

COupling DIgital Twins

Van technologie naar praktijktoepassing

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innovation
for life



Het ecosysteem van digitalisering

Bronnen van informatie

- **Sensoren** – Klimaat, plant, substraat, weer
- **Modellen** – Plant, kassystemen, weer
- **AI** – Computer vision, data analyse & voorspellingen

Kansen & uitdagingen

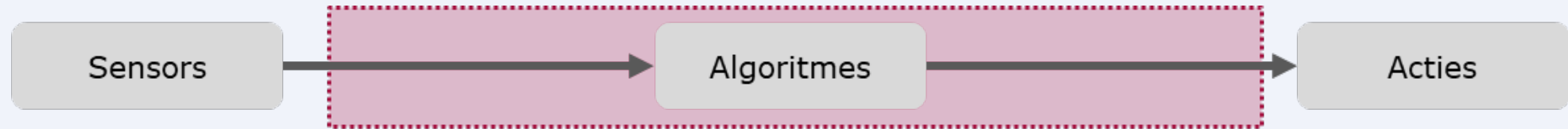
- Van data naar informatie
- Connectiviteit van platformen – holistische aanpak
- Voorspelling vs. real-time feedback

Digital Twin

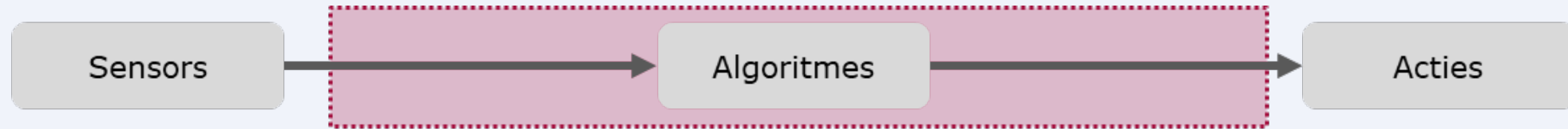
- **Live** – model gevoed met real-time data
- Fysiek systeem **monitoren**, data gebruiken om te **simuleren**, adviseren en te **optimaliseren**.



