#	Authors	Year	Journal	Type		Impact Category					Industrial Sector								Temporal Issue					
				Methodological / Conceptual	Case Study / Methodological LCA	GWP/other climate	Toxicity or heavy metals only	LUC	other environmental	General	Landfills	Carbon Storage	Transport / Mobility	Buildings / Civil Engineering	Production	Energy	Biomass Production / EOL	General	Time Horizon	Discounting / Temporal Weighting	Temporal Resolution Inventory	Time-Dependent Characterization	Dynamic Weighting	Time-Dependent Normalization
	Colors:																		Equivalence of time horizon and discounting Time Horizon as a subjective decision Action orientation Measurement orientation Importance of the time horizon Different types of time horizons and consistency issues	Importance of the discount rate Equivalence of tome horizon and discounting Subjectivity of discounting Reason for discounting: monetization, opportunity costs, social discounting Physical discounting Reason for discounting: uncertainty Reason: time preference Time dependency of the discount rate Reason for discounting: uncertainty,chances, risks	Importance of a dynamic inventory and interdependencies Methods	Importance of a dynamic characterization and interdependencies Methods Changing background concentration Changing sensitivity of the ecosystem		
1	Almeida, Joana; Degerickx, Jeroen; Achten, Wouter M.J.; Muys, Bart	2015	Carbon Management		X	X		X									X		➢ criticize frequent temporal inconsistency between TH of analysis and analyzed object ➢ long TH ignores short term actions (like sequestration) ➢ short TH emphasizes short term climate change ➢ TH is equivalent to discounting ➢ TH of 20,100, 500 years applied because necessary for GWP indicator	➢ no position, stated discount rate as non-consensual	➢ Application of dyn. LCI, but not regarded as useful compared to static LCI because of not solving time horizon/cut-off issue, increased complexity, not fully available in software, static easier to communicate ➢ dyn. approach necessary for advanced climate indicators like albedo or soil-atmosphere carbon-fluxes	➢ dyn. CF should consider changing sensitivity of climate to emissions		
2	Bakas, I.; Hauschild, M. Z.; Astrup, T. F.; Rosenbaum, R. K.	2015	International Journal of Life Cycle Assessment		X		X				X								➢ short TH can lead to underestimation, long TH to overestimation if not assessed dynamically ➢ long term effects are often ignored because of complexity, diversity of approaches and uncertainty together with short time preference of policymakers	➢ Application of 0.01% discount rate → 100,000 years time horizon ➢ discounting is very decisive, rates near 0 are suggested ➢ regard rate as subjective ➢ suggest for value choices and assumptions on future development cultural theory (Hofstetter et al. 2000) as guideline	➢ accumulated inventory can lead to overestimation of constant and low emissions over long time, so it should have a temporal resolution	➢ permanent dilution over time could lead to impact overestimation if not regarded, solution: second indicator "stored toxicity" for impact exceeding the time horizon ➢ is regarded as alternative to discounting ➢ time-dependent CF must regard changing background concentrations, changing ecosystem and changing overall emissions → not only inventory but also taking system must be modeled ➢ time dependent CF do not challenge time equality principle of LCA, discounting and time horizons do		
3	Beloin-Saint-Pierre, Didier; Heijungs, Reinout; Blanc, Isabelle	2014	International Journal of Life Cycle Assessment		X	X												X	➢ path analysis applied here requires process related information with start and ending point conforming to real operation status		➢ introduction of path dependent process model "enhanced structural path analysis" (ESPA) to build temporal differentiated LCI without creating much data because same processes are reused many times in different processes or different products ➢ temporal resolution should depend on goal and scope and reflect e.g. seasonality or daytime if necessary			
4	Beloin-Saint-Pierre, Didier; Levasseur, Annie; Margni, Manuele; Blanc, Isabelle	2016	Journal of Industrial Ecology		X											X			➢ choice of time horizon is subjective ➢ sensitivity analysis should be performed ➢ GWP100 starts at year 0 here, not at end of life		➢ not all inventory data must be temporally differentiated ➢ Here, 85% of total emissions is differentiated, rest is put at beginning (conservative for GWP100) ➢ study shows decisive different outcomes for different resolutions (yearly, monthly) ➢ yearly resolution may not be enough, ESPA should be able to assess at different temporal resolutions			
5	Berntsen, Terje; Tanaka, Katsumasa; Fuglestvedt, Jan S.	2010	Climatic Change	X		X												X	➢ time horizon should fit to political goals ➢ if goals for impacts are set lower, the time horizon should become shorter because it is assumed that the target year is earlier ➢ "Note that the target determines the metric and not the other way around; one should first define the target, and then choose an appropriate metric and a consistent time horizon."					
