Study of Human Embodied Energy for Masonry Work during Building Construction

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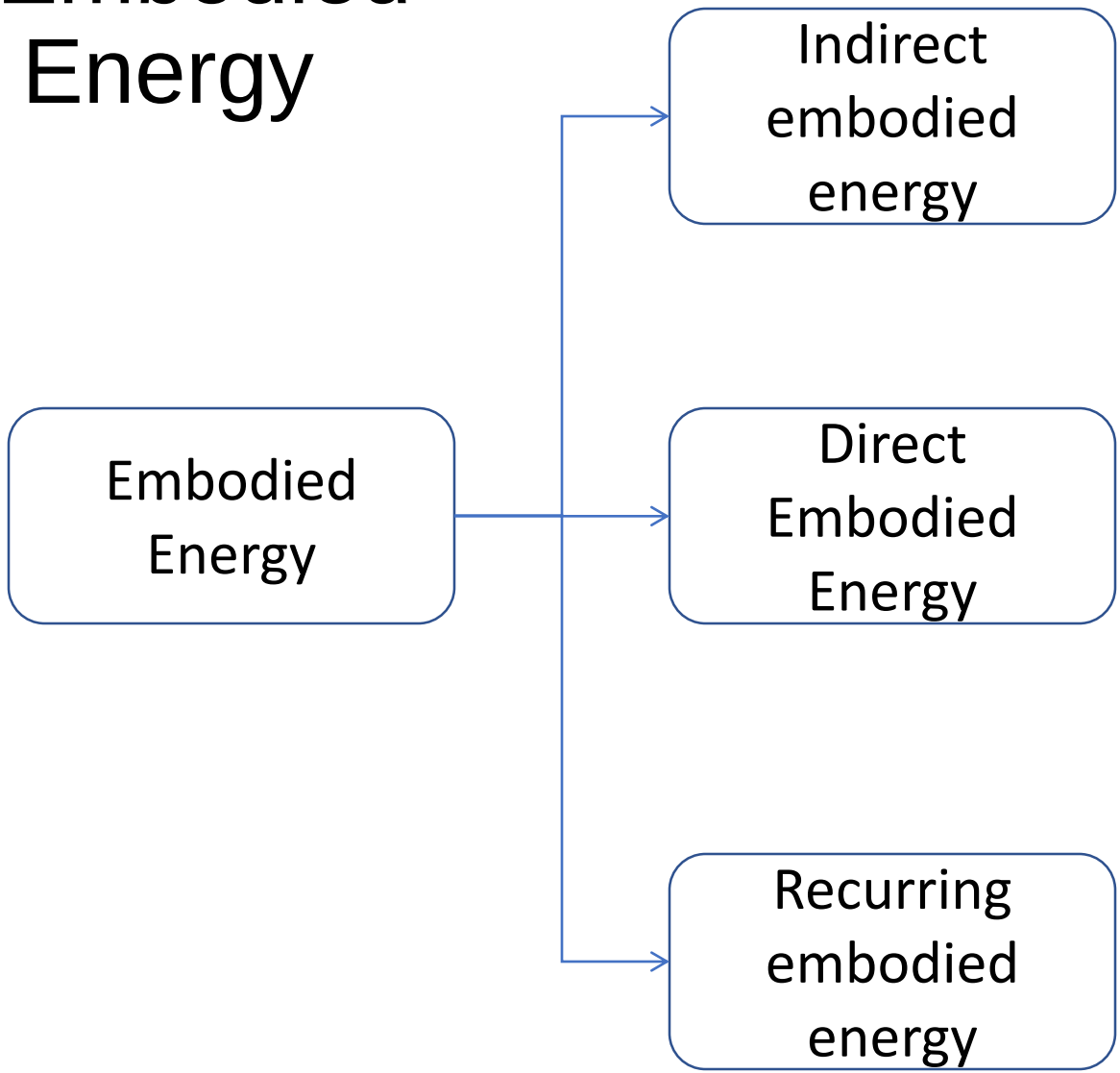
Embodied Energy

