

## Background

- TORKSIM is a computer program for simulation of the softwood timber drying process in batch kilns.
- The simulation is based on a model which is made as physically correct as possible...
- ...on the other hand, the use of the software is kept simple so that, for instance, kiln operators without a higher education can use it.
- The first version was launched in 1998 and about 110 licenses have been distributed in Scandinavia

## Background 2

Three languages are available for the program interface:



1. English



2. Swedish



3. Estonian

## Program function

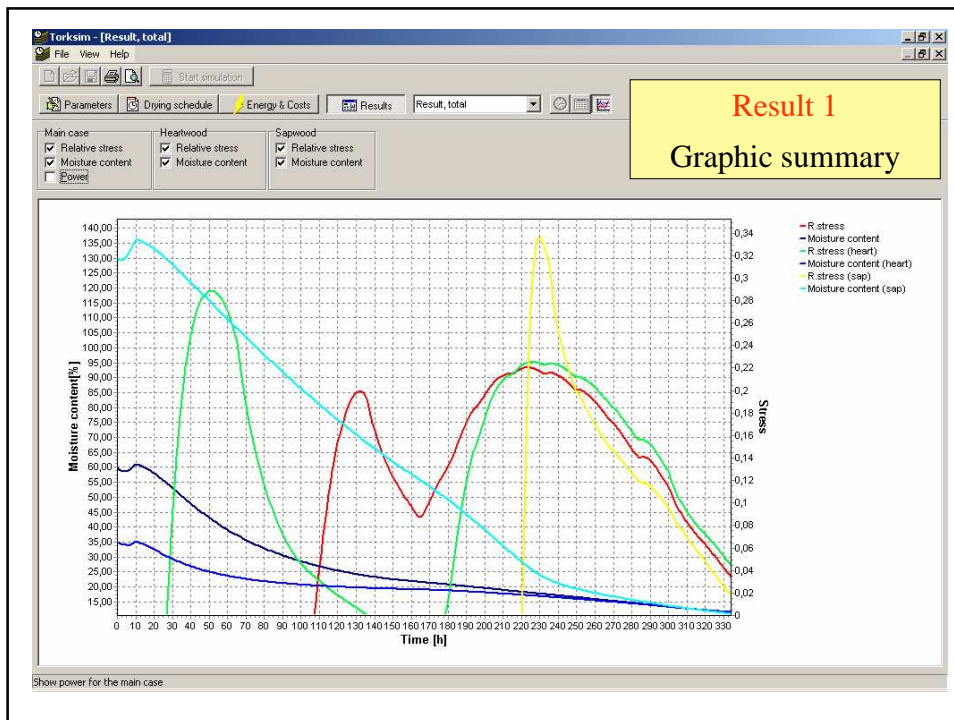
Input data:

1. Information about the **timber** being dried
2. Air **velocity** between board layers in kiln stack
3. A **drying schedule**
  - Either time based, or
  - Moisture content based
4. **Energy** consumption background data. (optional)
5. Drying **costs** background data. (optional)

**Model input, page 1**  
Wood species, dimension  
and properties  
Air velocity in stack

**Model input, page 2**  
Drying schedule

Time	Dry bulb temp.	Wet bulb temp.	Relative humidity	WBD
1	0	60.79	60.00	96.2
2	17.1	62.40	60.00	88.9
3	34.1	62.52	60.00	88.3
4	51.2	62.54	60.00	88.3
5	68.2	62.51	60.00	88.4
6	85.3	62.44	60.00	88.7
7	102.3	62.37	60.00	89.0
8	119.4	62.31	60.00	89.2
9	136.4	62.24	60.00	89.6
10	153.5	62.19	60.00	89.8
11	170.5	62.85	60.00	86.9
12	187.6	63.87	60.00	82.8
13	204.6	65.21	60.00	77.7
14	221.7	66.90	60.00	71.7
15	238.7	69.02	60.00	65.1
16	255.8	71.64	60.00	57.9
17	272.8	74.44	60.00	51.3
18	289.9	78.42	60.00	43.5
19	306.9	80.00	60.00	40.9
20	324.0	80.00	60.00	40.9



Torksim - [Result, main case]