Digitale landschap



Digitale landschap



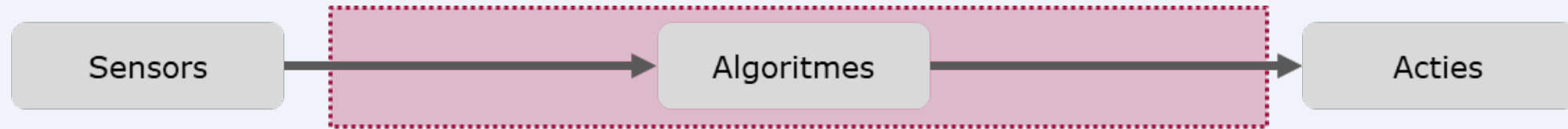
Data partners



Application partners



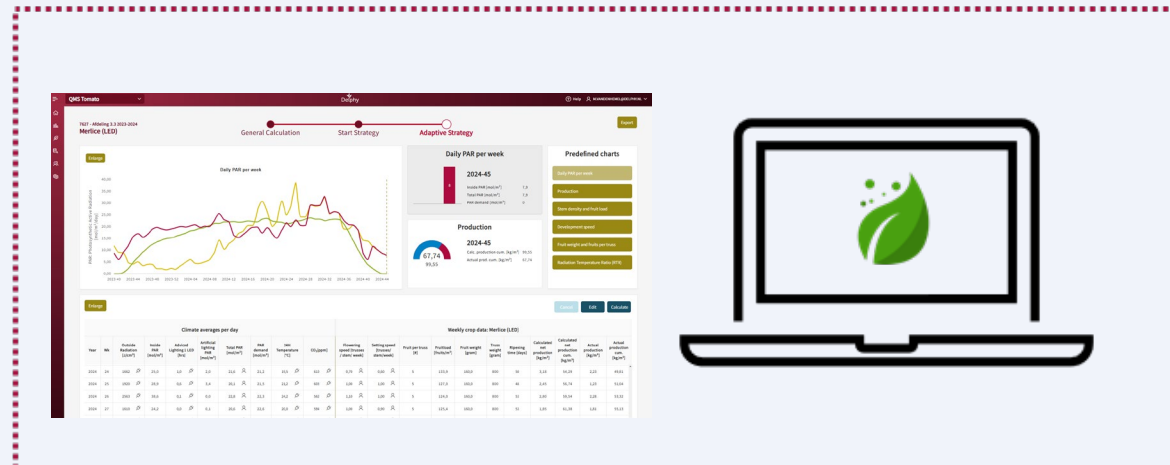
Digitale landschap



Data partners



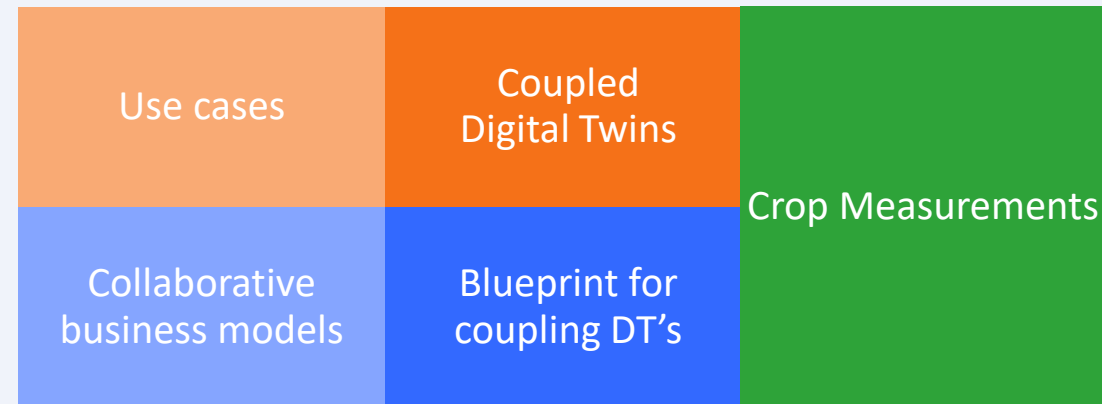
CODIT (digital twin)