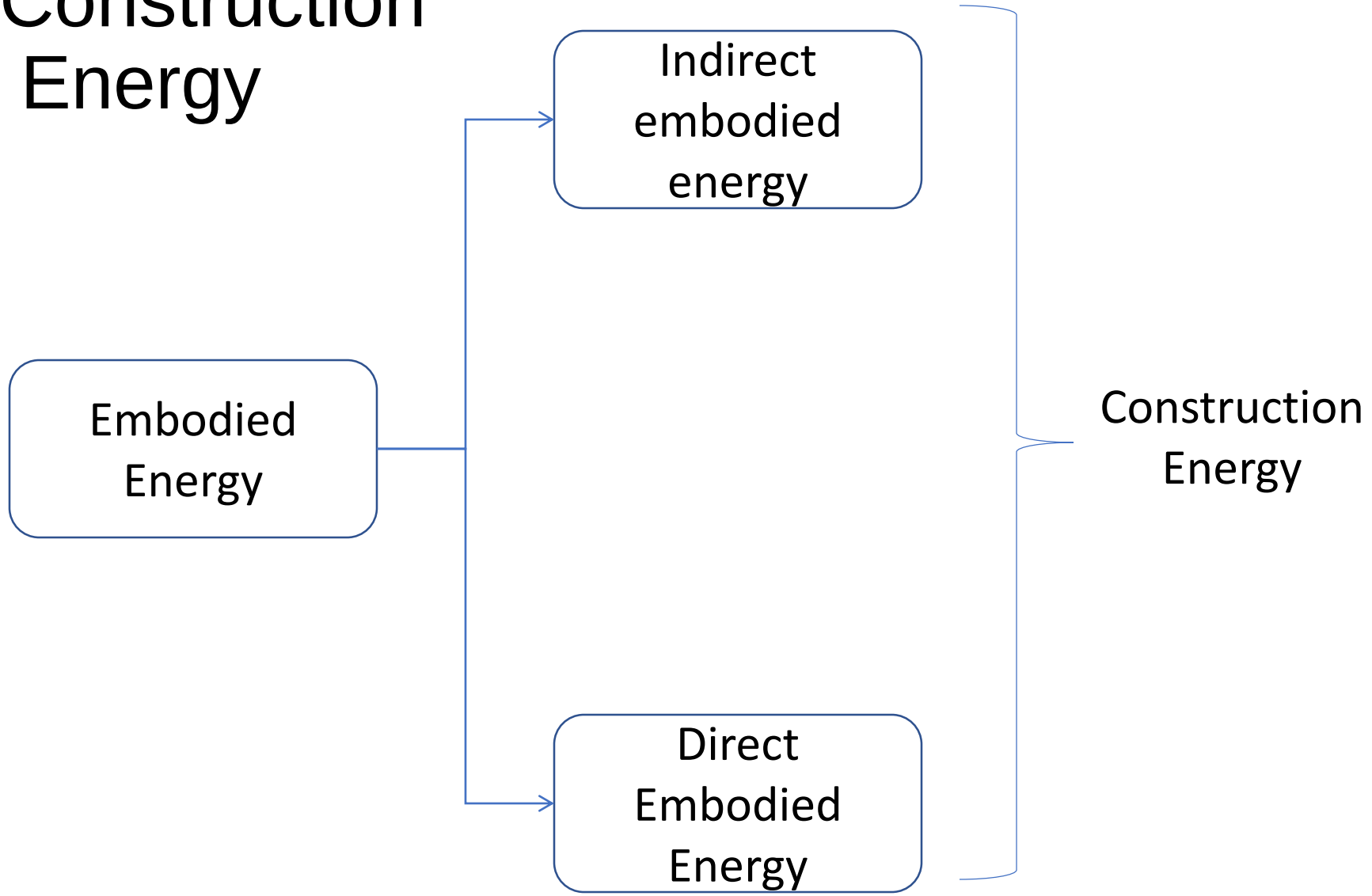


Manufacturing of construction materials

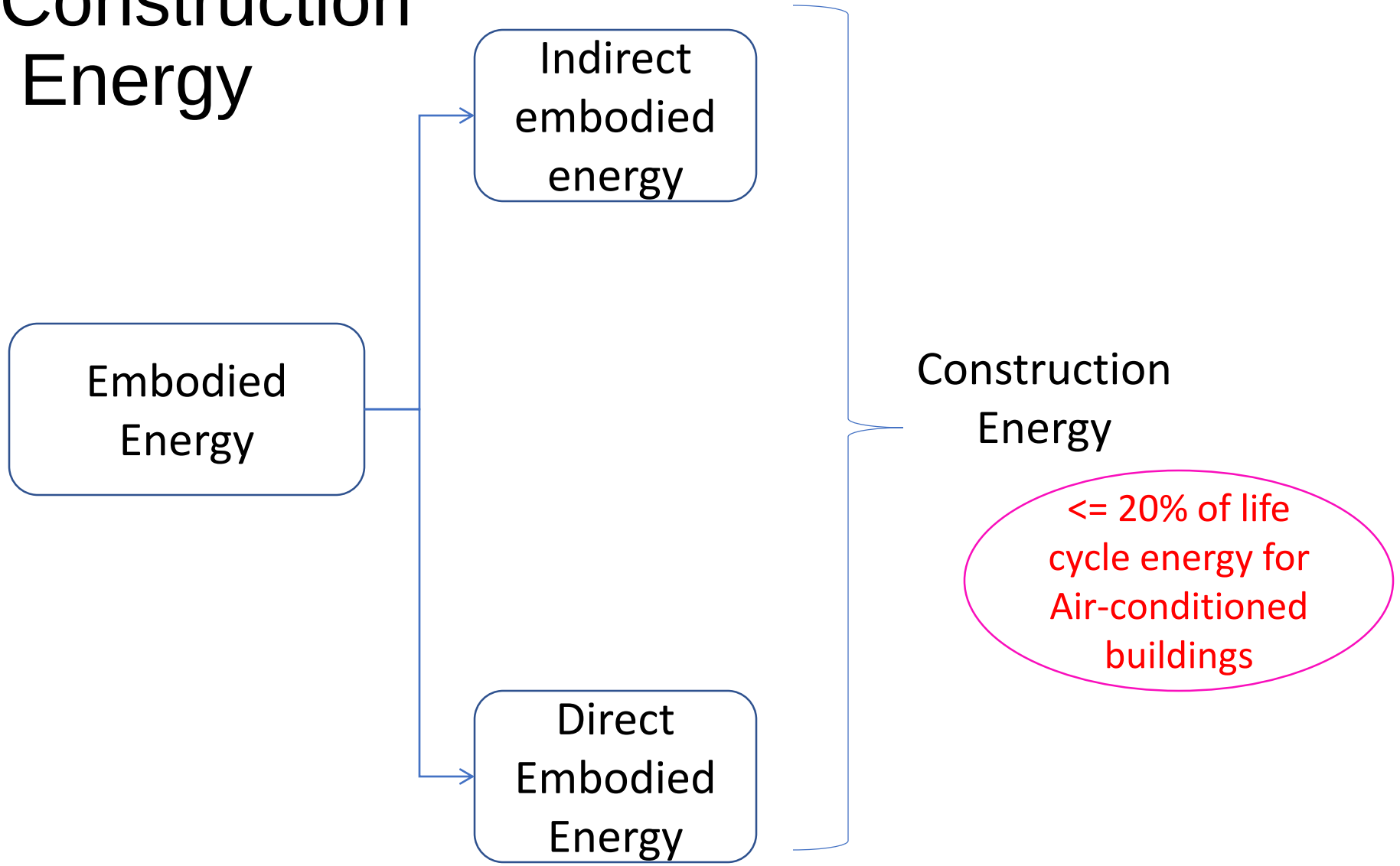
On-site construction processes

Maintenance, repair, renovation

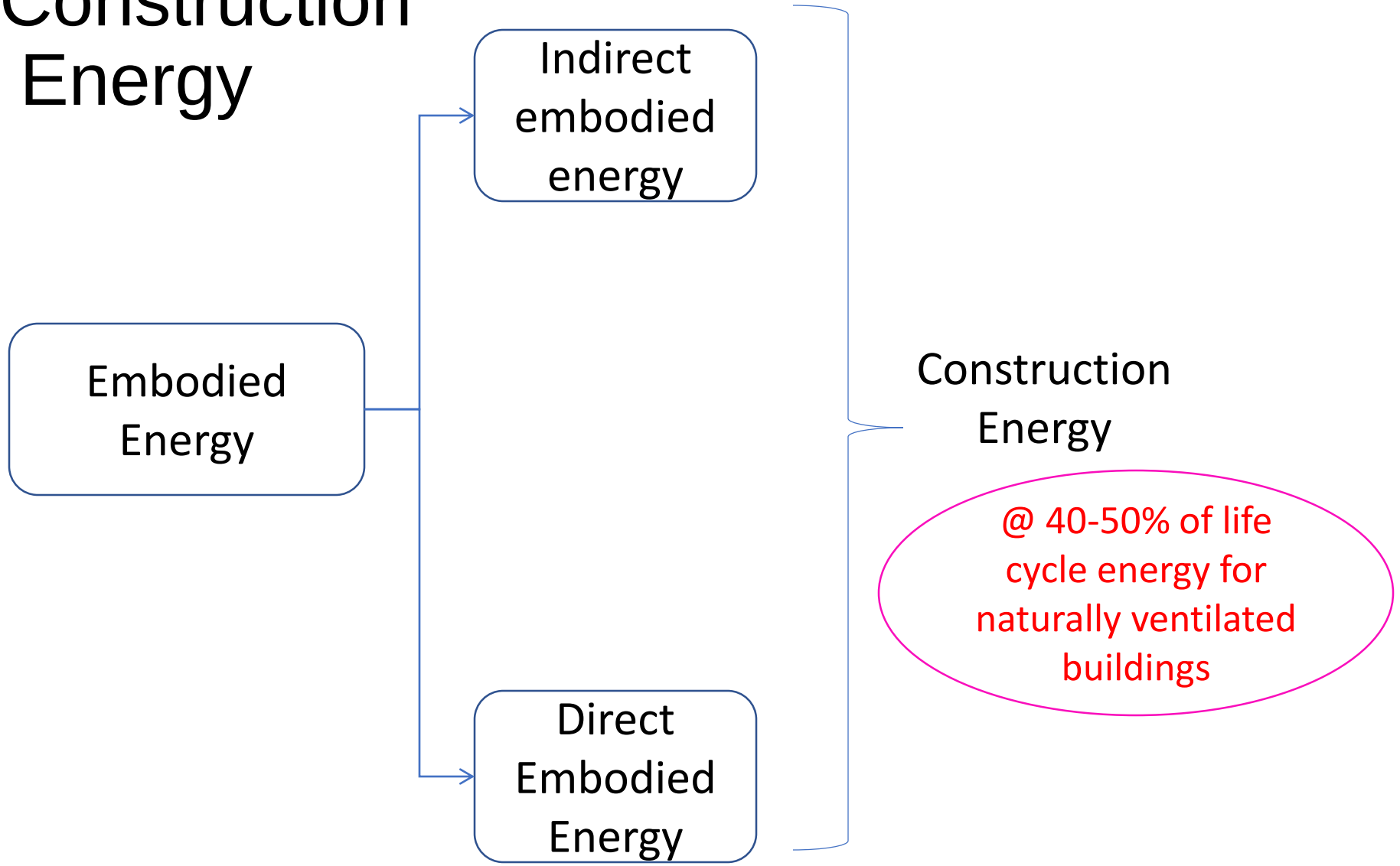
Construction Energy



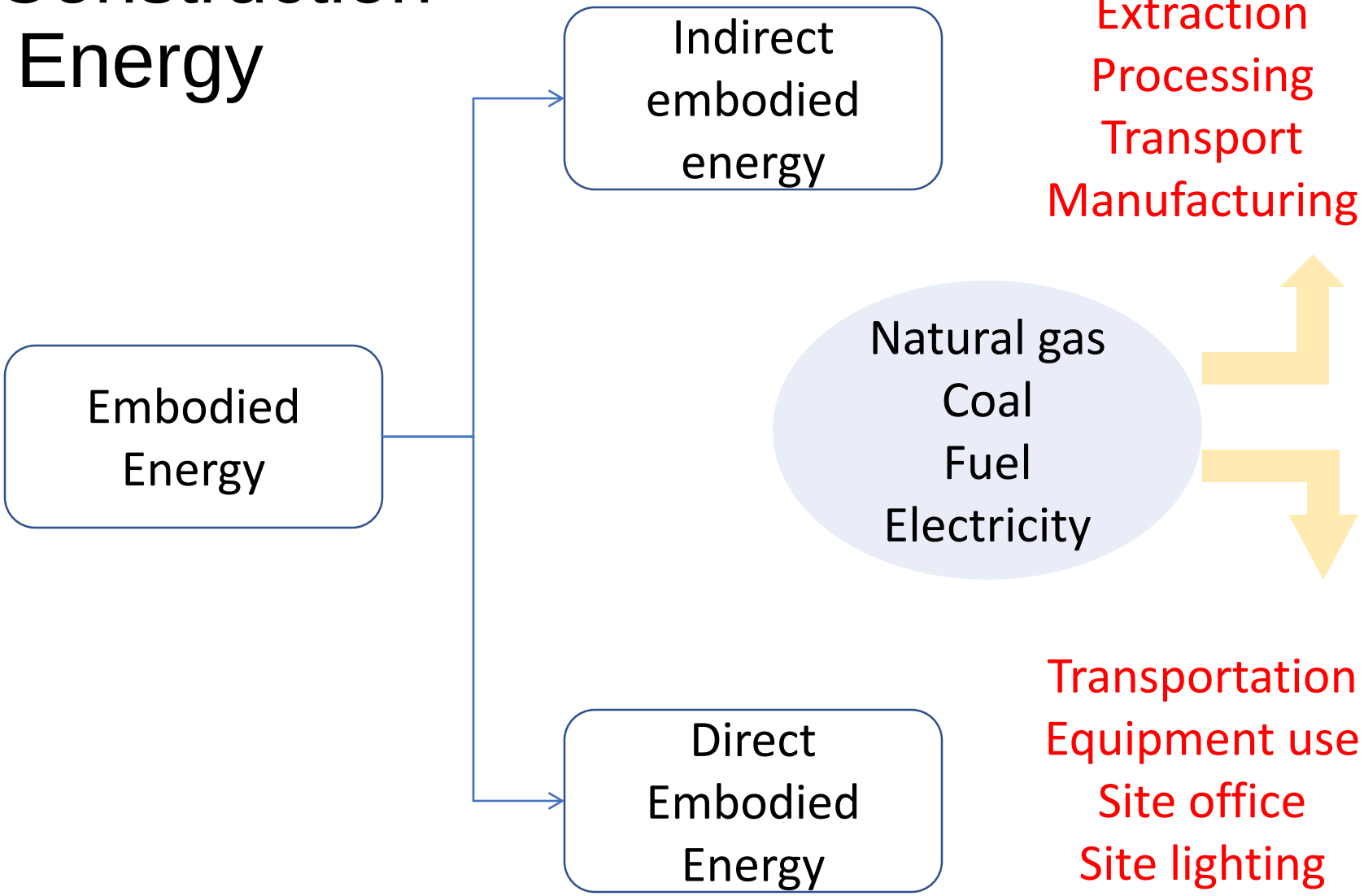
Construction Energy



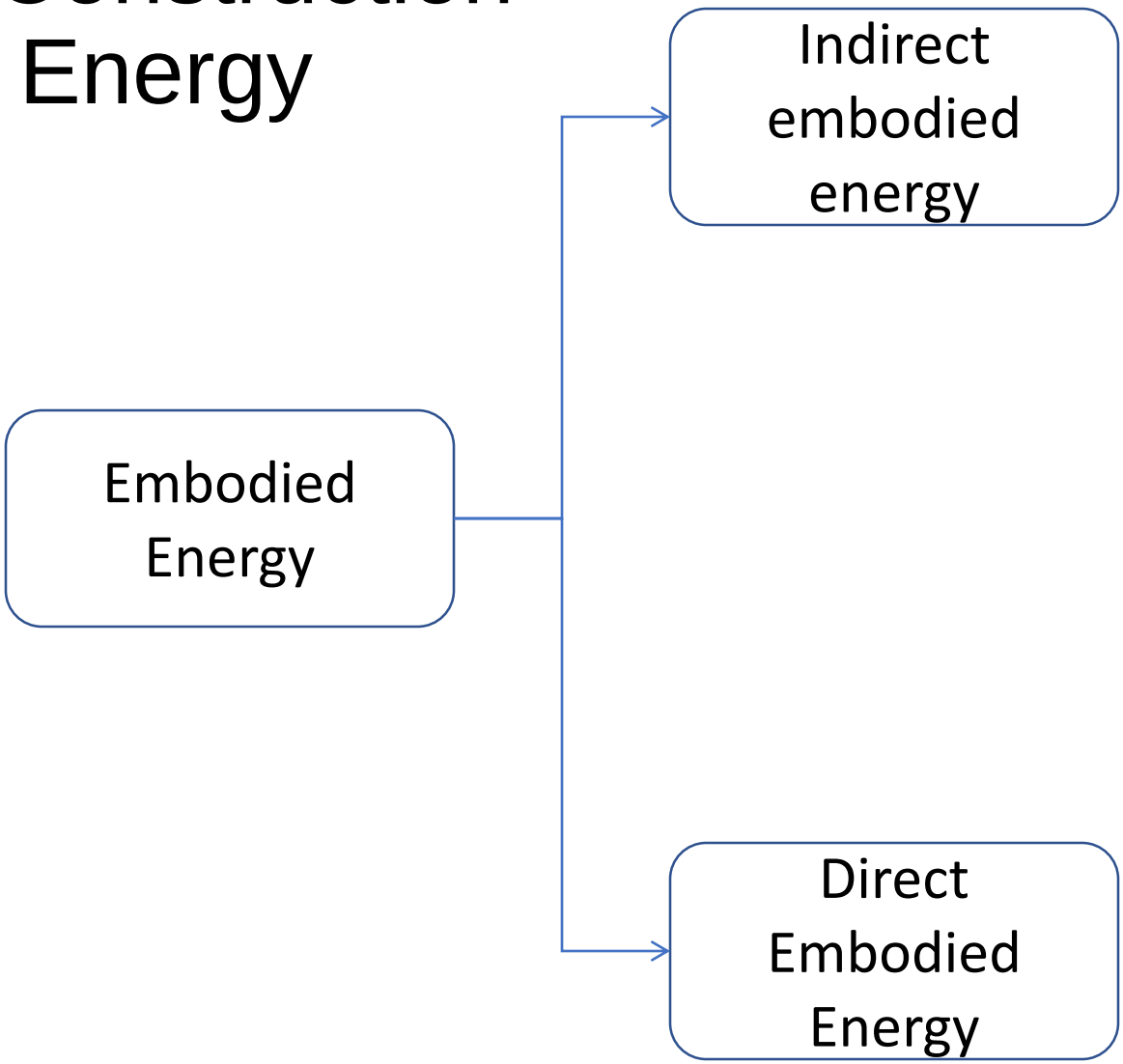