File View Help

Start simulation

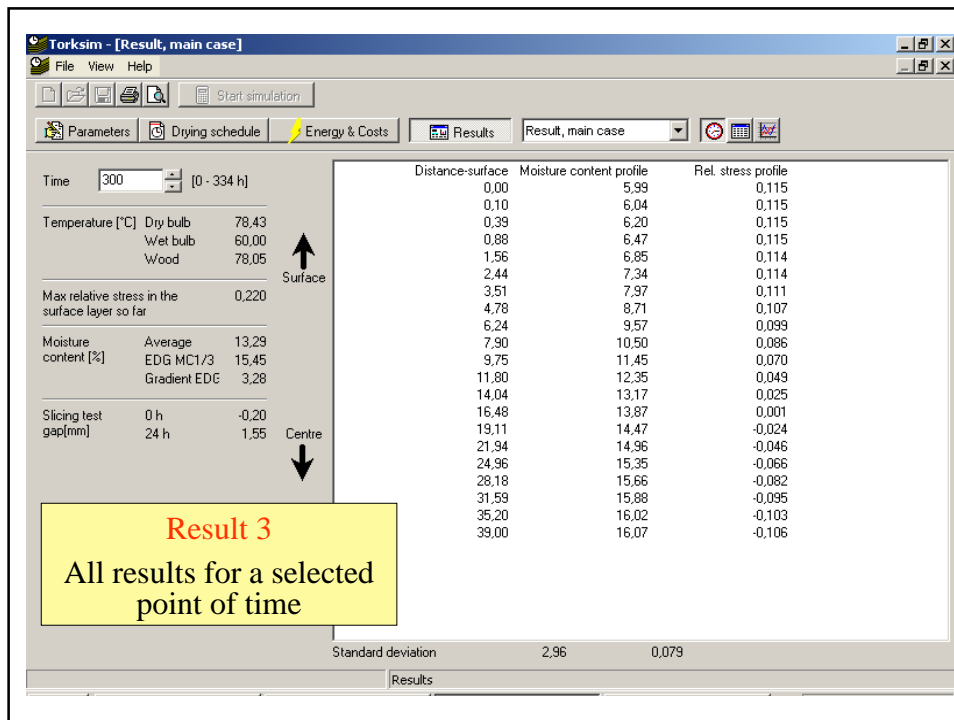
Parameters Drying schedule Energy & Costs Results Result, main case

Drying time [h]	Moist. cont. average [%]	EDG MCI/3	Gradient EDG	Max relative stress-surface	Slicing test gap [mm]		Temperature [°C]		
					0 h	24 h	dry bulb	wet bulb	wood
112	26.52	27.30	1.35	0.072	-0.02	0.00	62.37	60.00	61.76
113	26.37	27.16	1.37	0.082	-0.03	0.00	62.37	60.00	61.76
114	26.22	27.02	1.38	0.093	-0.04	0.00	62.37	60.00	61.77
115	26.08	26.89	1.39	0.107	-0.05	0.01	62.36	60.00	61.78
116	25.94	26.75	1.42	0.116	-0.06	0.01	62.36	60.00	61.78
117	25.80	26.62	1.43	0.128	-0.07	0.01	62.36	60.00	61.79
118	25.67	26.48	1.49	0.136	-0.08	0.01	62.35	60.00	61.80
119	25.53	26.35	1.50	0.146	-0.10	0.02	62.35	60.00	61.81
120	25.40	26.23	1.60	0.153	-0.12	0.02	62.34	60.00	61.81
121	25.28	26.10	1.67	0.161	-0.13	0.03	62.34	60.00	61.82
122	25.15	25.97	1.73	0.167	-0.15	0.03	62.34	60.00	61.83
123	25.03	25.84	1.79	0.173	-0.16	0.04	62.33	60.00	61.83
124	24.91	25.71	1.76	0.179	-0.18	0.04	62.33	60.00	61.84
125	24.79	25.58	1.74	0.184	-0.20	0.05	62.33	60.00	61.84
126	24.67	25.46	1.69	0.188	-0.21	0.05	62.32		
127	24.56	25.32	1.66	0.191	-0.23	0.06	62.32		
128	24.45	25.18	1.61	0.194	-0.24	0.06	62.32		
129	24.34	25.04	1.58	0.196	-0.26	0.07	62.31		
130	24.23	24.87	1.53	0.198	-0.27	0.08	62.31		
131	24.12	24.68	1.49	0.199	-0.28	0.08	62.31		
132	24.02	24.51	1.45	0.199	-0.29	0.09	62.30	60.00	61.88
133	23.92	24.38	1.40	0.199	-0.30	0.10	62.30	60.00	61.88
134	23.82	24.29	1.34	0.198	-0.31	0.10	62.29	60.00	61.89
135	23.72	24.21	1.27	0.196	-0.32	0.11	62.29	60.00	61.89
136	23.62	24.14	1.18	0.192	-0.32	0.12	62.28	60.00	61.89
137	23.53	24.05	1.01	0.185	-0.30	0.13	62.28	60.00	61.90
138	23.44	23.95	0.96	0.178	-0.28	0.14	62.28	60.00	61.90
139	23.35	23.85	0.92	0.171	-0.26	0.14	62.27	60.00	61.90
140	23.26	23.76	0.90	0.165	-0.25	0.15	62.27	60.00	61.91