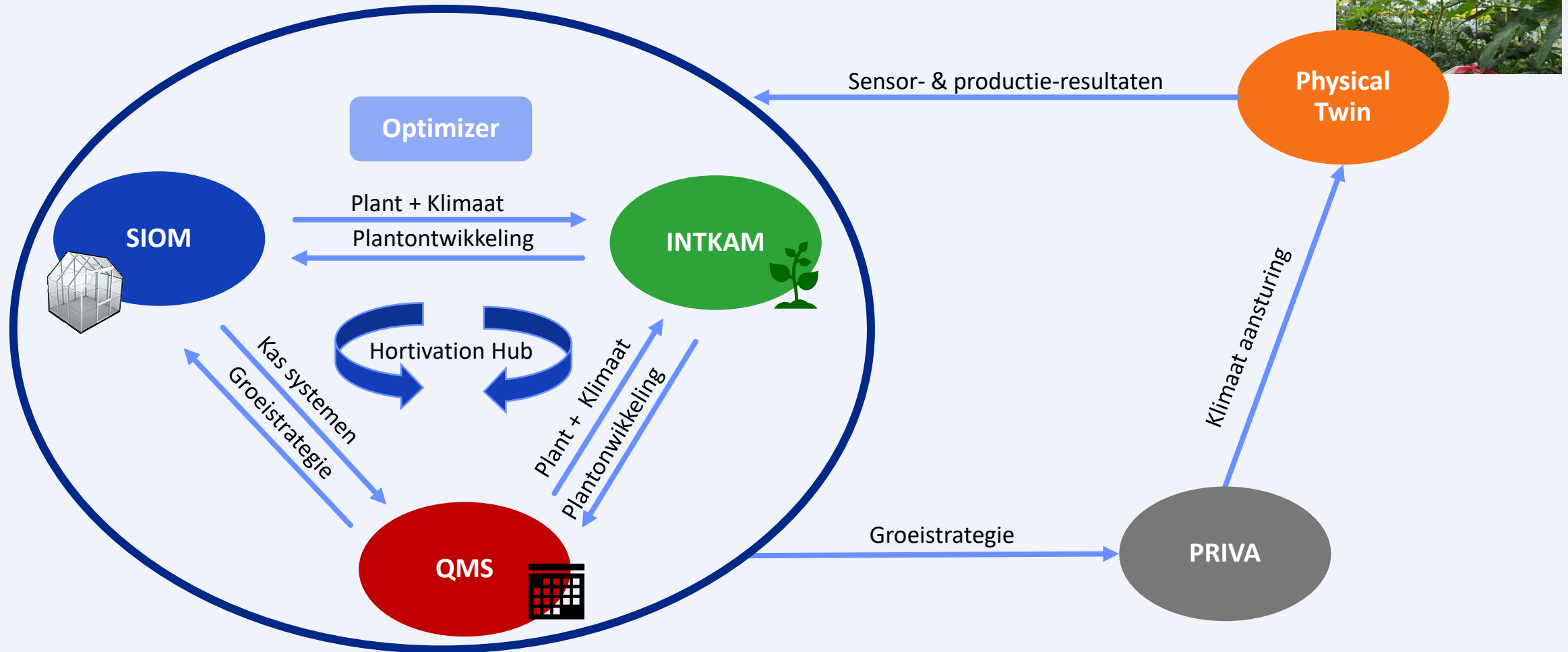
Application partners



Setup & Doel

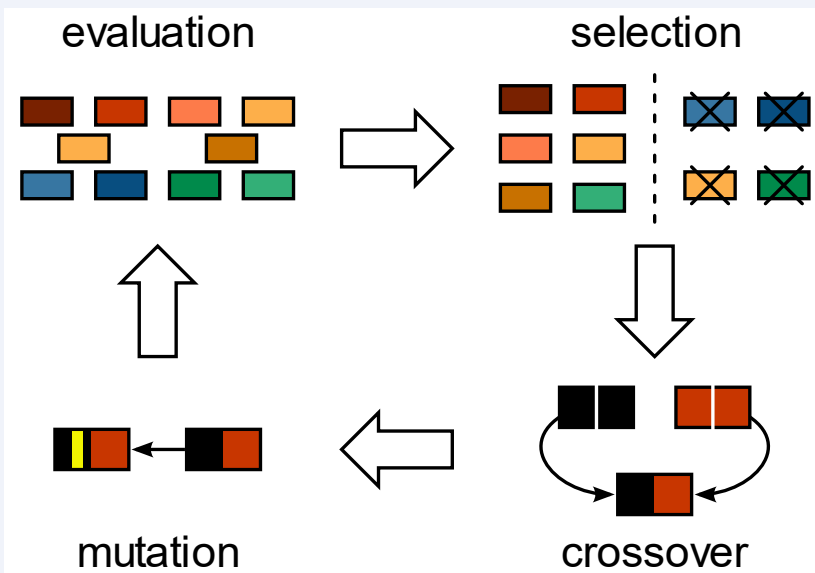


Coupled Digital Twins – Model interacties



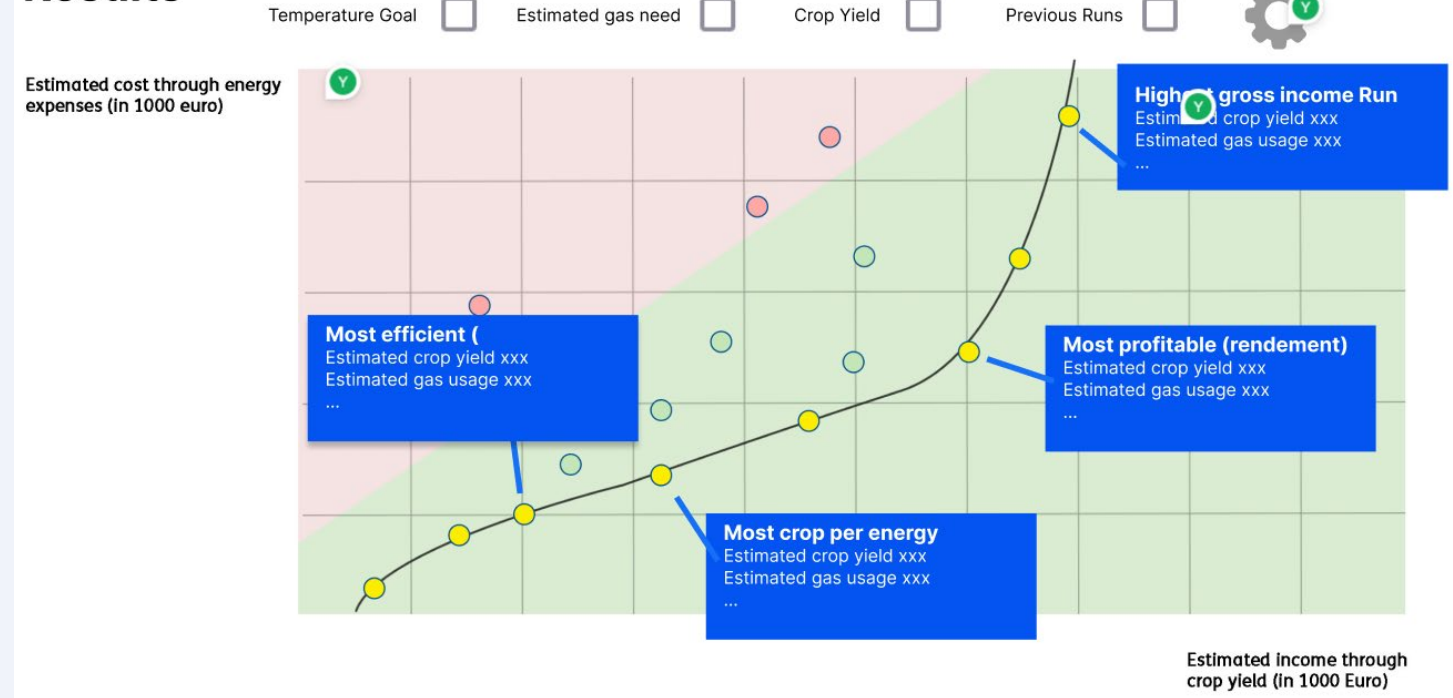
Optimaliseren met Evolutionaire Algoritmes

Multi-objective evolutionair algoritme



Output: Meerdere 'gelijkwaardige' optimale oplossingen (het Pareto front)

Results



CODIT Dashboard

INSTRUCTIONS

GROWING STRATEGY

GREENHOUSE

INSTRUCTIONS

GREENHOUSE SETTINGS

GROWING STRATEGY

CLIMATE CONTROL SETTINGS

RESULTS AND VISUALISATION

ECONOMIC INPUT

HISTORIC AND REALIZED

Set filters to show results in graph

Username

Description

APPLY FILTERS

Results for calculated scenarios

Click on a datapoint in the graph to fill the fields below.