Construction Energy



Construction Energy



Construction Energy



Extraction
Processing
Transport
Manufacturing

Transportation
Equipment use
Site office
Site lighting

Construction Energy

Indirect embodied energy

Embodied Energy

Non-renewable energy
versus
Human energy

Direct Embodied Energy

Transportation
Equipment use
Site office
Site lighting
Manpower

Objectives and Scope

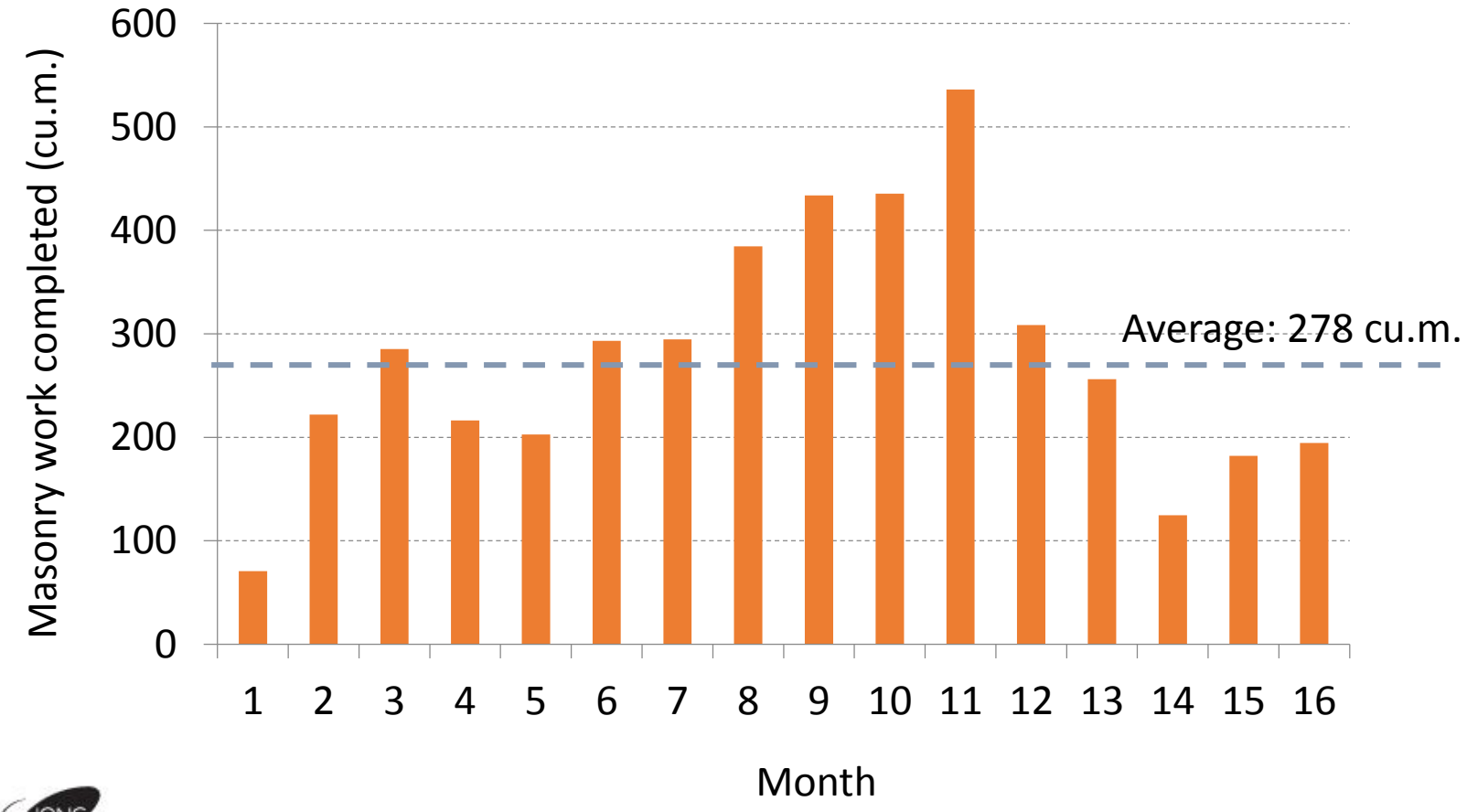
- To determine the energy use by human workforce during construction.
- To determine the relation between human energy and non-renewable energy used for construction processes.
- The scope is limited to masonry work of high-rise residential building construction.