6	Boucher, O.	2012	Earth System Dynamics		X	X													➢ fixed TH is equivalent to discounting	➢ Applied rates of 1-3% like in "climate change socio-economic studies" ➢ discussion of from 3.5% to 1% declining rate because of change from individual to intergenerational discount rate after 30 years and because of growing uncertainty				
7	Brandão, M.; Levasseur, A.; Kirschbaum, M.U.F.; Weidema, B. P.; Cowie, A. L.; Jørgensen, S. V.; Hauschild, M. Z.; Pennington, D. W.; Chomkhamsri, K.	2013	International Journal of Life Cycle Assessment	X		X					X						X		➢ short TH emphasizes short-lived GHG ➢ state that for most impacts infinite TH is used but temporal carbon storage at infinite TH is useless ➢ short TH violates principle of intergenerational equity, long TH does not take into account the urgency of the problem ➢ long TH has more uncertainty of background concentration - CO_2 concentration could fall and GHGs would not have much impact anymore ➢ time horizon should represent the time until impact is no longer relevant and not represent the period of assessment ➢ characterization TH and assessment period do not need to be the same ➢ fixed time horizons lead to wrong incentives for CCS - until one year after end of assessment	➢ discounting could reflect the opportunity - e.g. fossil fuel vs. biomass fuel over the TH	➢ carbon neutrality factor = carbon emissions of biomass (+-) divided by emissions of oil	➢ authors see trend of combining indicators instead of creating new ones		
8	Brandão, Miguel; Levasseur, Annie	2011	JRC Scientific and Technical Reports (no reviewed journal)	X		X					X								➢ "A distinction was made between the choice of a time horizon and discounting, two different ways to express time preferences. Choosing a time horizon consists in looking at a particular environmental problem, which can be measured and documented, and then in making decisions on the emergency of the situation or the relevance of future actions." ➢ 100 year cutoff encourages emission shifting to end of the period and temporal emission storage without consumption reduction ➢ long TH reduces demand for short term actions ➢ short TH encourages delaying emissions only for a short time ➢ THs for different categories do not need to be consistent ➢ TH is arbitrary and value loaded ➢ infinite TH marginalizes gases with high short term GWP ➢ TH could represent the urgency of the endpoint damage (long-term sea level rise vs. short-term temperature change) ➢ suggest fixed TH rather than fixed endpoint unless the latter is attractive because policy often has fixed temporal goals, but assessments with fixed endpoint can not be compared well to later LCAs because of the nearer endpoint, the impact is reduced (or the old LCA needs to be recalculated with new starting point)	➢ "Discounting is based on the assumption that future impacts are less important because future generations will be better able to cope with the damage. There is science behind discounting (economics, social science), but it is different from the 'physical discounting' on which time horizons are based." ➢ "The general attitude in the LCIA community is to avoid discounting and time cut-offs. The choice of time horizons or discount rates is value-laden, but cannot be excluded from this subject because it is impossible to give a value to temporary carbon storage without using time preferences."	➢ dynamic inventory and static TH of impact assessment (GWP100) is inconsistent and especially problematic for long life cycles			
9	Cherubini, Francesco; Guest, Geoffrey; Strømman, Anders H.	2012	GCB Bioenergy		X	X											X		➢ "tipping point issues and commitment periods and targets provide motivation for time-constrained assessment approaches"		➢ "Neglecting the distribution over time of CO2 fluxes is appropriate if the analysis has an infinite time frame, but is questioned when specific time boundaries are set" ➢ application of dyn. LCA with dyn. Inventory and characterization and use of statistical measures for fate mechanisms, esp. chi-square distribution for corrosion processes	➢ static GWP is not useful for assessment of biomass, temporal profile of CO_2 fluxes should be integrated over time and assessed in relation to the global carbon cycle ➢ "For biomass systems characterized by time-distributed emissions, absolute metrics showing the variation of the climate impact over time are preferable over more traditional normalized metrics, such as GWP." ➢		➢ time-dependent normalization is suggested
