Solution Architect for Global
Bioeconomy & Cleantech Opportunities

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Dynamic simulation tools for evaluation of biomass supply systems

Seminar on Sustainable Bioenergy Solutions for Tomorrow

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Contents

Introduction

- Biomass procurement takes place in both **ecological** and **industrial** environment
  - Ecological environment includes
    - Geography
    - Meteorology
    - Seasonality
    - Randomness
    - Unpredictability

Himmanen 2016

Himmanen 2016

Karttunen et al. 2010

Kärki et al. 2014

Seasonality, randomness, unpredictability?

Year 2015 was the warmest in records

12.1.2016 11:43

According to the Finnish Meteorological Institute statistics, 2015 was a record warm year in the most parts of the country.


Photo: Eija Vallinheimo

Lapland was the only province in which the year was not quite the warmest but in the shared second place. The mean temperature in 2015 was 4.2°C, which is about 1.9°C warmer than the long-term average i.e. the period 1981–2010. As regards the whole country, only June and July were colder than average. February and March as well as November and December were proportionally the warmest periods as the mean temperature in the whole country was 4-6°C warmer than normal.

Warm weather records were broken in both November and December. The new w… weather record for November, 14.3°C, was measured on 3 November in Kemiöns… The record for December was 11.3°C, which was measured in Pori and Kokemäk… 20 December.

The highest temperature of the year, 31.4°C, was recorded on 3 July in Kouvola. There were only 19 hot days during the entire summer, which is about half the normal number of hot days. The first hot day was as late as on 29 June, which makes it the second latest first hot day recorded since 1961. The majority of hot days were not until in August. Because of the bleak summer weather, the numbe… thunderstorms was record low this year. The lowest temperature of the year, -39… was recorded in Utsjoki on 11 January.

The new record for annual precipitation measured in Puolanka

The level of annual precipitation varied between the 500mm in Northern Lapland… just over 1,000mm in Kainuu. The highest level of rainfall was measured in Puolanka, where 1,242mm of rain was received at the Paljakka station. This exceeds clearly the previous record for annual precipitation, which was 1,109mm measured in Nupuri in Espoo in 1981.

Statistics Finland

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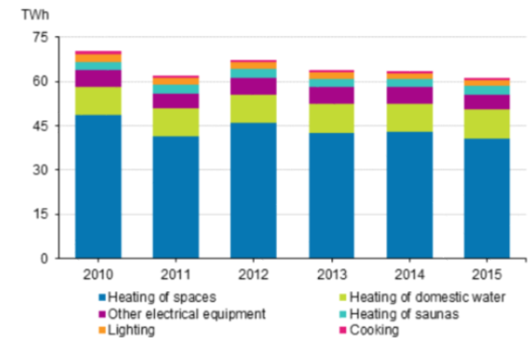
RELATED TOPICS
- Energy 2015 table service

Published: 18 November 2016

Warm weather decreased energy consumption in households in 2015

…decreased by four per cent from the previous year. The record warm weather diminished the consumption of heating energy for spaces by five per cent. The energy consumption of household appliances went down by six per cent due to, for example, the decreased need to heat car interiors. The data are based on Statistics Finland's statistics on energy consumption in households.

Energy consumption in households 2010-2015



Sixty-seven per cent of energy consumption in households concerned heating of residential buildings, 16 per cent heating of domestic water, and five per cent heating of saunas. In domestic

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FINGRID

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Electricity consumption exceeded 15,000 MW for the first time on 7 Jan 2016

1/7/2016 5:25 PM - Current News

According to Fingrid's operational control measurements, the average hourly power of Finnish electricity consumption reached a new record, 15,100 megawatts, on 7 January 2016 around 5-6 pm. 10,800 megawatts of electricity were produced in Finland, and the remaining 4,300 megawatts were imported from neighbouring countries. The adequacy of electricity was not threatened during the peak consumption.