Case Study: Masonry work

- Duration of data collection: 16 months
- Project type: high-rise residential building construction
- No of blocks(buildings): 5
- Material hoist: One per block
- Total quantity of work: 4441 cu.m.

Quantity of masonry work completed

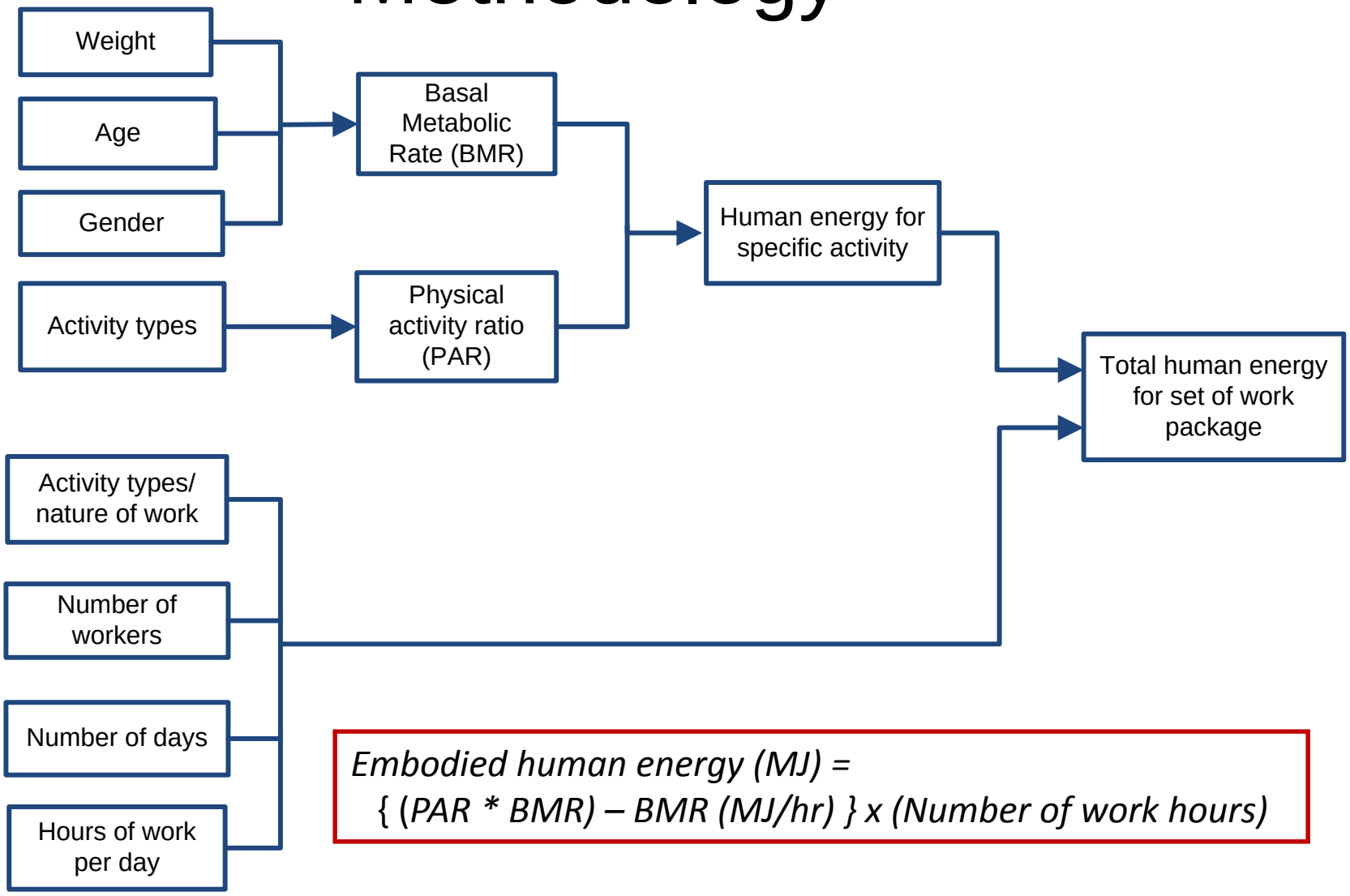
Total quantity of work: 4441 cu.m.