10	Cherubini, Francesco; Peters, Glen P.; Berntsen, Terje; Strømman, Anders H.; Hertwich, Edgar	2011	GCB Bioenergy	X		X											X		➢ biomass can be seen as climate neutral only in longer TH (500 years)			➢ GWP Bio index is introduced as CF for assessing biogene CO_2 emissions which contribute to the global warming because of an athmospheric decay, depending on the rotation period of the biomass species ➢ has to be multiplied with standard GWP		
11	Chester, Mikhail V.; Cano, Alex	2016	Transportation Research Part D: Transport and Environment		X	X			X				X								➢ dyn. inventory is useful even if the outcome is similar to the static approach because it can show break-even points, contribution to emissions in a certain time frame, or when a political goal will be fulfilled			
12	Collinge, W. O.; Landis, A. E.; Jones, A. K.; Schaefer, L. A.; Bilec, M. M.	2013	International Journal of Life Cycle Assessment		X	X	X		X					X							➢ here explicite temporal data of emission events ("technosphere") and temporal immission mechanisms ("biosphere") ➢ here changes in supply chain are regarded but time lags in supply chain disregarded (error source)	➢ "Temporally variable CFs need to take into account changes in background chemical concentrations, environmental systems, and the distributions of exposed populations, as well as time horizon relevance" ➢ not much information on temporal CF available ➢ dyn. CF regard changes in system sensitivity due to background concentrations or distribution of populations ➢ here fate mechanisms regarded in CF, not in inventory ➢ CF not available for most categories, used for global warming and photochemical ozone, static CF for rest ➢ dyn. CF are in literature under some premises (local) also available for eutrophication, acidification, and ozone depletion		
13	Dyckhoff, Harald; Kasah, Tarek	2014	Journal of Industrial Ecology		X	X											X		➢ time horizon is subjective, represents temporal preference and weighting of decision maker ➢ infinite time horizon is no solution because dynamics would be disregarded ➢ here, TH is not fixed but impact is calculated for a long time and decision makers can choose their TH in a graph which also shows critical TH or break-even points ➢ some alternatives are less favorable in every TH → "time dominance" of the others	➢ with knowledge of a discount rate a TH could be calculated after which the impact would be disregardable				
14	Fearnside, Philipp M.; Lashof, Daniel A.; Moura-Costa, Pedro	2000	Mitigation and Adaption Strategies for Global Change		X			X									X		➢ TH and discounting are both time preference schemes ➢ suggest 100 yrs. For GWP "for a variety of reasons"	➢ "a decision to use a zero discount rate is just as much a decision as choosing any other rate. (…) Sound reasons exist for adopting a discount rate for C greater than the zero value currently used in most discussions of C accounting." ➢ discounting could take into account threshold effects if they were known exactly enough ➢ delaying emissions within the TH has no benefit unless they are discounted ➢ discounting=net present value but term "immediate C emission equivalent" is suggested ➢ discounting reasons: time preference, change in wealth and change in marginal utility of changing wealth ➢ "The choice of discount rates for other purposes, such as private investment decisions, public expenditures, and public regulation of renewable natural resources management, all have independent rationales. Since decisions are so sensitive to discount rate choices (…), the consequences of allowing choices on global warming decisions to be determined by discount rates derived in other spheres could be severe." ➢ there are "distortions" if there is no discounting in long TH ➢ high discount rates make renewable energies less attractive as they produce many emissions at the beginning and would prefer saving forest instead of planning new one → immediate effects favored over long term effects ➢ interactions between impact categories and different weighting of those categories, especially environmental against social, in different parts of the world make discounting difficult if the value of the discount rate is derived from other dimensions or categories - systematic problem		➢ suggest to use ton-years for mitigation projects		
