

## Supplementary Materials

### List of Investigated Unit Load Scenarios with Different Pallet Wood Species.

**Table S1.** Rank, UOR, and specification of investigated green high-density hardwood unit load scenarios for analysis. Scenarios selected at regular intervals and minimum required condition analysis are highlighted as yellow and green, respectively.

Wood Species	Rank	UOR	Box weight decrease (kg)	Pallet weight increase (kg)	Initial top deck thickness (mm)	Increased top deck thickness (mm)	Initial board grade (kg/mm ECT)	Decreased board grade (kg/mm ECT)	Flute size	Box size
Green High-Density Hardwood	1	0.035	0.73	20.86	15.9	31.8	0.57	0.52	C	Small
	2	0.040	0.44	10.88	9.5	17.5	0.57	0.52	C	Large
	3	0.051	0.87	17.23	12.7	25.4	0.57	0.52	C	Medium
	4	0.114	0.73	6.35	12.7	17.5	0.57	0.52	C	Small
	5	0.137	0.87	6.35	9.5	14.3	0.57	0.52	C	Medium
	6	0.160	0.73	4.54	9.5	12.7	0.57	0.52	C	Small
	7	0.189	2.39	12.70	15.9	25.4	0.91	0.86	BC	Large
	8	0.211	3.63	17.23	19.1	31.8	0.91	0.86	BC	Small
	9	0.218	6.53	29.93	9.5	31.7	0.71	0.57	C	Medium
	10	0.264	2.39	9.07	9.5	15.9	0.91	0.86	BC	Large
	11	0.293	2.39	8.16	12.7	19.1	0.91	0.86	BC	Large
	12	0.320	2.61	8.16	15.9	22.3	0.91	0.86	BC	Medium
	13	0.328	5.66	17.23	12.7	25.4	0.79	0.71	C	Large
	14	0.446	5.66	12.70	9.5	19	0.79	0.71	C	Large
	15	0.576	2.61	4.54	9.5	12.7	0.91	0.86	BC	Medium
	16	0.576	2.61	4.54	12.7	15.9	0.91	0.86	BC	Medium
	17	0.600	6.53	10.88	12.7	20.7	0.79	0.71	C	Medium
	18	0.657	11.32	17.23	12.7	25.4	1.27	1.09	BC	Medium
	19	0.686	8.71	12.70	15.9	25.4	0.79	0.71	C	Small
	20	0.733	7.98	10.88	9.5	17.5	0.71	0.57	C	Small
	21	0.800	3.63	4.54	12.7	15.9	0.91	0.86	BC	Small
	22	0.800	20.32	25.40	12.7	31.8	1.09	0.91	BC	Small
	23	1.000	3.63	3.63	15.9	19.1	0.91	0.86	BC	Small
	24	1.240	13.50	10.88	9.5	17.5	1.09	0.91	BC	Medium
	25	1.248	11.32	9.07	9.5	15.9	1.27	1.09	BC	Medium
	26	1.267	13.79	10.88	12.7	20.7	1.27	1.09	BC	Small
	27	1.333	3.63	2.72	9.5	11.1	0.91	0.86	BC	Small
	28	1.371	8.71	6.35	12.7	17.5	0.79	0.71	C	Small

29	1.440	6.53	4.54	9.5	12.7	0.79	0.71	C	Medium
30	1.920	8.71	4.54	9.5	12.7	0.79	0.71	C	Small
31	2.171	13.79	6.35	9.5	14.3	1.27	1.09	BC	Small
32	3.200	20.32	6.35	9.5	14.3	1.09	0.91	BC	Small

\*Note: Size of small box is 203.2 mm x 304.8 mm x 254 mm, medium box is 406.4 mm x 254 mm x 254 mm, and large box is 609.6 mm x 337.8 mm x 254 mm (Kim et al., 2021 [35]).

**Table S2.** Rank, UOR, and specification of investigated green low-density hardwood unit load scenarios for analysis. Scenarios selected at regular intervals and minimum required condition analysis are highlighted as yellow and green, respectively.