Schedule of manpower (human workforce)

Months	Number of Masons	Number of male helpers	Number of female helpers
1	89	135	119
2	252	384	327
3	321	487	418
4	259	399	338
5	233	355	303
6	319	484	417
7	317	479	416
8	401	610	527
9	457	695	600
10	451	682	592
11	541	817	701
12	359	541	471
13	302	459	397
14	162	250	215
15	229	350	292
16	230	350	294
Total	4922	7477	6427

Methodology



Embodied human energy (MJ) =
*{ (PAR * BMR) – BMR (MJ/hr) } x (Number of work hours)*

Methodology

Non renewable energy used for lifting (material hoist)

= *No. of lift cycles* x *kWh/lift cycle*

Gender	Age	BMR (MJ/day)	Avg. weight (kg)	BMR (MJ/day)
Male	18-30	0.063 W + 2.896	62.5	6.83
Female	18-30	0.062 W + 2.036	57.5	5.60

Food and Agriculture Organization, 2001

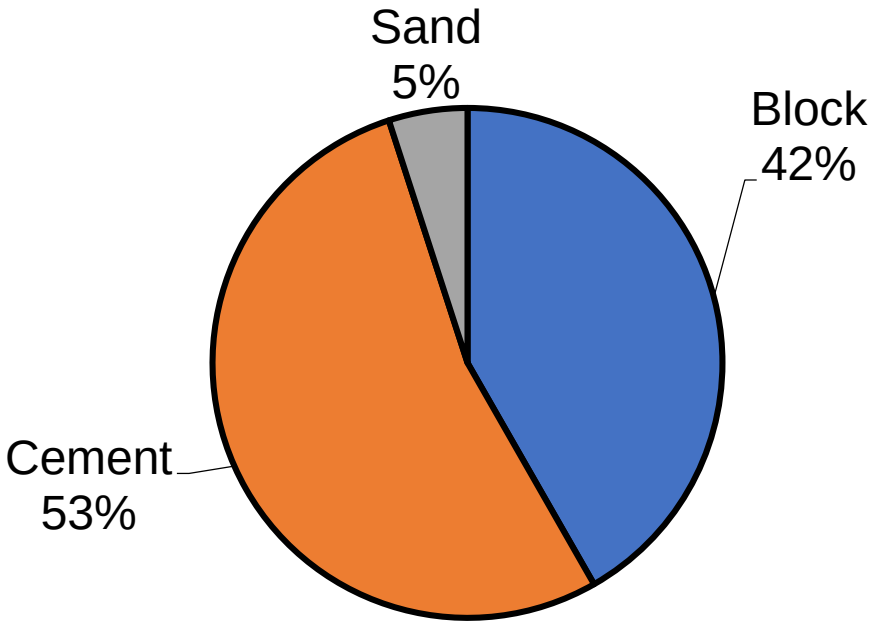
Methodology

Construction Activity	PAR
Pour Concrete (Foundation)	4.81
Brick Laying	4.81
Transport (Walk with 25-30 kg)	3.9
Place cement mortar	3.3
Rebar cutting and bending	3.3
Making Bricks	3

Food and Agriculture Organization, 2001

Energy Use: Manufacturing and Transport

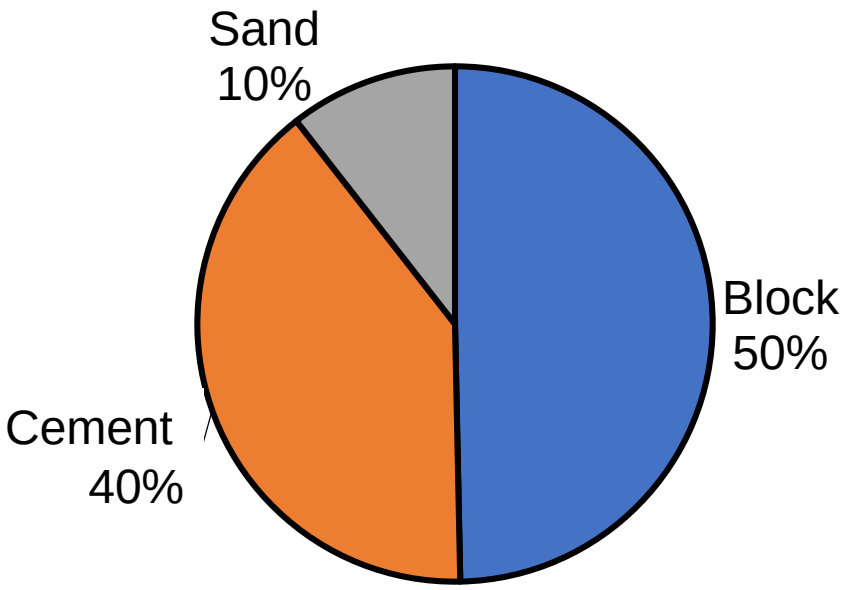
Manufacturing



Material flow: 1.82 tons/cu.m.

Energy : 1.41 GJ/cu.m.

Transportation to site



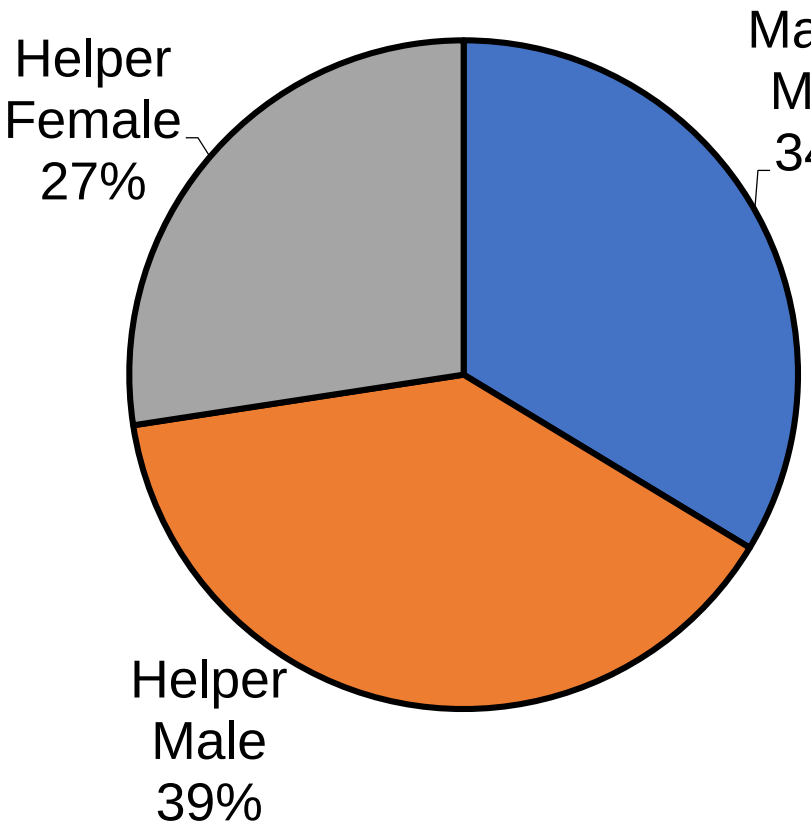
Energy : 67.1 MJ/cu.m.