The average hourly power of Finnish electricity consumption first rose to around 14,900 megawatts on Thursday morning 7 January 2016, but this top figure was exceeded in the evening of the same day. Consumption has reached its highest figures this winter due to the very low sub-zero temperatures at the start of the year. Power plants have been operating without significant disturbances. Nearly all available power plants are already in use, but so far, the peak

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Sources: Finnish Meterological Institute, Statistics Finland, Fingrid

Modelling of biomass supply systems

Performance evaluation models

- Cost-calculation models
- GIS-based models
- Simulation models

Optimization models

- Deterministic models
- Stochastic models
- Multi-objective models

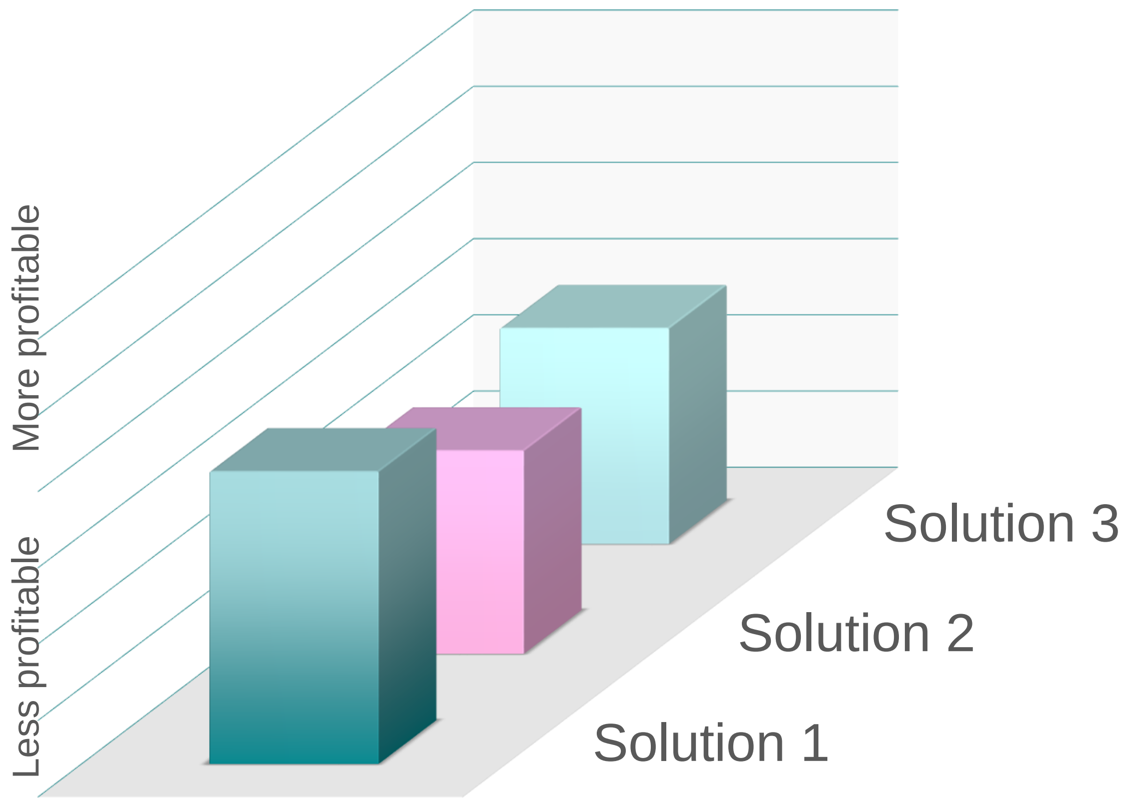
Ba et al. (2016)

Why simulation?