Wood Species	Rank	UOR	Box weight	Pallet weight	Initial top deck	Increased top	Initial board	Decreased	Flute size	Box size
			decrease (kg)	increase (kg)	thickness (mm)	deck thickness (mm)	grade (kg/mm ECT)	board grade (kg/mm ECT)		
Green Low-Density Hardwood	1	0.021	0.44	20.86	12.7	31.8	0.57	0.52	C	Large
	2	0.040	0.44	10.88	9.5	19	0.57	0.52	C	Large
	3	0.073	0.73	9.98	15.9	25.4	0.57	0.52	C	Small
	4	0.096	0.87	9.07	12.7	20.7	0.57	0.52	C	Medium
	5	0.133	0.73	5.44	12.7	17.5	0.57	0.52	C	Small
	6	0.160	0.87	5.44	9.5	14.3	0.57	0.52	C	Medium
	7	0.192	2.61	13.61	19.1	31.8	0.91	0.86	BC	Medium
	8	0.200	0.73	3.63	9.5	12.7	0.57	0.52	C	Small
	9	0.220	2.39	10.88	9.5	19	0.91	0.86	BC	Large
	10	0.240	2.39	9.98	15.9	25.4	0.91	0.86	BC	Large
	11	0.267	6.53	24.49	9.5	31.7	0.71	0.57	C	Medium
	12	0.330	2.39	7.26	12.7	19.1	0.91	0.86	BC	Large
	13	0.416	5.66	13.61	12.7	25.4	0.79	0.71	C	Large
	14	0.446	5.66	12.70	9.5	20.6	0.79	0.71	C	Large
	15	0.480	2.61	5.44	15.9	20.7	0.91	0.86	BC	Medium
	16	0.647	13.5	20.86	12.7	31.8	1.09	0.91	BC	Medium
	17	0.720	2.61	3.63	9.5	12.7	0.91	0.86	BC	Medium
	18	0.720	2.61	3.63	12.7	15.9	0.91	0.86	BC	Medium
	19	0.900	6.53	7.26	12.7	19.1	0.79	0.71	C	Medium
	20	1.000	3.63	3.63	15.9	19.1	0.91	0.86	BC	Small
	21	1.000	3.63	3.63	19.1	22.3	0.91	0.86	BC	Small
	22	1.040	11.32	10.88	12.7	22.2	1.27	1.09	BC	Medium
	23	1.100	7.98	7.26	9.5	15.9	0.71	0.57	C	Small
	24	1.200	8.71	7.26	15.9	22.3	0.79	0.71	C	Small
	25	1.560	11.32	7.26	9.5	15.9	1.27	1.09	BC	Medium

26	1.800	6.53	3.63	9.5	12.7	0.79	0.71	C	Medium
27	1.860	13.5	7.26	9.5	15.9	1.09	0.91	BC	Medium
28	1.900	13.79	7.26	12.7	19.1	1.27	1.09	BC	Small
29	2.000	3.63	1.81	9.5	11.1	0.91	0.86	BC	Small
30	2.000	3.63	1.81	12.7	14.3	0.91	0.86	BC	Small
31	2.400	8.71	3.63	9.5	12.7	0.79	0.71	C	Small
32	2.400	8.71	3.63	12.7	15.9	0.79	0.71	C	Small
33	2.533	13.79	5.44	9.5	14.3	1.27	1.09	BC	Small
34	2.800	20.32	7.26	12.7	19.1	1.09	0.91	BC	Small
35	3.733	20.32	5.44	9.5	14.3	1.09	0.91	BC	Small

\*Note: Size of small box is 203.2 mm x 304.8 mm x 254 mm, medium box is 406.4 mm x 254 mm x 254 mm, and large box is 609.6 mm x 337.8 mm x 254 mm (Kim et al., 2021 [35]).

**Table S3.** Rank, UOR, and specification of investigated green southern yellow pine unit load scenarios for analysis. Scenarios selected at regular intervals and minimum required condition analysis are highlighted as yellow and green, respectively.