Selected Scenario

Gas usage

64.78 m³/m²

Electricity usage

211.20 kWh/m²

SIOM Fruit Fresh Weight

92.02 kg/m²

Username

Seymour

Description

Siom only test

Date and Time

2024-04-26 11:13:31

SHOW DETAILS FOR PRIVA COMPUTER INPUT

Stored predictions (sorted by time):

GET ALL STORED PREDICTIONS (INCLUDING SIOM-ONLY)

Themes

Production

Temperature

Lighting

CO₂

Comparison Between Historic Predictions And Realized Measurements

Production

Date range

week 02 - 2024

to

week 46 - 2024

Apply range

Start

End

Fresh fruit production per week

kg/m²

Weekly fresh fruit production

6,00

5,00

4,00

3,00

2,00

1,00

0,00

kg/m²

Cumulative weekly fresh fruit production

60

50

40

30

20

10

0

02

04

06

08

10

12

14

16

18

20

22

24

26

28

30

32

34

36

38

40

42

44

46

48

week nr.

Weekly fresh fruit production

Weekly fresh fruit production [CODIT]

Weekly fresh fruit production [Realized]

Cumulative weekly fresh fruit production

Cumulative weekly fresh fruit production [CODIT]

Cumulative weekly fresh fruit production [Realized]

Average fresh fruit weight per week

g

6,00

5,00

4,00

3,00

2,00

1,00

0

02

04

06

08

10

12

14

16

18

20

22

24

26

28

30

32

34

36

38

40

42

44

46

48

week nr.

Average fresh fruit weight [CODIT]

Average fresh fruit weight [Realized]

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Delphy

Growth Trial Experiments



Congratulations
healthy strong crop!!



Experiment Setup

- Full-year crop trial
- Goal: **energy-efficient growing**
- Crop advisor uses CODIT weekly for new strategies
- Continuous monitoring
- Involved sensor manufacturers

Challenges

- Botrytis
- Low temperature growing
- Technical challenges

Delphy

De Ruiter
Grow better together

Vivent

MTx
MechaTronix

Hazera
Seeds of Growth

sendot

Delphy

Grodan

wirelessvalue

2GROW

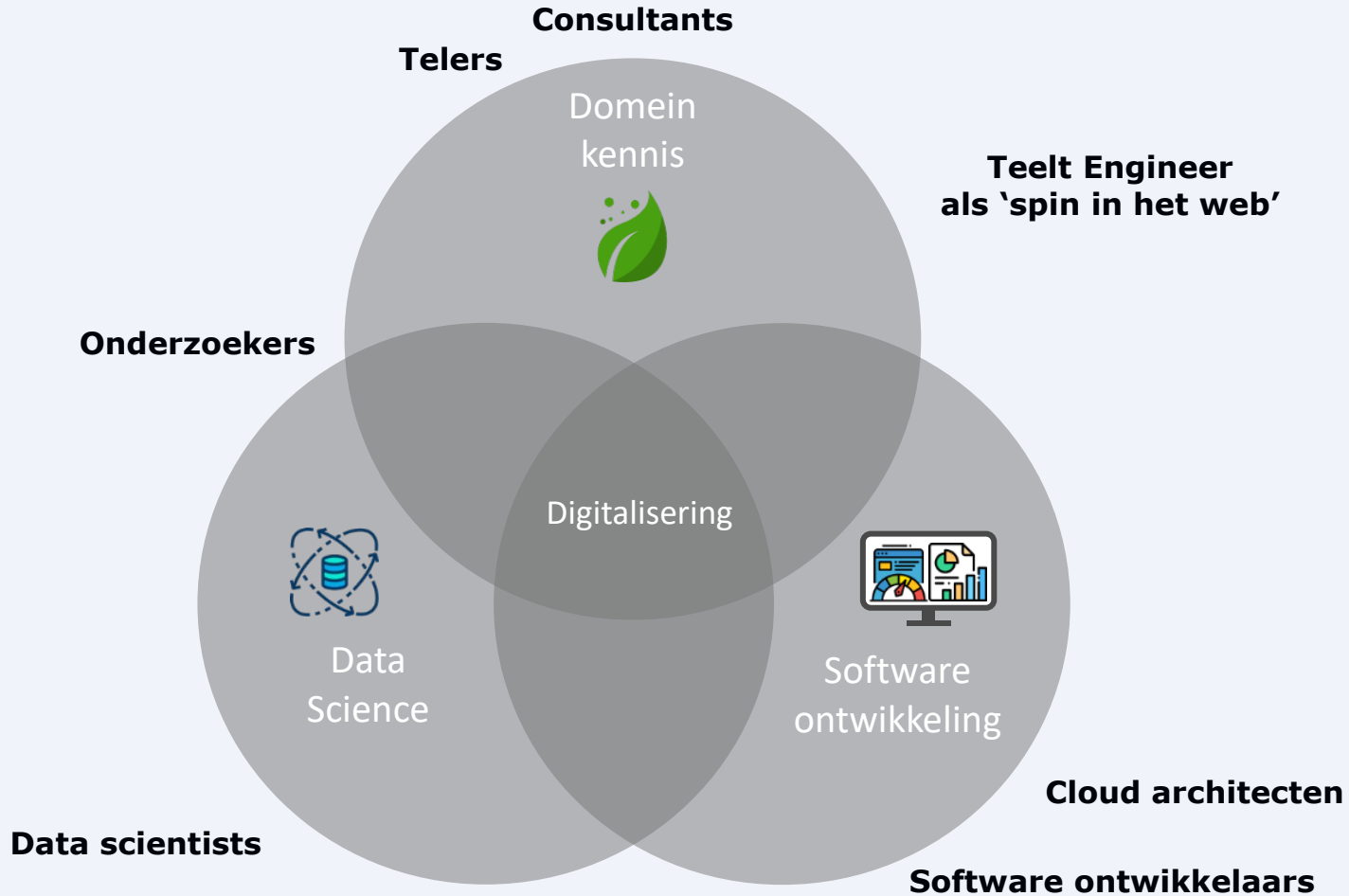
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Delphy