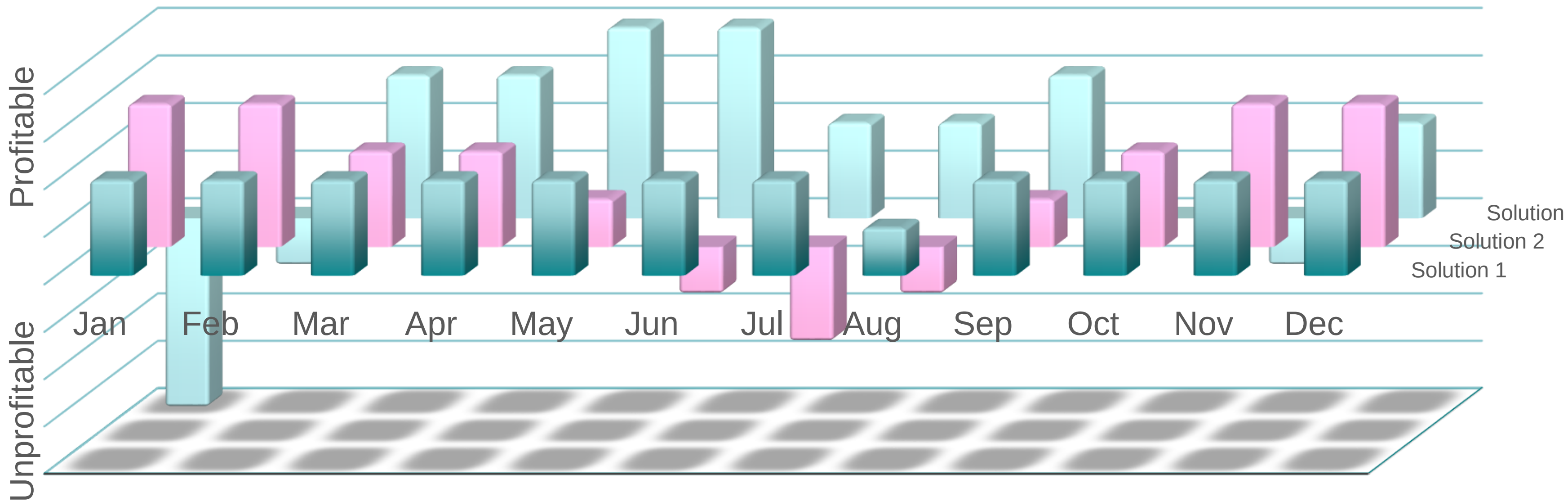
Simulation can be used to

- evaluate the performance of
  - ✓ an existing logistics system
  - ✓ a new system based on heuristic decision-making
  - ✓ a new system suggested by ***static analyses*** (from e.g. optimization model)
- account for seasonality and stochasticity
- account for strong system interactions
  - ✓ usually too complex for analytic models

Example: profitability of logistics solutions



Example: profitability of logistics solutions



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Dynamic simulation modelling

- Dynamic: able to change over **time**
  - ✓ We need to account for the **quality changes of biomass** on its way to the end-user
- Dynamic: possibility to change parameters
  - ✓ We need to provide different logistical options and possibility to change initial data because **of case-specific features** and **randomness** in actual cases

Application 1: Feed-in terminal (partial simulation approach)

The objective of the simulation run is to secure a typical demand by nearby power plant(s)

- Runtime 1 year (Jul-Jun)
- Scalable and flexible model
- Spatial, but non-geographical
- Model user has liberties and responsibilities
- Input parameters are imported from spreadsheets

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Feed-in terminal: Input data

Truck properties

1= yes 0 = no

Truck type	m³	Unloading, min	± min	Stationar Crusher	Weighing	Sampling
Woodchip 1	0	0	0	0	0	0
Woodchip 2						
Woodchip						
ForestRes						
ForestRes						
Stem 1						
Stem 2						
Stem 3						
WholeThre						
WholeThre						
Stump						
Agro 1						
Agro 2						
Other						

Month
1
2
3
4
5
6
7
8
9
10
11
12

	dry CV	bulk density	Storage capacit	Unloading plac	Waiting place
Fuel	[MJ/kg]	t/m3 loose	m3 loose	#	#
Chip	0	0	0	4	2
ForestRes					
Stem					
WholeThr					
Stump					
Agro					
Other					
Crusher					

Month	Chip
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	

Plant utilization

Month	Needed fuel amount [MWh]	# of trucks	# of mobile crusher	Shift
1	49000	2	2	2
2	45000	2	2	2
3	49000	2	2	2
4	42000	3	2	2
5	39000	3	2	2
6	29000	1	1	2
7	0	0	0	1
8	0	0	0	1
9	18000	2	1	1
10	43000	2	2	2
11	42000	2	2	2
12	44000	2	2	2

