final calibrated recovery pot. PNK	5.6.1	Adjusted recovery potential	Empirically supported P (N, K) recovery potential. Used as input to policy discussions and to gauge the strategic national/regional commercial value of the value chain.	RISE (together with all)

Delivery:

- Characterisation of raw materials i) suitability as raw materials in various technology tracks, and ii) content of pollutants and assessment against current or possible future regulations
- Organisation of data, knowledge sharing ⇒ required for new regulation for recycled products. Challenges.
- Calibration of the recycling potential of P, N, K

Status:

- Act. 5.1. & 5.3 Started recently
- Act 5.2 & 5.5 In progress

Knowledge sharing

Establish regulations for recycled products - need for quality requirements for new products

The topic has also been raised by the Scientific Committee for Food and Environment (VKM), which recognises how important this is for the implementation of risk assessments and the development of regulations to safeguard the environment and health when using recycled products.

MOTKULTUR DEBATT

NATIONEN

Viktigheten av deling av kunnskap

Sirkulærøkonomi fordrer spleiselag om ny kunnskap og deling av kunnskap.

Trine Eggen,
medlem av Vitenskapskomiteen for mat og miljø
Harald Gjein,
direktør, Vitenskapskomiteen for mat og miljø

FØR NÆRINGSLIVET kan resirkulere ressurser for å utvikle nye produkter, er det behov for grundige vurderinger av hvilke effekter resirkulering kan ha på helse og miljø. Da trenger vi sterkere satsning på generering og deling av kunnskap og data, på tvers av fag og sektorer.

Vitenskapskomiteen for mat og miljø (VKM) gjør risikovurderinger innenfor området trygg mat, matproduksjon og miljø. I løpet av de siste 20 årene har VKM gjennomført flere risikovurderinger hvor vi har vurdert mulige negative effekter på mennesker, dyr og miljø hvis jorda blir tilført ulike gjødselvarer og jordforbedringsmidler.

Slike vitenskapelig baserte vurderinger krever mye data og kunnskap. Det gjelder blant annet data om hvilke miljøgifter som allerede finnes i jord og gjødselprodukt og i hvilke konsentrasjoner, og data og kunnskap om miljøgiftenes egenskaper, som har betydning for overføring til miljøet og til fôr og mat.

Det gjelder data og kunnskap om regionale variasjoner i jordegenskaper og i klima. Vi trenger også kunnskap om hvor skadelig ulike miljøgifter er for organismer som lever i jord, vann og sedimenter, og hva som er tålegrensen for inntak av miljøgifter, både for dyr og mennesker.

Det er også aktuelt å stille spørsmål om hvordan klimaendringer kan påvirke risikobildet. Mer nedbør og flere intensive nedbørsepisoder gir økt avrenning fra jord til vannmiljø. Det kan føre til økte konsentrasjoner av miljøgifter, og ha negative konsekvenser for organismer som lever i vann, men også føre til opphopning av miljøgifter i fisk, og dermed øke eksponeringen for miljøgifter hos mennesker.

Det er ikke uvanlig at tilgangen til datagrunnlag er mindre enn man ønsker til en risikovurdering. Det kan være ulike årsaker til det. I noen tilfeller mangler vi nødvendige data. En annen årsak er at datagrunnlag ikke er tilgjengelig for risikovurderingsarbeid før det har blitt publisert i et vitenskapelig tidsskrift, eller det kan være at vi ikke har tilgang eller kjennskap til alle relevante databaser.

Datamangel øker usikkerheten i vurderingen. Derfor er det viktig at kunnskap som allerede finnes, gjøres lett tilgjengelig for dem som utfører vurderingen. Å lete etter data krever mye tid og ressurser, og kunnskap som ville ha styrket risikovurderingen kan gå tapt.

Det må være mulig å finne løsninger for å bruke offentlig finansierte data i risikovurderinger, uten at det er til hinder for at forskningsmiljøene som har fremskaffet dataene, kan publisere dem senere.