Delphy Digital



- We **versterken** telers in het maken van de juiste beslissingen

QMS: Teelt doelstellingen vs Teelt plan



VRUCHT
GEWICHT



VRUCHTEN PER TROS



PRODUCTIE



BRONNEN
(ENERGIE, ARBEID)



TEMPERATUUR?



STRALING?

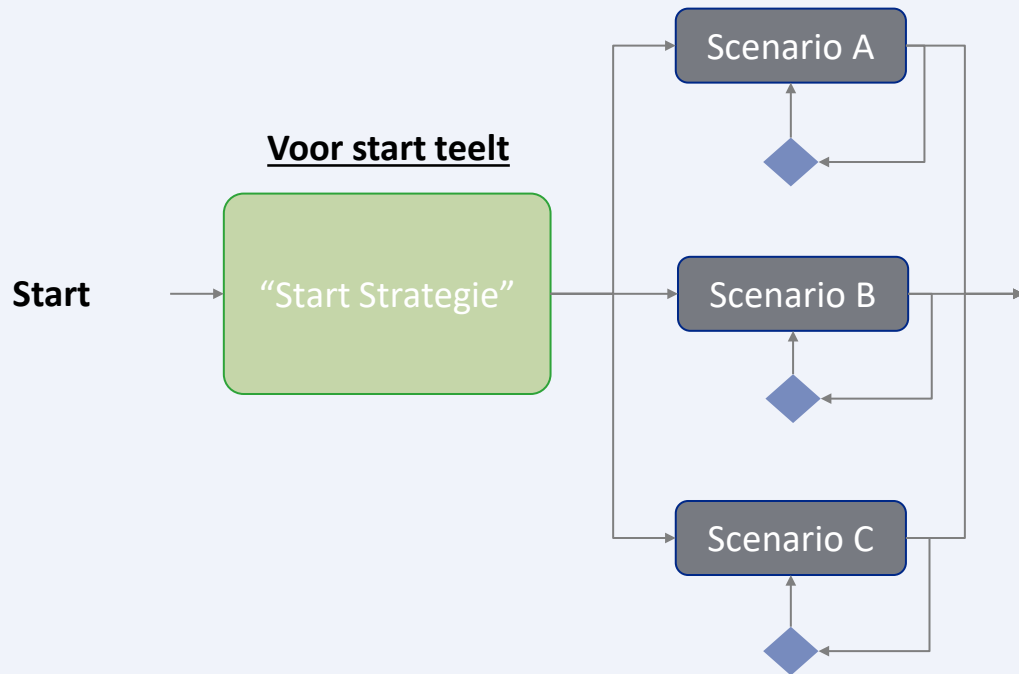


RAS?



PLANT
DICHTHEID?