15	Fearnside, Philip M.	2001	Ecological Economics	X		X						X						X	➢ TH is policy decision, should be rather short so that it reflects political goals, long TH as excuse for not acting today ➢ should be around 100 years (when grandchildren of appr. 50-year-old decision makers die) ➢ long TH makes mitigation projects less profitable, short TH encourages projects with only short term effects and hampers useful long-term investments ➢ investment calculations on TH can lead to gaming, so choice of short TH should consider actions of actors after the TH	➢ represents growth of capital and pure time preference ➢ is equivalent to TH, equivalent discount rate can be calculated for every TH ➢ decision on discount rate can not be avoided, 0 is also a discount rate ➢ 100 years is maximum TH where discount rate of 0 could be applied without too much distortion in common decision making		➢ ton-year as indicator for temporally mitigated emissions (t CO_{2eq})	➢ emissions after the TH (e.g. 100 years) could get a fixed weight (e.g. 10%)	
16	Fearnside, Philip M.	2002	Mitigation and Adaptation Strategies for Global Change	X		X												X	➢ TH and discounting are equivalent, TH is easier to explain ➢ long TH marginalize short term impacts (counterintuitive)	➢ Is policy decision, not scientific, decision can not be avoided ➢ even small discount rates (around 1%) marginalize impacts after few decades ➢ discount rate is function of capital growth and pure time preference (e.g. because of mortality) ➢ as societies do not die and capital as emission rights/rights to utilize nature can not grow to infinity, discount rates must be low, permanent losses (biodiversity) can not be discounted ➢ future generations can not be compensated with more present money unless it is completely invested in the future but delaying emissions (global warming) must have a value, so there must be time preference ➢ rates can be time-dependent (falling) → short TH with high weight and a long TH afterwards with low weight are suggested ➢ in detail: 4 generations with falling weights are regarded → discrete discount function "generation weighted index"			➢ dynamic weighting could reflect changes in the distribution of age in a society	
17	Field, Frank; Kirchain, Randolph; Clark, Joel	2001	Journal of Industrial Ecology		X	X							X							➢ decision on discounting must be made by the one who has to make decisions (*unclear: not the one who makes the LCA?)*	➢ suggest not only to assess single products but fleets of products because there is not necessarily a linear relation between a single product and a number of products distributed over time ➢ statistical approach for temporal distribution of the product fleet ➢ product failures and replacement of older products can be included in calculation			
18	Finnveden, Göran	1999	Resources, Conser-vation and Recycling	X			X				X								➢ TH separated into surveyable time period where a steady state is reached (no gas production in landfill anymore) and infinite period	➢ is an ethical evaluation				
19	Guo, M.; Murphy, R. J.	2012	Science of the Total Environment		X	X	X		X						X				➢ "We recommend that in general LCA studies, time horizons varying from 20-years to infinite-time for impact categories like GWP, ODP and toxicity potentials should be examined in the LCIA phase as a measure of robustness for LCAs, especially comparative LCAs, in order to deliver unbiased information for policy makers. " ➢ "Even for specific LCA studies providing information for policy-making with targeted time horizon (e.g. next 100 year), the different time perspective should be still examined to provide transparent LCIA results with full recognition of the effects of various time horizons."		➢ "LCAs derived only from static models run the risk of bias in providing evidence"	➢ CF must fit to time horizon if emissions decrease in the environment (e.g. ODP substances exist 1-3000 years)		