### Result 2

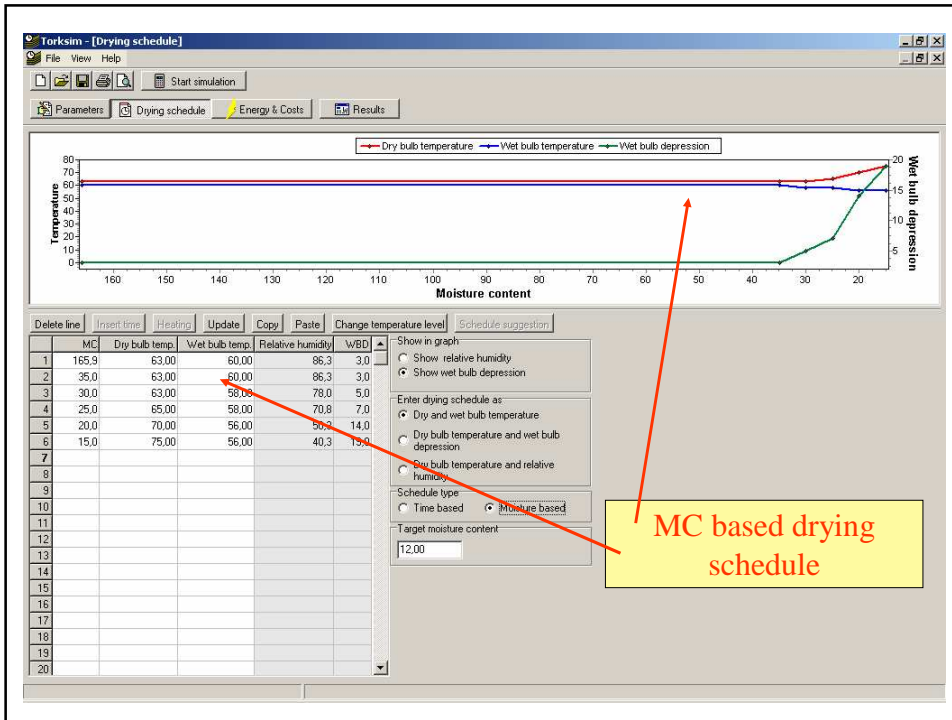
### Numerical table

Results

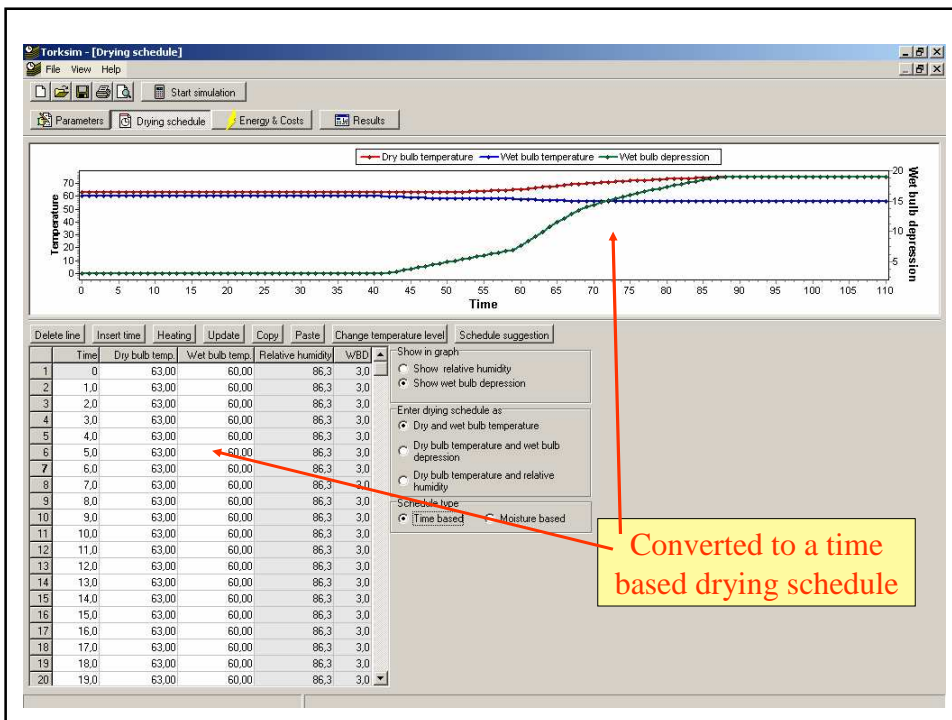


## Drying schedule, modes

- Starting from version 4.0 of TORKSIM, both **time based** and **MC based** schedules can be used.
- For mathematical reasons the simulation has to be performed as a function of time. If a MC based schedule is entered, then it is converted to a time based schedule during the simulation.
- After the simulation both modes of schedules are available for the actual case.