Distance between plant and terminal 5000 m
Average speed of terminal trucks 60 km/h

Yard properties

Total storage capacity in the terminal	m³	10000000
Feeder truck capacity		150
Max vehicle count allowed at plant		100
Max vehicle count allowed to wait weighing		5
Max vehicle count allowed to wait weighing out		5
Max vehicle count allowed to wait Sampling		5

Weighing time (in), min	min	1
Weighing time (out), min	min	0,5
Sampling time	min	10

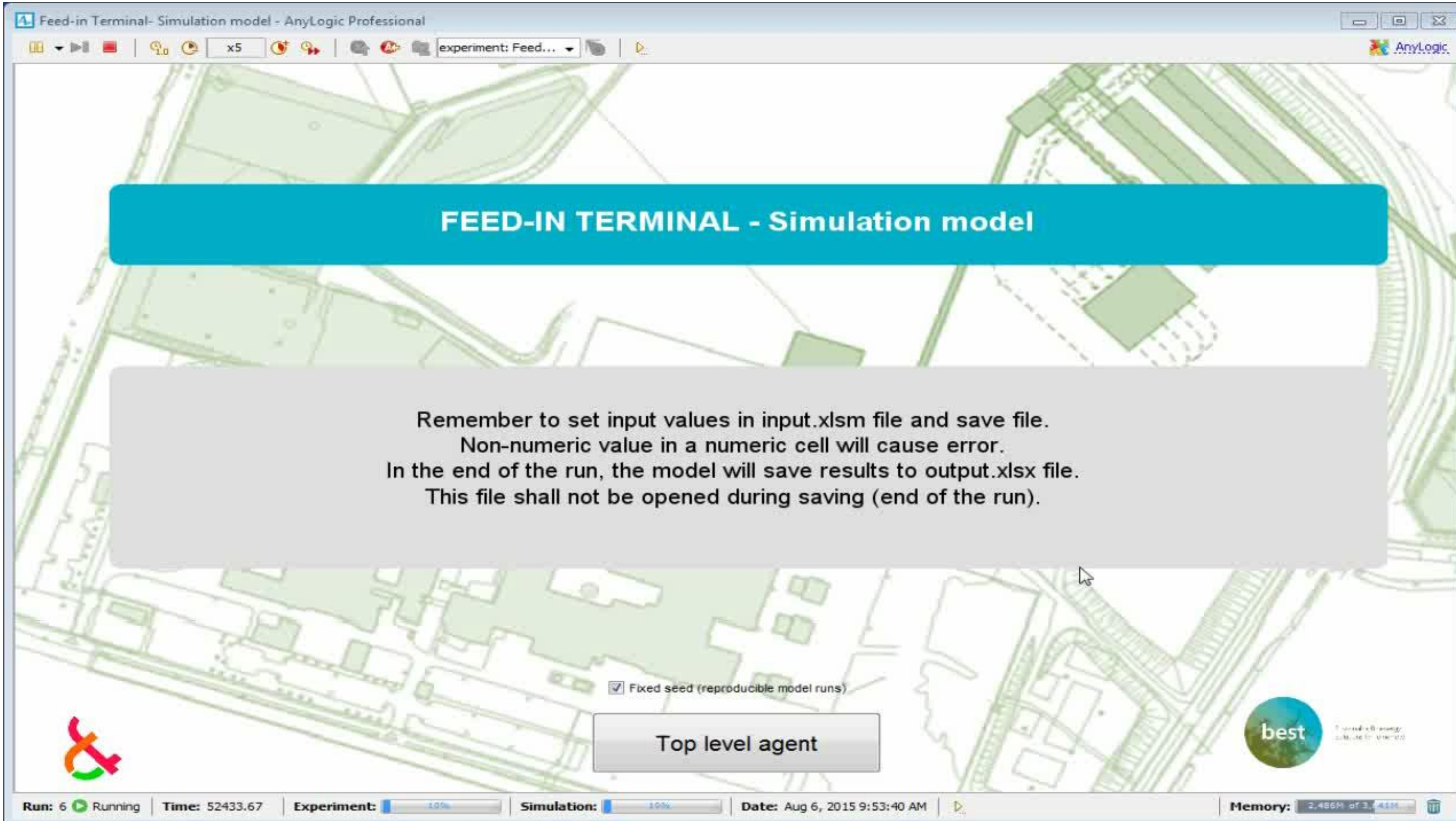
Number of wheel loaders	#	1
Wheel loader loading speed	m3/s	0,1
mobile crusher	m3/s	0,04
Stationary crusher	m3/s	0,06