Planning



Scenario A

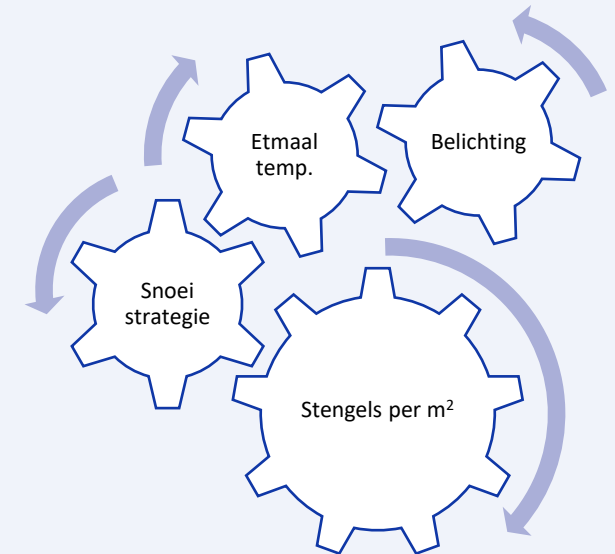
- Snoei strategie
- > Vruchten per tros

Scenario B

- Hoge plantdichtheid

Scenario C

- Meerdere dieven aanhouden



Optimaliseer

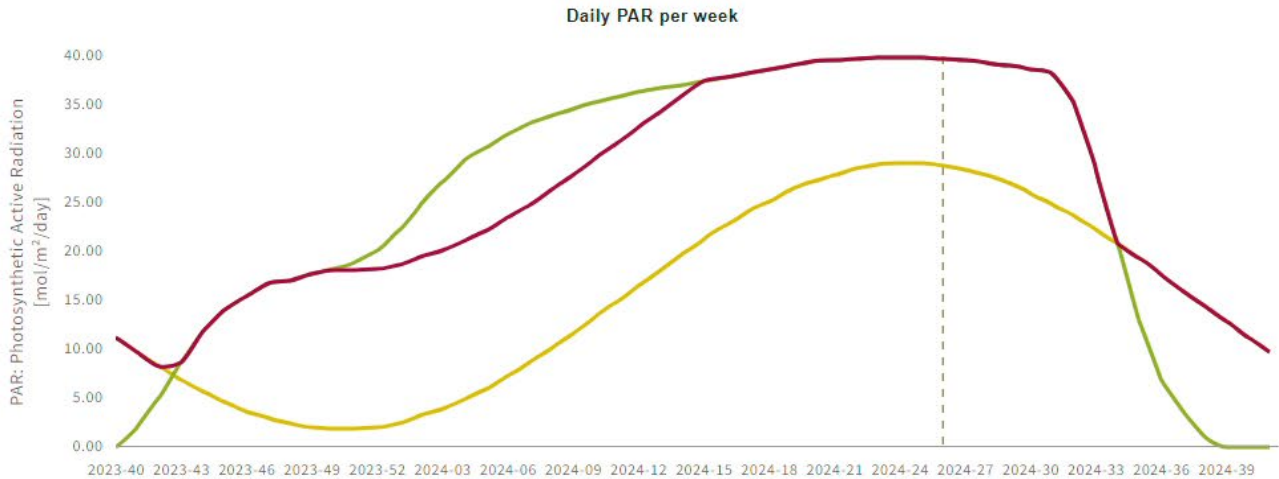


Wekelijks



Eenmalig

Enlarge



Daily PAR per week



Production



Predefined charts

Stem density and fruit load

Development speed

Fruit weight and fruits per truss

Ratio Temperature Radiation (RTR)



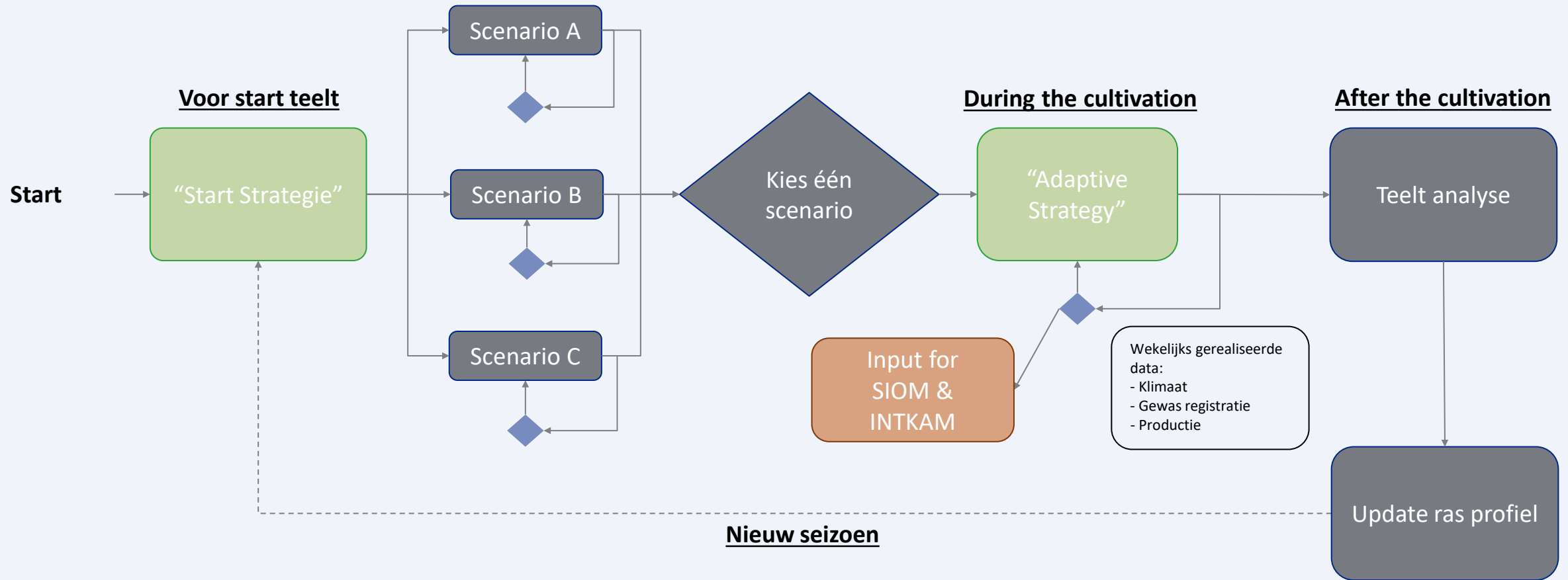
Cancel

Edit

Calculate

Climate averages per day									Weekly crop data: Merlice (LED)							
Year	Wk	Outside Radiation [J/cm²]	Inside PAR [mol/m²]	Adviced Lighting 1 LED [hrs]	Artificial lighting PAR [mol/m²]	Total PAR [mol/m²]	PAR demand [mol/m²]	24H Temperature [°C]	Flowering speed [trusses / stem/ week]	Fruit per truss [#]	Fruitload [tom./m²]	Fruit weight [gram]	Truss weight [gram]	Ripening time [days]	Calculated net production [kg/m²]	Calculated net production cum. [kg/m²]
2023	40	744	11.2	0.0	0.0	11.2		20.2								
2023	41	643	9.7	0.0	0.0	9.7	2.0	19.9	0.83	5	10.3	160.0	800	61		
2023	42	547	8.2	0.0	0.0	8.2	5.2	19.6	0.80	5	20.3	160.0	800	60		
2023	43	458	6.9	2.0	1.8	8.7	8.7	19.4	0.78	5	30.1	160.0	800	60		
2023	44	378	5.7	6.9	6.2	11.9	11.9	19.1	0.76	5	39.6	160.0	800	59		