MC based drying schedule



Converted to a time based drying schedule

**Torksim - [Energy]**

File View Help

Start simulation

Parameters Drying schedule Energy & Costs Results

**Energy calculation input**

Average RH of ambient air (%)	70,0	Heat trans.coeff floor [W/m2K]	0,20
Temperature in dryer at start (°C)	40,0	Heat trans.coeff wall,roof [W/m2K]	1,00
Ambient temperature (°C)	5,0	Specific heat wall, roof [kJ/kg °C]	0,90
Mass in walls/roof (kg)	100000,0	Specific heat floor [kJ/kg °C]	0,90
Mass in floor (kg)	40000,0	Soil temperature (°C)	5,0
Dryer length (m)	9,0	Wood density (kg/m3)	430
Dryer width (m)	6,0	Green timber volume in kiln (m3)	100
Dryer height (m)	8,0	Number of free walls	2

**Cost**

Investment 1, €	200000
Pay back time, year	10,00
Interest rate, %	8,00
Investment 2, €	200000
Pay back time, year	20,00
Interest rate, %	80,00
Yearly maintenance as % of total investment	5,00
Personell cost, €/year	20000
Price of heat, cent/kWh	0,03
Price of heat, €/GJ	0,08
Price of electricity, cent/kWh	0,05
Electric power consumption by fans for the air velocity given	30,00 kW
	4,00 m/s

**Result from energy calculations**

Losses with exhaust air (kWh)	Total energy consumption (kWh)
Transmission losses (kWh)	Total energy consumption (MJ)
Acc. energy in timber (kWh)	Average energy consumption (kJ/kg evaporated H2O)
Acc. energy in building (kWh)	

**Model input 3 (Optional)**  
Input data for energy and cost calculations

**Torksim - [Energy]**

File View Help

Start simulation

Parameters Drying schedule Energy & Costs Results

**Energy calculation input**

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Mass in walls/roof (kg)	100000,0	Specific heat floor [kJ/kg °C]	0,90
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Electric power consumption by fans for the air velocity given	30,00 kW
	4,00 m/s

**Result from energy calculations**

Losses with exhaust air (kWh)	21707,8	Total energy consumption (kWh)	8203,4
Transmission losses (kWh)	3740,9	Total energy consumption (MJ)	101532,4
Acc. energy in timber (kWh)	1754,7	Average energy consumption (kJ/kg evaporated H2O)	4850,5
Acc. energy in building (kWh)	1000,0		

**Result 4**  
Energy consumption

Torksim - [Result, main case]