Routing features

		Distance, m	Speed, km/h
1	Gate >> Waiting (for weighing)	50	20
2	Waiting area >> Weighing scales 1	25	8
3	Gate >> Passing weihging	75	20
4	Weighing >> Waiting (Sampling)	10	5
5	Waiting area >> sampling	20	5
6	Weighing >> Pass sampling	30	20
7	Waiting area >> Weighing out	20	5
8	Weighing out >> Gate	75	15
9	waiting area >> gate (pass weighing)	50	15

Routing features For fuel storage

Route		Chip	ForestResec	Stem
Sampling >> Waiting area to unload	Distance	1	1	260
	Speed	1	1	20
Waiting >> unloading	Distance	1	1	35
	Speed	1	1	10
Unloading >> weighing out	Distance	1	1	430
	Speed	1	1	30



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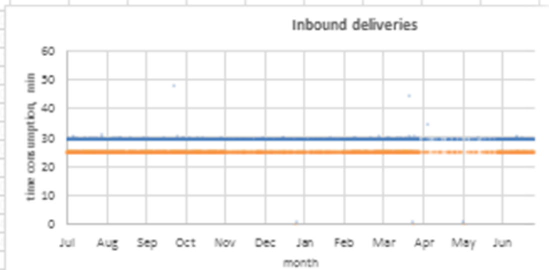
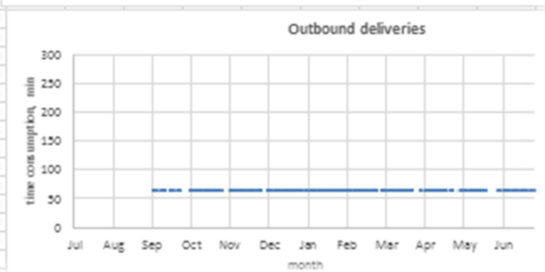
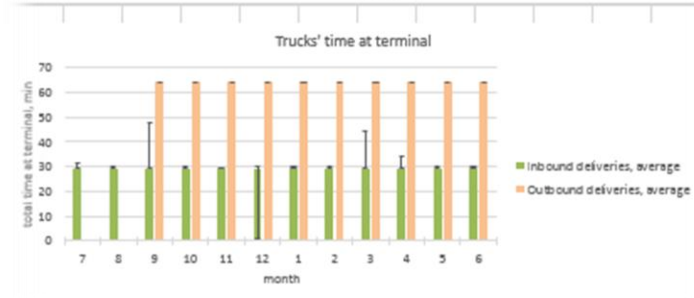
Feed-in terminal: Result data

rriving truc	Month	# trucks	min visit	avg visit	max visit
	1	178	29,2	29,2	30
	2	294	29,2	29,2	30,1
	3	408	29,2	29,3	44,6
	4	61	29,2	29,3	34,4
	5	61	29,2	29,2	30,2
	6	247	29,2	29,2	30,3
	7	409	29,2	29,2	31,2
	8	344	29,2	29,2	30,2
	9	365	29,2	29,3	48
	10	364	29,2	29,2	30,2
	11	186	29,2	29,2	29,7
	12	190	0,8	29,2	30,2
		3107	0,8	29,2	48

eparting tr	Month	# trucks	min visit	avg visit	max visit
	1	345	64,2	64,2	64,2
	2	316	64,2	64,2	64,2
	3	344	64,2	64,2	64,2
	4	296	64,2	64,2	64,2
	5	274	64,2	64,2	64,2
	6	188	64,2	64,2	64,2
	7	0			
	8	0			
	9	128	64,2	64,2	64,2
	10	302	64,2	64,2	64,2
	11	295	64,2	64,2	64,2
	12	309	64,2	64,2	64,2
		2797	64,2	64,2	64,2