Wood Species	Rank	UOR	Box		Initial top deck thickness (mm)	Increased top deck thickness (mm)	Initial board grade (kg/mm ECT)	Decreased board grade (kg/mm ECT)	Flute size	Box size
			weight decrease (kg)	Pallet weight increase (kg)						
Green Southern Yellow Pine	1	0.023	0.44	19.05	12.7	31.8	0.57	0.52	C	Large
	2	0.048	0.44	9.07	9.5	19	0.57	0.52	C	Large
	3	0.107	0.87	8.16	12.7	20.7	0.57	0.52	C	Medium
	4	0.114	0.73	6.35	12.7	19.1	0.57	0.52	C	Small
	5	0.192	0.87	4.54	9.5	14.3	0.57	0.52	C	Medium
	6	0.206	2.61	12.70	19.1	31.8	0.91	0.86	BC	Medium
	7	0.240	2.39	9.98	15.9	25.4	0.91	0.86	BC	Large
	8	0.267	0.73	2.72	9.5	12.7	0.57	0.52	C	Small
	9	0.330	2.39	7.26	9.5	17.5	0.91	0.86	BC	Large
	10	0.377	2.39	6.35	12.7	19.1	0.91	0.86	BC	Large
	11	0.400	6.53	16.33	15.9	31.8	0.79	0.71	C	Medium
	12	0.446	5.66	12.70	12.7	25.4	0.79	0.71	C	Large
	13	0.480	2.61	5.44	15.9	20.7	0.91	0.86	BC	Medium
	14	0.520	5.66	10.88	9.5	20.6	0.79	0.71	C	Large
	15	0.554	6.53	11.79	9.5	22.2	0.71	0.57	C	Medium
	16	0.571	3.63	6.35	19.1	25.5	0.91	0.86	BC	Small
	17	0.709	13.5	19.05	12.7	31.8	1.09	0.91	BC	Medium
	18	0.844	13.79	16.33	15.9	31.8	1.27	1.09	BC	Small
	19	0.873	8.71	9.98	15.9	25.4	0.79	0.71	C	Small

20	0.960	2.61	2.72	12.7	15.9	0.91	0.86	BC	Medium
21	1.000	3.63	3.63	15.9	19.1	0.91	0.86	BC	Small
22	1.100	7.98	7.26	9.5	17.5	0.71	0.57	C	Small
23	1.387	11.32	8.16	12.7	20.7	1.27	1.09	BC	Medium
24	1.440	6.53	4.54	12.7	17.5	0.79	0.71	C	Medium
25	1.920	8.71	4.54	12.7	17.5	0.79	0.71	C	Small
26	2.000	3.63	1.81	12.7	14.3	0.91	0.86	BC	Small
27	2.080	11.32	5.44	9.5	15.9	1.27	1.09	BC	Medium
28	2.171	13.79	6.35	12.7	19.1	1.27	1.09	BC	Small
29	2.400	6.53	2.72	9.5	12.7	0.79	0.71	C	Medium
30	2.480	13.5	5.44	9.5	15.9	1.09	0.91	BC	Medium
31	2.880	2.61	0.91	9.5	11.1	0.91	0.86	BC	Medium
32	3.040	13.79	4.54	9.5	14.3	1.27	1.09	BC	Small
33	3.200	8.71	2.72	12.7	19.1	1.09	0.91	BC	Small
34	3.200	20.32	6.35	9.5	12.7	0.79	0.71	C	Small
35	4.000	3.63	0.91	9.5	11.1	0.91	0.86	BC	Small
36	4.480	20.32	4.54	9.5	14.3	1.09	0.91	BC	Small

\*Note: Size of small box is 203.2 mm x 304.8 mm x 254 mm, medium box is 406.4 mm x 254 mm x 254 mm, and large box is 609.6 mm x 337.8 mm x 254 mm (Kim et al., 2021 [35]).

**Table S4.** Rank, UOR, and specification of investigated kiln-dried southern yellow pine unit load scenarios for analysis. Scenarios selected at regular intervals are highlighted.