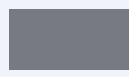
Planning + management



Optimize



Weekly



One-time

Gebruik van CODIT in de praktijk

- **Gebruik bij Delphy Improvement Centre**
 - Teeltproef 2023-2024
 - Ras: Merlice
 - Plantdatum wk 40-2023
 - LED belichting: 270 $\mu\text{mol}/\text{m}^2/\text{s}$
- **Verschillende model runs**
 - Zichtbaar in CODIT dashboard
- **Klimaatinstellingen naar Priva computer**
 - Wekelijks gerund
 - Wekelijkse strategie invoeren

Voorbeeld export

Climate settings for week

Week 22 (27-05-2024 t/m 02-06-2024) ▼

Temperature

	Unit	Period 1	Period 2	Period 3	Period 4
Time	Hours	00	03	11	20
Ventilation strategy	°C	13.5	17.5	19.5	
Heating strategy	°C	12.5	16.5	18.5	

Lighting

	Unit	Period 1	Period 2
Time	Min	20:58	22:00

Geactiveerd	ja/nee	nee	nee
PAR Lighting	%	0	0
Release influence high PAR-sum	W/m ²	Nee	Nee
Extra invloed, aanp. PAR belichten (SwitchOffRadiation)	PAR	0	0
Tijd PAR decrease (per 10µmol)	Min	00:00	00:02
Time PAR increase (per 10µmol)	Min	00:02	00:00

CO₂

	Unit	Period 1 (20:58)	Period 2 (22:00)
CO ₂ dose type		Geen	Geen
Minimum CO ₂ -concentration	ppM	672	
Maximum CO ₂ -concentration	ppM	571	

Conclusies & Aanbevelingen

(eerste keer) Digital Twins koppelen kost veel effort

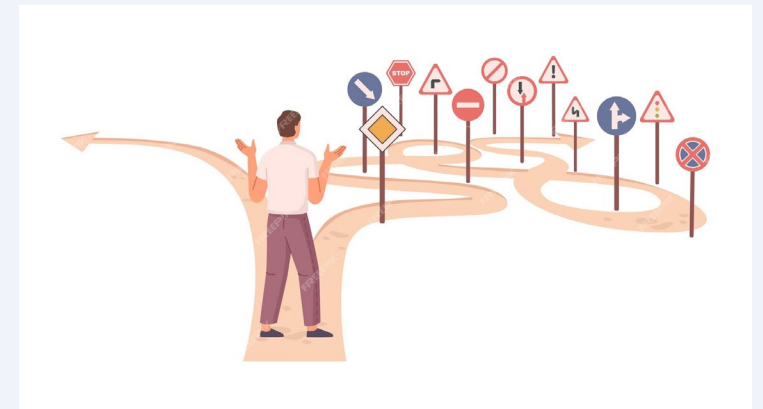
- Zorg voor een goede **technische basis** en API's
- Baseer interacties op **Meta-data**
- Spreek dezelfde taal met het **CGO**
- Begrijpen we elkaar (echt)?

Centrale aansturing via CODIT dashboard

- Voordeel: één UI
- Nadeel: parallel product om te ontwikkelen, daardoor soms instabiel
- Nadeel: beheer & onderhoud?