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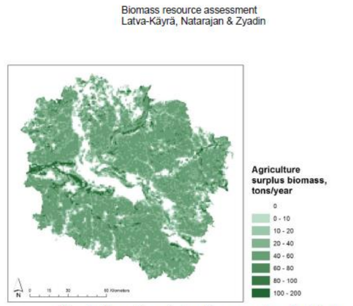
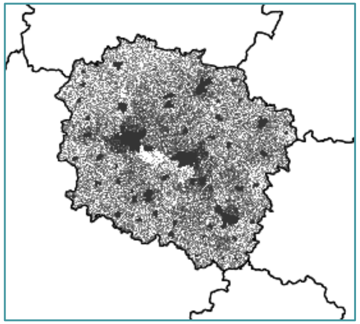
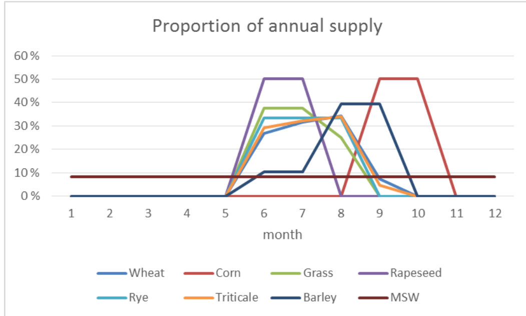
Application 2: Case Poland (holistic simulation approach)

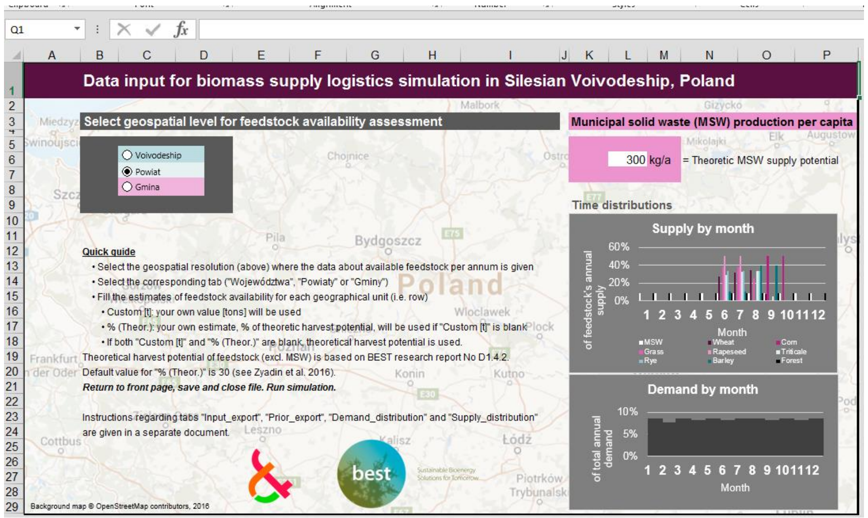


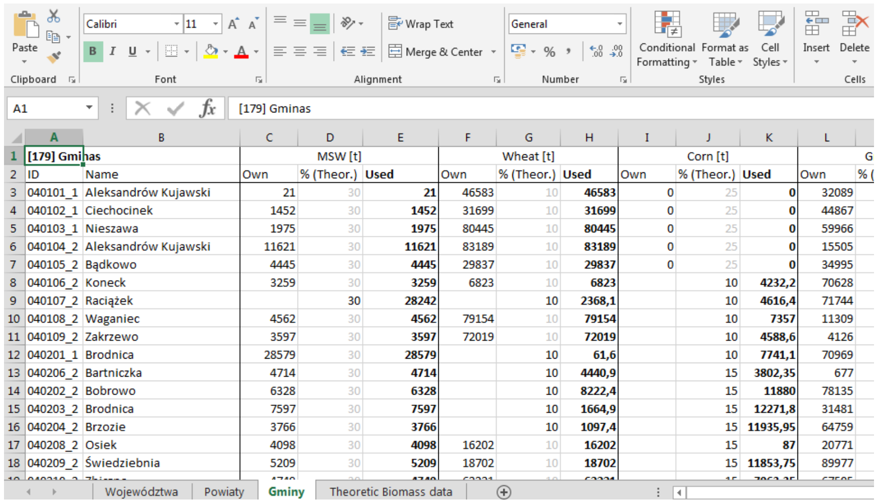
Kujawsko-Pomorskie agriculture biomass surplus estimate in tons per year.