Wood Species	Rank	UOR	Box		Initial top deck thickness (mm)	Increased top deck thickness (mm)	Initial board grade (kg/mm ECT)	Decreased board grade (kg/mm ECT)	Flute size	Box size
			weight decrease (kg)	Pallet weight increase (kg)						
Kiln-dried Southern Yellow Pine	1	0.16	0.73	4.54	11.1	28.6	0.57	0.52	C	Small
	2	0.527	2.39	4.54	11.1	28.6	1.27	1.09	BC	Large
	3	0.575	2.61	4.54	11.1	28.6	1.27	1.09	BC	Medium
	4	0.799	3.63	4.54	11.1	28.6	1.27	1.09	BC	Small
	5	1.918	8.71	4.54	11.1	28.6	0.79	0.71	C	Small

\*Note: Size of small box is 203.2 mm x 304.8 mm x 254 mm, medium box is 406.4 mm x 254 mm x 254 mm, and large box is 609.6 mm x 337.8 mm x 254 mm (Kim et al., 2021 [35]).

### Input and outputs for the raw material production of different wood species groups.

**Table S5.** Inputs and outputs for the raw material production of 1 kg of wooden pallet built with green high-density hardwood (modified from Alanya-Rosenbaum et al. [20]).

	Unit	Weighted average	Allocation (%)
<b>Outputs: Products/Coproducts</b>			
Wood board	kg	1	82.3
Sawdust	kg	0.083	6.8
Hogged material	kg	0.052	4.3
Wood chips	kg	0.063	5.2
Scrap wood	kg	0.0006	0.05
Shavings	kg	0.016	1.35
<b>Inputs: materials/fuels</b>			
Sawn lumber, softwood, rough, green, at sawmill,			
SE/m3/RNA	m3	1.40E-03	
Greases	g	1.78E+00	
Motor oil	g	5.17E+00	
Hydraulic fluid	g	1.08E+01	
Lubricating fluid	g	7.17E+00	
Plastic wrapping	g	4.55E+00	
Cardboard packaging	g	3.42E+00	
Natural gas	L	1.88E+02	
Diesel	L	5.41E-01	
Gasoline	L	5.50E-03	
Liquefied petroleum gas	L	2.48E-02	
Wood fuel	OD kg	1.40E-02	
Diesel, forklift	L	1.67E-01	
Diesel, truck	L	7.37E-02	
Gasoline, truck	L	7.49E-04	

Propane, forklift	L	5.31E-01
<b>Inputs: electricity/heat</b>		
Electricity, at grid, SERC, 2010/kWh/RNA	kWh	0.002
<b>Outputs: Waste/emissions to treatment</b>		
Steel scrap	g	2.99E+02
Plastic wrap	g	6.99E+00
Cardboard packaging	g	7.60E+01
Hydraulic fluid	g	1.14E+00
Motor oil	g	1.67E-01
Greases	g	3.04E-02
Lubricants	g	1.49E+01

**Table S6.** Inputs and outputs for the raw material production of 1 kg of wooden pallet built with green low-density hardwood (modified from Alanya-Rosenbaum et al. [20]).

	Unit	Weighted average	Allocation (%)
<b>Outputs: Products/Coproducts</b>			
Wood board	kg	1	82.3
Sawdust	kg	0.083	6.8
Hogged material	kg	0.052	4.3
Wood chips	kg	0.063	5.2
Scrap wood	kg	0.0006	0.05
Shavings	kg	0.016	1.35
<b>Inputs: materials/fuels</b>			
Sawn lumber, softwood, rough, green, at sawmill,			
SE/m3/RNA	m3	1.70E-03	
Greases	g	2.16E+00	
Motor oil	g	6.28E+00	
Hydraulic fluid	g	1.31E+01	
Lubricating fluid	g	8.71E+00	

Plastic wrapping	g	5.52E+00
Cardboard packaging	g	4.15E+00
Natural gas	L	2.29E+02
Diesel	L	6.57E-01
Gasoline	L	6.68E-03
Liquefied petroleum gas	L	3.01E-02
Wood fuel	OD kg	1.70E-02
Diesel, forklift	L	2.03E-01
Diesel, truck	L	8.95E-02
Gasoline, truck	L	9.10E-04
Propane, forklift	L	6.44E-01
<b>Inputs: electricity/heat</b>		
Electricity, at grid, SERC, 2010/kWh/RNA	kWh	0.003
<b>Outputs: Waste/emissions to treatment</b>		
Steel scrap	g	3.63E+02
Plastic wrap	g	8.49E+00
Cardboard packaging	g	9.23E+01
Hydraulic fluid	g	1.38E+00
Motor oil	g	2.03E-01
Greases	g	3.69E-02
Lubricants	g	1.81E+01

**Table S7.** Inputs and outputs for the raw material production of 1 kg of wooden pallet built with green southern yellow pine (modified from Alanya-Rosenbaum et al. [20]).