Klimaatsturing vergt commitment

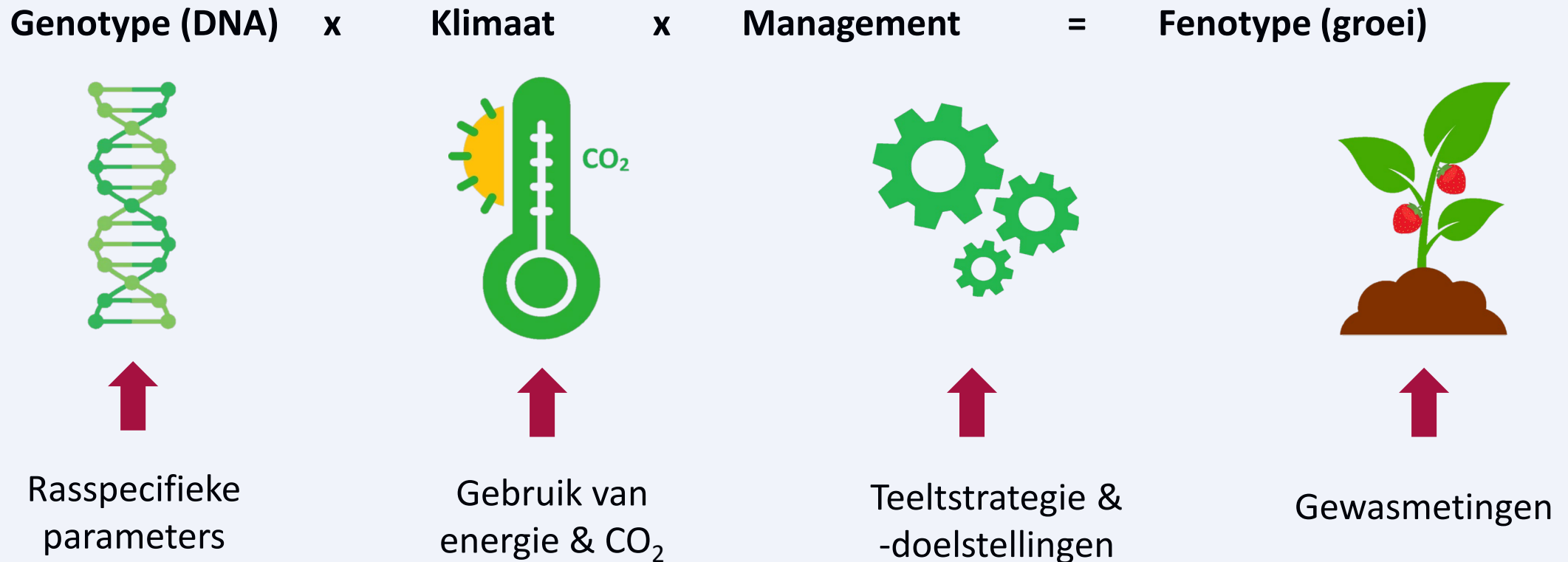
- Koppeling naar Priva niet optimaal (periodes)
- Brug te ver?





Aanbevelingen

Dit kan je met de ontwikkelde koppeling in CODIT:



Stelling: Ik wil onderzoeken hoe ik **zelf** met CODIT aan de slag kan gaan, evt in aangepaste vorm.



Vervolgstappen

Gebruik CODIT

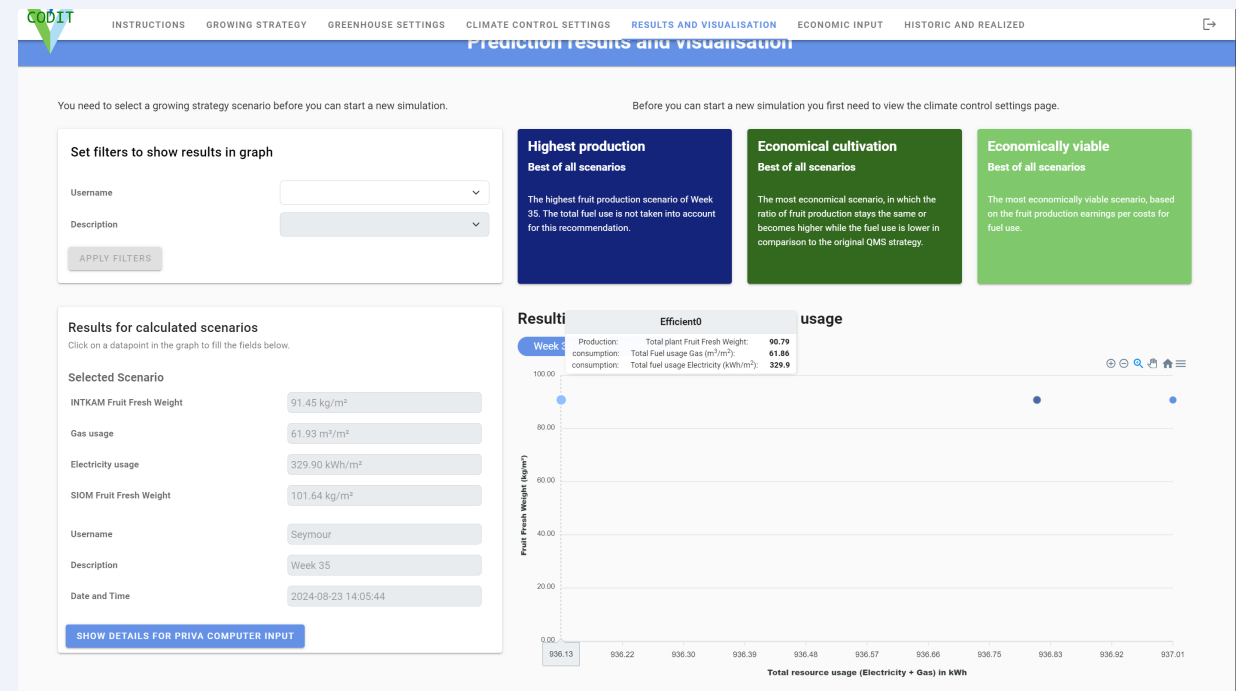
- Als simulatie/verkenning tool
- Van teeltstrategie → energieverbruik & gewasgroei (productie)
- Versterkt resultaten van basis (QMS-)strategie

Gebruik de 'optimizer'

- Zoeken naar optimale strategie
- Klimaat & gewas
- Wat is optimaal?

Resultaten

- Visualiseren, vergelijken en analyseren
- Demonstrator



Bedankt voor uw aandacht

Graag zetten we samen de volgende stap!

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