Etter å ha utført risikovurderinger innenfor mat, helse og miljø i snart 20 år, er det vår erfaring er at det er helt nødvendig at vi deler på kunnskap og data som vi trenger til den type arbeid. I tillegg trenger vi ny kunnskap og samarbeid på tvers av sektorer og fagområder, også samarbeid for å finansiere dette. Det gjelder ikke minst for å løse utfordringene vi står overfor for å lykkes med sirkulær økonomi.

Den type spleiselag ser man for eksempel i MAREANO-programmet. Programmet, som har pågått siden 2005, skal øke kunnskapen om havbunnen, og bidra til en kunnskapsbasert og bærekraftig forvaltning og næringsutvikling.

Programmet finansieres av Nærings- og fiskeridepartementet og Klima- og miljødepartementet. Den øverste ledelsen utgjøres av styringsgruppen med representanter fra fire departementer, og Norges geologiske undersøkelse, Havforskningsinstituttet og Kartverket sjødivisjonen står for den daglige driften.

For å få fart på kunnskapsdeling og fremskaffe ny kunnskap som er nødvendig for å resirkulere ressurser til mat og fôr, kan en mulig løsning være å etablere et tilsvarende program som MAREANO. Programmet og samarbeidet må inkludere fagekspertise og støttes av forvaltning innen områdene helse, mat, fôr, miljø og næring..

WP 6: Communication and option - study trip(s) to existing P recovery plants

Resp.	Main executors	Act. #	Description of activity	Task #	Task description	Output	Active partners
NIBIO	All	6.1	Workshops, seminars, information etc	6.1.1	Workshops & seminar	Communication and gaining knowledge during the project.	NIBIO/RISE
	Willing	6.2	Study trips to P recov. plants	6.2.1	Study trips	Gaining in-depth understanding of selected technologies in order to evaluate how this can be used/adjusted for our purpose.	NIBIO/RISE

Delivery:

- Communication
- If of interest, visit selected plants to look at technology(s)

Status:

- Act. 6.1. Workshop, seminar and information/communication
  Joint meetings with members of Norwegian Water, NCE aquatech cluster and civa (min. 2 duringthe project
  Press release in Norwegian and English distributed
- Act. 6.2. Yet no plans

WP 7: The road to implementation

Resp.	Main executors	Act. #	Description of activity	Task #	Task description	Output	Active partners
RISE	All	7.1	Compilation of high-level techno-economic analysis	7.1.1	CAPEX & OPEX	High-level, example-based CAPEX and OPEX estimations.	RISE
				7.1.2	Balance plant & operation cost	High-level, example-based estimate of other costs that affect production cost.	RISE
				7.1.3	Project param./product. cost ® sensitivity analysis	2 - 4 project parameters that will undergo sensitivity analysis	RISE
				7.1.4	Project param. ® sensitivity analysis	Advise on important project parameters	All
				7.1.5	Techno-economic analysis (1-3 products)	High level, example-based range of production costs for 1-3 selected mineral P products & organo-mineral P products based on processed secondary raw materials	RISE
	All	7.2	Description of a possible path to realization	7.2.1	Current status & future targets (1-3 cases)	Current status and future targets of the most important project parameters (technical, economic/market or regulatory) to achieve commercial feasibility (1-3 example cases).	RISE+
				7.2.2	Decide how to process further	Discussions, input and expert opinions	All

Delivery:

- Conduct techno-economic analysis: CAPEX & OPEX, assess process parameters, product cost, sensitivity analysis for selected technology tracks
- Describe status and future opportunities for 1-3 realistic technology tracks
- Discussions and choices for the way forward

Status: Starts when we prioritised 1-3 realistic technology tracks based on knowledge from WP 2, 3, 4 and 5

Financing

Innovation Norway Trøndelag & Trøndelag County	2.682.126 NOK
In-Kind (hours)	2.141.250 NOK
Cash from actors	540.875 NOK
Purchased external services, analysis, knowledge and other project costs	3.223.000 NOK
Total economy frame	5.364.250 NOK