20	Hauschild, Michael; Olsen, Stig Irving; Hansen, Erik; Schmidt, Anders	2008	International Journal of Life Cycle Assessment		X		X		X		X								➢ two TH: 100 years and after 100 years			➢ new impact categories "stored toxicity" for impacts after 100 years until infinity ➢ regarded only as interim solution until exact methods for inventory and characterization of long-term impacts ➢ use of multipliers: if stored toxicity <= 10x normal tox -> use normal tox, if between 10-100 --> use both with same weight, if >100 use stored tox with higher weight or ignore normal tox completely		➢ stored toxicity can not be normalized with current emissions but with simulated future emissions of the whole system
21	Hellweg, Stefanie; Hofstetter, Thomas B.; Hungerbühler, Konrad	2003	International Journal of Life Cycle Assessment	X					X								X			➢ discounting and TH are equivalent, are like temporal weighting ➢ LCA is value-based decision support tool and should apply discounting ➢ must not be at constant rate ➢ ethical consensus that discounting because of pure time preference is immoral, should not be used in LCA but can be used by decision makers ➢ discounting because of monetary value of future environmental damages and the opportunity costs of compensation funds, if it can be assumed that future generations are satisfied with monetary compensations, rate depends on opportunity costs -> economic growth, can result in negative discount rate ➢ discounting because of uncertainty should be avoided and uncertainty should be considered in the damage prediction ➢ uncertainty can lead to higher or lower discount rates, depending on uncertain positive or negative effects ➢ if possible, discounting as dyn. characterization should be avoided because of the mostly exponential discount function that does not reflect the true temporal characterization function			➢ discounting is mixed with time dependent normalization. Normalization is regarded like inflation or deflation which influences a nominal discount rate	
22	Hellweg, Stefanie; Hofstetter, Thomas B.; Hungerbühler, Konrad	2005	Journal of Cleaner Production		X		X			X									➢ discounting is regarded as measure of dyn. characterization and normalization ➢ discount rate reflects changing background concentration		➢ Characterization can depend on background concentration that changes over time, there can be a non-linear dependency ➢ "a threshold-weighting factor could, for instance, depend on the magnitude of exceedance of no-effect levels and, in case of dynamic modeling, on the time period of exceedance"		➢ changing future background concentrations lead to different outcomes in future normalization
23	Herrchen, Monika	1998	Chemosphere	X					X									X	➢ should exceed EOL if emissions still cause impact		➢ should be applied, including fate mechanisms	➢ should be applied		➢ Different normalization factors for current toxicity and stored toxicity indicator
24	Herzog, Howard; Caldeira, Ken; Reilly, John M.	2003	Climatic Change	X		X						X							➢ short TH makes temporal carbon storage attractive, long TH not ➢ question of the meaning of "permanent", avoided fossil resource use means the resources can be used in the future → policy issue	➢ different scenarios: 1, 3, 5, 7%		➢ impact mechanism can be non-linear, e.g. due to saturation		
25	Hu, Ming	2018	Energy and Buildings		X				X					X					➢ TH and discounting depend on personal preferences of decision maker ➢ Personal preferences can be categorized in five categories according to cultural theory ➢ They can be applied to LCA, showing different outcomes depending on the cultural group (like a scenario analysis)		➢ a simplified dyn. inventory could be based on different inventory "sequences" representing different stages in a life cycle like construction, operation, renovation, and future operation of a building			
26	Huijbregts, M.A.J; Guinée, J.B; Reijnders, L.	2001	Chemosphere		X		X											X	➢ show highly different assessment outcomes for 20, 100, 500 years		➢ Used time-dependent functions instead of collected data			
27	Kendall, A.	2012	International Journal of Life Cycle Assessment	X		X												X	➢ show impacts for several time horizons 20-500 years			➢ Introduction of time adjusted warming potential (TAWP) instead of GWP, smaller than GWP because it does not count impact from year 0 but from the emission year until the time horizon		