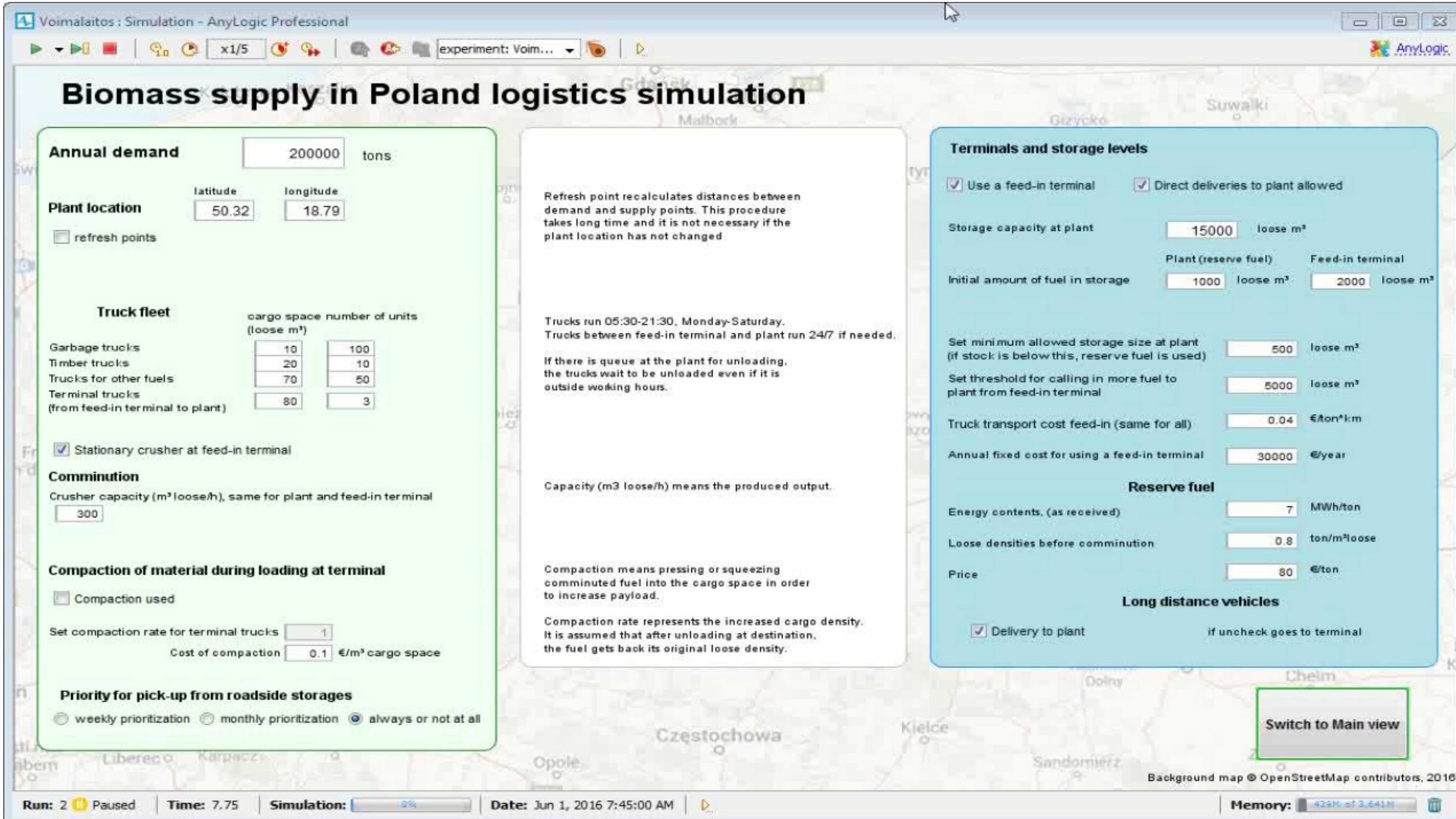
Fixed input parameters





[179] Gminas		MSW [t]			Wheat [t]			Corn [t]			
ID	Name	Own	% (Theor.)	Used	Own	% (Theor.)	Used	Own	% (Theor.)	Used	Own
040101_1	Aleksandrów Kujawski	21	30	21	46583	10	46583	0	25	0	32089
040102_1	Ciechocinek	1452	30	1452	31699	10	31699	0	25	0	44867
040103_1	Nieszawa	1975	30	1975	80445	10	80445	0	25	0	59966
040104_2	Aleksandrów Kujawski	11621	30	11621	83189	10	83189	0	25	0	15505
040105_2	Bądkowo	4445	30	4445	29837	10	29837	0	25	0	34995
040106_2	Koneck	3259	30	3259	6823	10	6823		10	4232,2	70628
040107_2	Raciążek		30	28242		10	2368,1		10	4616,4	71744
040108_2	Waganiec	4562	30	4562	79154	10	79154		10	7357	11309
040109_2	Zakrzewo	3597	30	3597	72019	10	72019		10	4588,6	4126
040201_1	Brodnica	28579	30	28579		10	61,6		10	7741,1	70969
040206_2	Bartniczka	4714	30	4714		10	4440,9		15	3802,35	677
040202_2	Bobrowo	6328	30	6328		10	8222,4		15	11880	78135
040203_2	Brodnica	7597	30	7597		10	1664,9		15	12271,8	31481
040204_2	Brzozie	3766	30	3766		10	1097,4		15	11935,95	64759
040208_2	Osiek	4098	30	4098	16202	10	16202		15	87	20771
040209_2	Świedziebnia	5209	30	5209	18702	10	18702		15	11853,75	89977

Modified by the user



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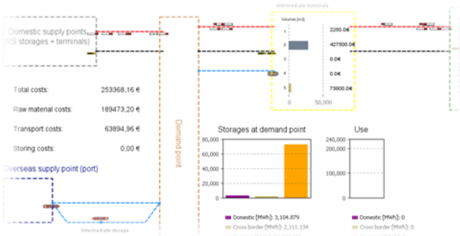