Energy use for construction equipment (material hoist)

Description	Quantity (cu.m.)	Energy use (kWh/cu.m.)	Energy use (MJ)
Masonry Block Quantity (75%)	3330.7	0.05	2038
Cement Mortar Quantity (25%)	1110.3	0.15	2038
Total Lifting Energy			4076

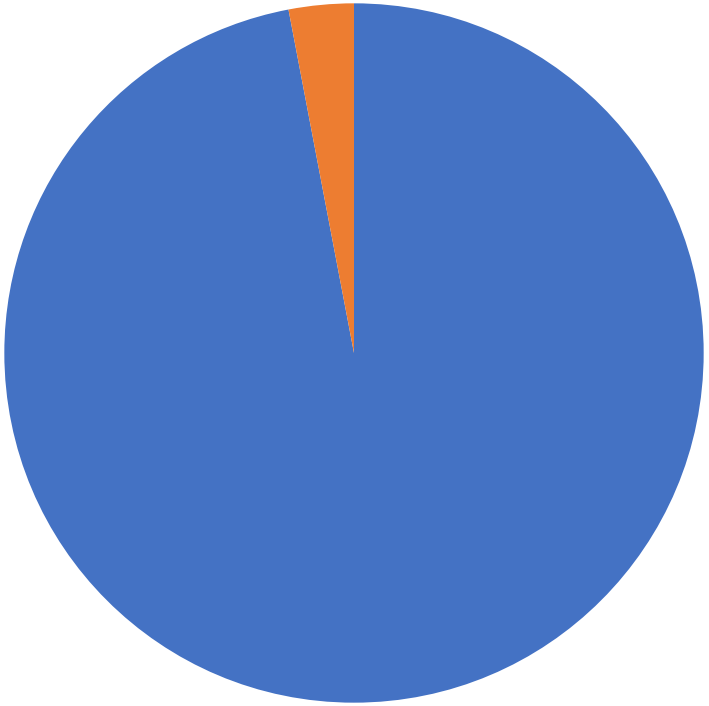
Energy : 0.92 MJ/cu.m.

Energy use (human workforce)



Human Energy :
29 MJ/cu.m.

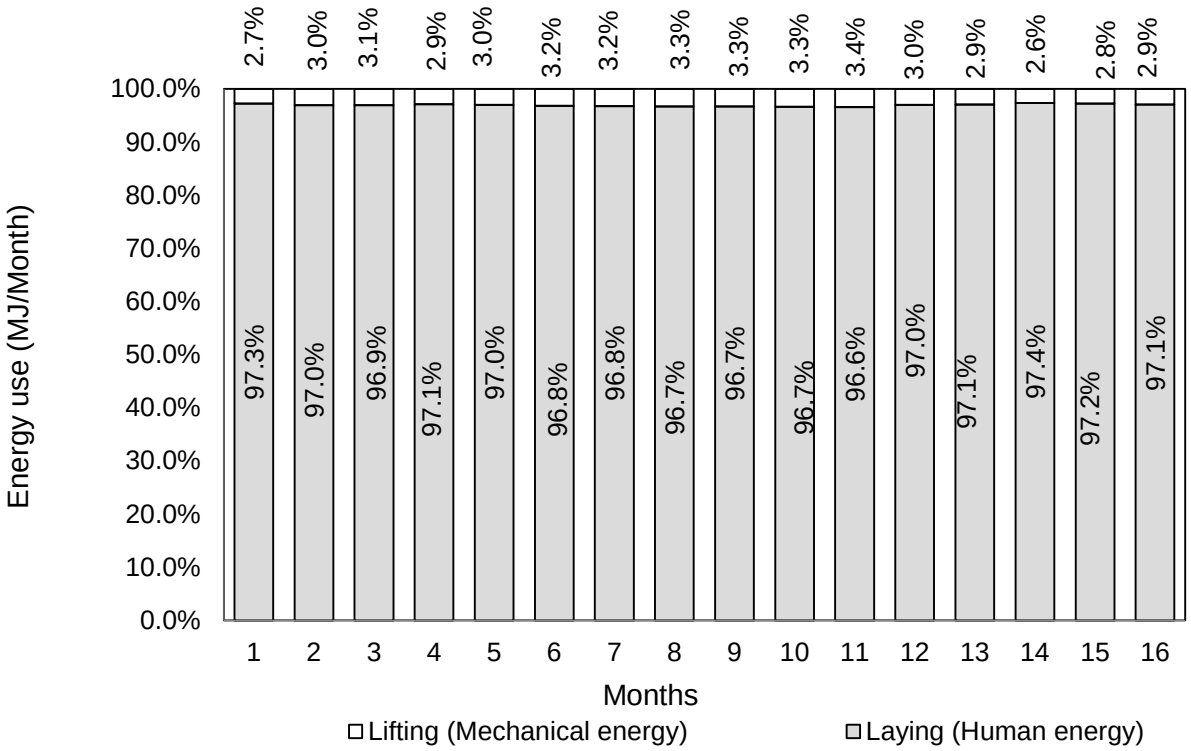
Comparison of energy use: Material hoist and human workforce