28	Kendall, Alissa; Chang, Brenda; Sharpe, Benjamin	2009	Environmental Science & Technology		X	X		X									X		➢ apply 20 and 30 years for LUC	➢ "The discounting of emissions generally reflects the logic that GHGs will cause a climate response, in turn causing climate change impacts with consequent economic damages to people and property, which can then be discounted using traditional economic methods."		➢ introduce a time correction factor for GWP for amortization calculations for GWP depending on time horizon. If emissions of e.g. ren. energy systems are distributed evenly over time, the impact is underestimated because of emissions occurring mostly early in time and have a cumulative effect over time		
29	Kendall, Alissa; Price, Lindsay	2012	Environmental Science & Technology		X	X												X	➢ long TH (100 years) leads to underestimation of constant emissions of high potential but short-lived GHG because in standard LCA they are accumulated at the beginning ➢ different TH scenarios suggested			➢ calculation of time correction factors for more precise assessment of emission timings in the TH ➢ suggest dynamic characterization (cumulative global warming)		
30	Kirkinen, Johanna; Palosuo, Taru; Holmgren, Kristina; Savolainen, Ilkka	2008	Environmental management		X	X										X			➢ TH discussion is mixed with turning point discussion --> because of climate turning points must be avoided in a few decades, the TH must be short ➢ long TH like 300 years unrealistic because e.g. LUC can not be predicted that far in the future					
31	Laratte, Bertrand; Guillaume, Bertrand; Kim, Junbeum; Birregah, Babiga	2014	Science of the Total Environment		X	X											X		➢ TH regarded as subjective, GWP100 used		➢ yearly dyn. inventory applied	➢ comparison of "partly dyn. LCA" with only dynamic LCI and static CF and "full dyn. LCA", recommend the last because significantly more exact		

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	Colors:																		Equivalence of time horizon and discounting Time Horizon as a subjective decision Action orientation Measurement orientation Importance of the time horizon Different types of time horizons and consistency issues	Importance of the discount rate Equivalence of time horizon and discounting Subjectivity of discounting Reason for discounting: monetization, opportunity costs, social discounting Physical discounting Reason for discounting: uncertainty Reason: time preference Time dependency of the discount rate Reason for discounting: uncertainty, chances, risks	Importance of a dynamic inventory and interdependencies Methods	Importance of a dynamic characterization and interdependencies Methods Changing background concentration Changing sensitivity of the ecosystem		
32	Lebailly, F.; Levasseur, A.; Samson, R.; Deschênes, L.	2014	International Journal of Life Cycle Assessment		X		X										X		➢ infinite TH avoids problem shifting to the future ➢ short TH because of uncertainty and future potential mitigation actions		➢ fate mechanisms should be applied for dyn. LCI	➢ "Short-term impacts are likely to be overestimated when using traditional CF values" ➢ "Nondynamic values are only compatible with quasi-infinite time horizons when adopting a conservative approach" ➢ "The dynamic LCA approach consists in developing a temporally disaggregated inventory and then assessing its impact over time using time-horizon-dependent characterization factors. The result is a curve showing the evolution of the potential impact caused by the life cycle emissions over time." ➢ dyn. CF are also TH-dependent, otherwise inconsistent with dyn. LCI		
33	Levasseur, Annie; Lesage, Pascal; Margni, Manuele; Brandão, Miguel; Samson, Réjean	2012	Climatic Change		X	X											X		➢ TH is a political decision			➢ advantages of dyn LCA compared with ton years for carbon sinks is shown→ more accurate, flexible, includes all life cycle stages, allows sensitivity analysis		
34	Levasseur, Annie; Lesage, Pascal; Margni, Manuele; Deschenes, Louise; Samson, Réjean	2010	Environmental Science & Technology		X	X							X			X	X		➢ TH = " giving a weight to time" = discounting ➢ different TH for LCIA and analysis would be inconsistent ➢ TH is decisive especially when dealing with short-time emissions			➢ time-dependent CFs give less impact to emissions later in the TH because it does not contribute to damage in the time before		