File View Help

Start simulation

Parameters Drying schedule Energy & Costs Results Result, main case

Drying time [h]	Moist. cont. [average] [%]	EDG MCI/3	Gradient EDG	Max relative stress-surface	Slicing test gap [mm]		Temperature [°C]			Power [kW]	Drying costs E/MC-%/m³	Drying costs €
					0 h	24 h	dry bulb	wet bulb	wood			
200	19.24	20.17	1.41	0.215	-0.24	0.53	64.84	60.00	64.53	38	3.82	5295.2
201	19.17	20.12	1.43	0.216	-0.24	0.54	64.92	60.00	64.61	38	3.84	5281.5
202	19.10	20.06	1.44	0.216	-0.24	0.55	65.00	60.00	64.68	38	3.85	5307.7
203	19.03	20.01	1.46	0.216	-0.24	0.56	65.08	60.00	64.76	38	3.87	5324.0
204	18.97	19.96	1.48	0.216	-0.24	0.57	65.16	60.00	64.84	38	3.89	5360.2
205	18.90	19.90	1.49	0.216	-0.24	0.58	65.24	60.00	64.93	38	3.91	5386.5
206	18.83	19.85	1.51	0.217	-0.24	0.60	65.34	60.00	65.02	39	3.91	5412.8
207	18.77	19.79	1.52	0.218	-0.24	0.61	65.44	60.00	65.12	39	3.91	5439.0
208	18.70	19.74	1.54	0.219	-0.24	0.62	65.54	60.00	65.22	39	3.90	5465.3
209	18.63	19.69	1.55	0.220	-0.24	0.63	65.64	60.00	65.32	39	3.91	5491.5
210	18.56	19.63	1.57	0.221	-0.24	0.64	65.74	60.00	65.42	39	3.91	5517.8
211	18.50	19.58	1.59	0.221	-0.24	0.65	65.84	60.00	65.52	39	3.92	5544.0
212	18.43	19.53	1.60	0.221	-0.24	0.66	65.94	60.00	65.62	39	3.93	5570.3
213	18.36	19.47	1.62	0.221	-0.25	0.67	66.04	60.00	65.72	39	3.94	5596.5
214	18.30	19.42	1.63	0.221	-0.25	0.68	66.14	60.00	65.82	39	3.96	5622.8
215	18.23	19.37	1.65	0.221	-0.25	0.69	66.24	60.00	65.92	39	3.97	5649.0
216	18.17	19.31	1.66	0.220	-0.25	0.71	66.34	60.00	66.02	39	3.99	5675.3
217	18.10	19.26	1.68	0.220	-0.25	0.72	66.44	60.00	66.12	39	4.01	5701.5
218	18.03	19.21	1.70	0.219	-0.25	0.73	66.53	60.00	66.22	39	4.02	5727.8
219	17.97	19.16	1.71	0.218	-0.25	0.74	66.63	60.00	66.32	39	4.04	5754.0
220	17.91	19.11	1.73	0.218	-0.25	0.75	66.72	60.00	66.42	39	4.06	5780.3
221	17.84	19.05	1.74	0.217	-0.25	0.76	66.82	60.00	66.52	39	4.08	5806.5
222	17.78	19.00	1.76	0.215	-0.24	0.77	66.92	60.00	66.62	39	4.10	5832.8
223	17.71	18.95	1.77	0.215	-0.24	0.78	67.02	60.00	66.72	40	4.10	5859.0
224	17.65	18.90	1.79	0.216	-0.24	0.79	67.12	60.00	66.82	40	4.09	5885.3
225	17.58	18.85	1.80	0.216	-0.24	0.80	67.22	60.00	66.92	40	4.09	5911.5
226	17.52	18.80	1.82	0.216	-0.24	0.81	67.32	60.00	67.02	40	4.09	5937.8
227	17.46	18.75	1.83	0.215	-0.24	0.82	67.42	60.00	67.12	40	4.09	5964.0
228	17.39	18.70	1.85	0.215	-0.24	0.84	67.53	60.00	67.22	40	4.10	5990.3
229	17.33	18.65	1.87	0.214	-0.24	0.85	67.63	60.00	67.32	40	4.10	6016.5
230	17.26	18.59	1.88	0.214	-0.24	0.86	67.73	60.00	67.42	40	4.11	6042.8
231	17.20	18.54	1.90	0.213	-0.24	0.87	67.84	60.00	67.52	40	4.12	6069.0
232	17.14	18.49	1.91	0.212	-0.24	0.88	67.94	60.00	67.62	40	4.12	6095.3
233	17.07	18.44	1.93	0.210	-0.24	0.89	68.05	60.00	67.72	40	4.14	6121.5
234	17.01	18.39	1.95	0.209	-0.24	0.90	68.16	60.00	67.82	40	4.15	6147.8
235	16.95	18.34	1.96	0.208	-0.24	0.91	68.26	60.00	67.92	40	4.16	6174.0
236	16.88	18.29	1.98	0.206	-0.24	0.93	68.38	60.00	68.02	40	4.17	6200.3
237	16.82	18.24	2.00	0.205	-0.24	0.94	68.50	60.00	68.12	40	4.19	6226.5
238	16.76	18.19	2.01	0.203	-0.24	0.95	68.62	60.00	68.22	40	4.20	6252.8
239	16.70	18.14	2.03	0.201	-0.24	0.96	68.74	60.00	68.32	40	4.21	6279.0
240	16.63	18.10	2.05	0.201	-0.24	0.97	68.86	60.00	68.42	41	4.20	6305.3

Results

Result 5  
Drying costs

## Summary of output data

- Moisture content, as a function of time
- Moisture gradient, - “ -
- Wood temperature, - “ -
- Stress development (checking), - “ -
- Slicing test gap, - “ -
- Energy consumption, - “ -
- Drying costs, - “ -



## Conclusions

- TORKSIM is a comprehensive software for prediction of several important features related to batch kiln softwood drying.
- It represents a valuable tool for quality control, trouble shooting and optimisation.
- It is also an efficient educational tool for kiln operators and people responsible for the kilning process, as well as for students in universities and technical schools.

## Offer

- TORKSIM is offered to kiln operators, researchers and others interested in the kiln drying of softwood.

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