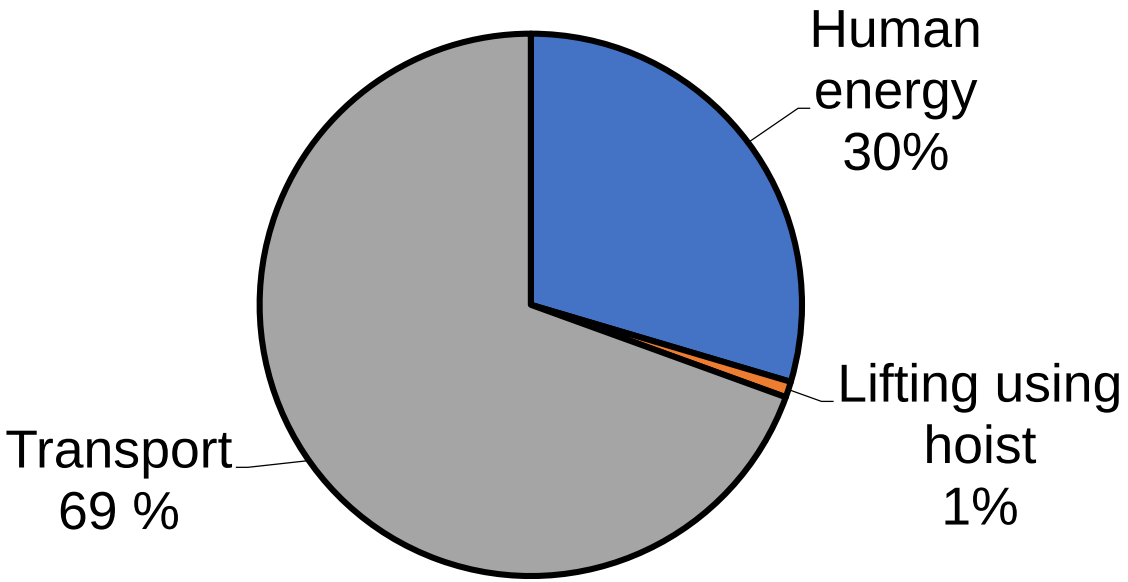
Material Hoist: 0.92 MJ/cu.m. [3%]

Human workforce: 29 MJ/cu.m. [97%]

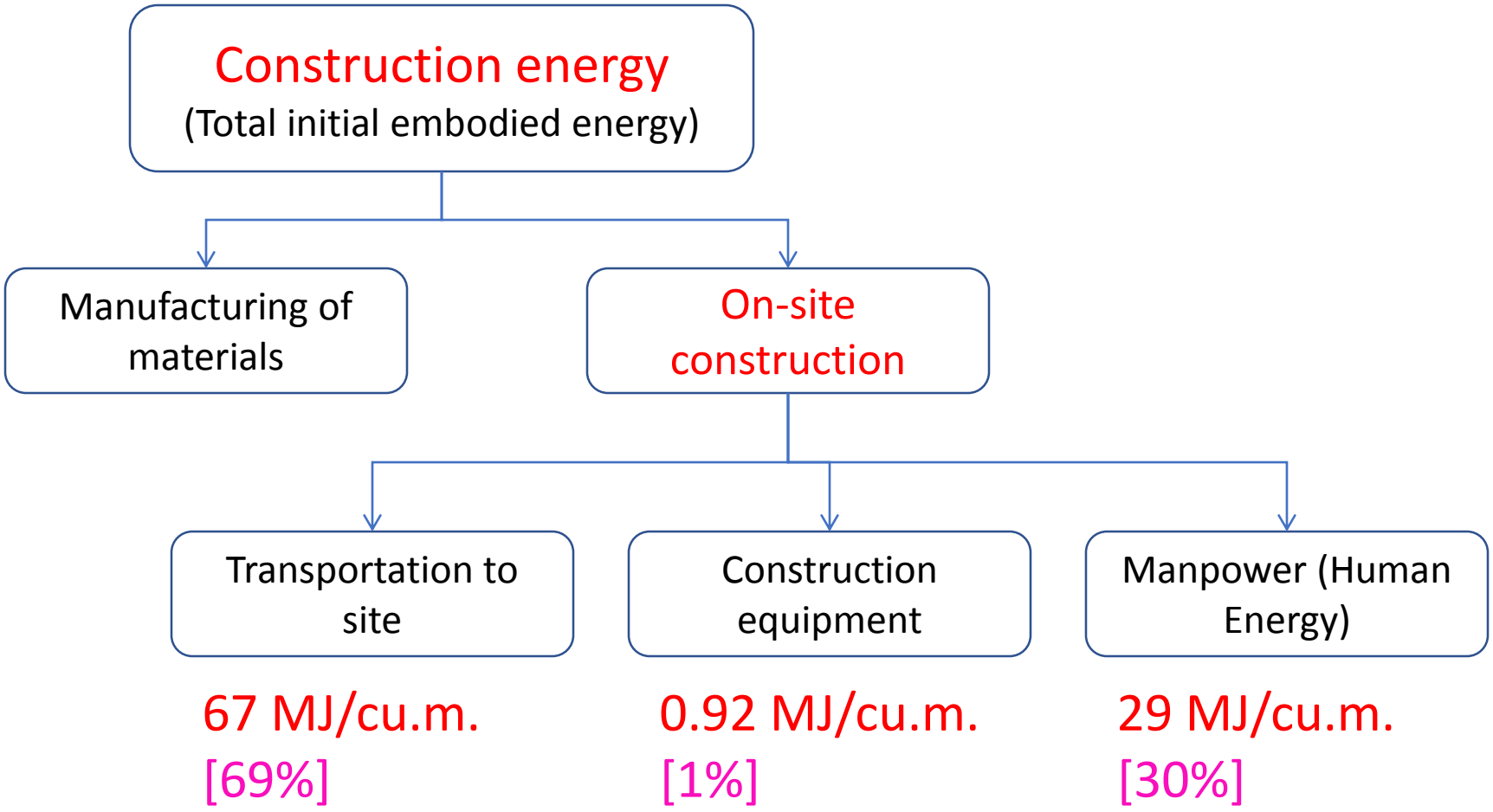
Comparison of energy use: Material hoist and human workforce



Comparison of energy use for transport, lifting (material hoist) and human resources



Summary and Conclusions



Summary and Conclusions

- Human energy is about 1/3 of the total energy used for on-site construction for masonry work.

- The relation between human energy and on-site construction energy is influenced by the degree of mechanization and manpower used.

Summary and Conclusions

Case-I	Case-II	Case-III
LESS mechanization	SEMI mechanization	HIGH mechanization
Irrigation projects rural areas	High-rise residential buildings urban areas	Major infrastructure projects of national importance
HIGH manpower use		LESS manpower use

Summary and Conclusions

- Limitation: Human energy calculation is based upon the published BMR and PAR in literature. These parameters may vary for construction workforce in India.

Thank you