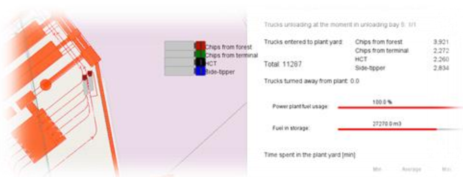
Note! The location of the demand point (plant) in this presentation has been determined by random WGS84 coordinates and is not based on any real plans to build a plant in this specific location.

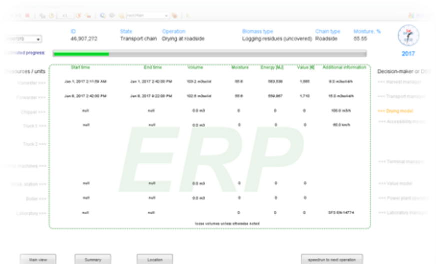
Other dynamic simulation applications



3) Simulation application for modelling **imported biomass deliveries**



4) Simulation application for modelling **biomass reception** of the plant



5) Simulation application for modelling **information management** through ERP

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Conclusions

- Growing biomass volumes bring economies of scale benefits, but investments in logistics are also bigger than before
  - Who wants to try first?
- A simulation model can try, with low costs
  - Vast amount of source data needed
- Simulation model brings temporal dimension to logistics research
  - Seasonality, randomness, unpredictability
- The most feasible solution in logistics is usually the most sustainable
  - Now: analyzed from result data
  - Future: inclusion of runtime sustainability variables (e.g. fuel consumption, emissions)

Thank you!

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