	Unit	Weighted average	Allocation (%)
<b>Outputs: Products/Coproducts</b>			
Wood board	kg	1	82.3
Sawdust	kg	0.083	6.8
Hogged material	kg	0.052	4.3

Wood chips	kg	0.063	5.2
Scrap wood	kg	0.0006	0.05
Shavings	kg	0.016	1.35

**Inputs: materials/fuels**

Sawn lumber, softwood, rough, green, at sawmill,

SE/m3/RNA	m3	0.0019	
Greases	g	2.41E+00	
Motor oil	g	7.01E+00	
Hydraulic fluid	g	1.47E+01	
Lubricating fluid	g	9.74E+00	
Plastic wrapping	g	6.17E+00	
Cardboard packaging	g	4.64E+00	
Natural gas	L	2.56E+02	
Diesel	L	7.34E-01	
Gasoline	L	7.47E-03	
Liquefied petroleum gas	L	3.36E-02	
Wood fuel	OD kg	1.90E-02	
Diesel, forklift	L	2.27E-01	
Diesel, truck	L	1.00E-01	
Gasoline, truck	L	1.02E-03	
Propane, forklift	L	7.20E-01	

**Inputs: electricity/heat**

Electricity, at grid, SERC, 2010/kWh/RNA	kWh	0.003	
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**Outputs: Waste/emissions to treatment**

Steel scrap	g	4.06E+02	
Plastic wrap	g	9.49E+00	
Cardboard packaging	g	1.03E+02	
Hydraulic fluid	g	1.55E+00	



Motor oil	g	2.27E-01
Greases	g	4.13E-02
Lubricants	g	2.02E+01

**Table S8.** Inputs and outputs for the raw material production of 1 kg of wooden pallet built with kiln-dried southern yellow pine (modified from Alanya-Rosenbaum et al. [20]).

	Unit	Weighted average	Allocation (%)
<b>Outputs: Products/Coproducts</b>			
Wood board	kg	1	82.3
Sawdust	kg	0.083	6.8
Hogged material	kg	0.052	4.3
Wood chips	kg	0.063	5.2
Scrap wood	kg	0.0006	0.05
Shavings	kg	0.016	1.35
<b>Inputs: materials/fuels</b>			
Sawn lumber, softwood, planed, kiln dried, at planer,			
SE/m3/RNA	m3	0.0023	
Greases	g	2.92E+00	
Motor oil	g	8.49E+00	
Hydraulic fluid	g	1.78E+01	
Lubricating fluid	g	1.18E+01	
Plastic wrapping	g	7.47E+00	
Cardboard packaging	g	5.62E+00	
Natural gas	L	3.10E+02	
Diesel	L	8.89E-01	
Gasoline	L	9.04E-03	
Liquefied petroleum gas	L	4.07E-02	
Wood fuel	OD kg	2.30E-02	
Diesel, forklift	L	2.75E-01	

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Diesel, truck	L	1.21E-01
Gasoline, truck	L	1.23E-03
Propane, forklift	L	8.72E-01
<b>Inputs: electricity/heat</b>		
Electricity, at grid, SERC, 2010/kWh/RNA	kWh	0.004
<b>Outputs: Waste/emissions to treatment</b>		
Steel scrap	g	4.91E+02
Plastic wrap	g	1.15E+01
Cardboard packaging	g	1.25E+02
Hydraulic fluid	g	1.87E+00
Motor oil	g	2.75E-01
Greases	g	4.99E-02
Lubricants	g	2.45E+01

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