35	Levasseur, Annie; Lesage, Pascal; Margni, Manuele; Samson, Réjean	2013	Journal of Industrial Ecology		X	X											X					➢ Temporal distribution of emissions can be important if there are natural limitations like tree growth time ➢ Chicken-egg problems in LCA: if harvested biomass was grown on agricultural area for harvesting, it will start with negative impacts because new biomass at the same place can store additional CO_2, if biomass was not planted for that purpose, it will start with a positive impact until the following biomass has grown ➢ when using dyn. LCI, CFs with fixed time horizon like GWP100 are inconsistent to TH of LCA, because first emissions are weighted higher than the later emissions ➢ dyn. LCA allows sensitivity analysis for TH		
36	Levine, Stephen H.; Gloria, Thomas P.; Romanoff, Eliahu	2007	Journal of Industrial Ecology	X		X							x		x					➢ reasons for discounting: growing wealth/declining value of money of env. damages or benefits, new technologies that make damages less expensive or reduce them, pure time preference	➢ necessary especially for LCA of fleets			
37	Mallapragada, D.; Mignone, B. K.	2017	Environmental Research Letters		X	X										X			➢ TH is a substitute for explicate discounting ➢ there can be a fixed time horizon (useful for midpoint indicators) or a fixed end point (useful for endpoint indicators)			➢ dyn. characterization must be consistent with mid- or endpoint		
38	Menten, Fabio; Tchung-Ming, Stéphane; Lorne, Daphné; Bouvart, Frédérique	2015	Renewable and Sustainable Energy Reviews		X	X										X	X		➢ different THs of assessment and characterization			➢ show different outcome if a dyn. inventory is assessed with dyn. or static CF. dyn. CF are to be preferred		
39	Moura Costa, Pedro; Wilson, Charlie	2000	Mitigation and Adaptation Strategies for Global Change	X		X						X									➢ dyn inv. based on calculated rotation periods of wood	➢ static CF calculated on basis of the TH, so at least TH-dependent but not fully dynamic - time adjusted C-ton years, but no dynamic cumulative temperature impact		
40	O'Hare, M.; Plevin, R. J.; Martin, J. I.; Jones, A. D.; Kendall, A.; Hopson, E.	2009	Environmental Research Letters		X	X							X			X				➢ reasons for discounting: declining value of money and pure time preference ➢ economic discounting can be made because there are markets where one can make future contracts ➢ "the discounting model applies to costs and benefits, not to physical phenomena that generate them, unless their economic value is otherwise stable over time" ➢ "conventionally discounting a physical quantity produces absurd results for reasons more fundamental than an incorrect choice of r," (e.g. because of seasonality that is not represented by a discount rate) ➢ discounting is only useful for damages, there must be a damage function, discounting physical units is incorrect unless emissions and damage are proportional and this proportion is constant over the whole TH				
41	Peters, Glen P.; Aamaas, Borgar; Lund, Marianne T.; Solli, Christian; Fuglestvedt, Jan S.	2011	Environmental Science & Technology	X		X												X	➢ TH is necessary if long- and short-term impacts are assessed together, otherwise long-term impacts will always marginalize short-term impacts ➢ different impacts may be analyzed with different TH because they can have different time scales					
42	Pingoud, Kim; Ekholm, Tommi; Savolainen, Ilkka	2012	Mitigation and Adaptation Strategies for Global Change		X	X		X									X					➢ GWP_{bio} by Cherubini et al (2011) enhanced by net GWP_{bio} which also considers a credit for displaced fossil emissions, time dependent ➢ with dynamic inventory, a break even point of GWP multiplied with the dimensionless GWP_{bio} and LUC emissions can be calculated		
43	Richards, Kenneth R.	1997	Critical Reviews in Environmental Science and Technology	X		X												X		➢ future impact can be discounted on the social discount rate ➢ change of marginal damage by the emissions must be regarded, rising marginal damage should lead to a declining discount rate over time				
44	Rosa, Michele de; Pizzol, Massimo; Schmidt, Jannick	2018	International Journal of Life Cycle Assessment		X	X		X									X		➢ depends on goal and scope ➢ must fit to used indicators (e.g. some GHG indicators do not make sense with short TH, such as sea level rise)					
45	Saez de Bikuna, Koldo; Hamelin, Lorie; Hauschild, Michael Zwicky; Pilegaard, Kim; Ibrom, Andreas	2018	Journal of Cleaner Production	X				X											➢ there are different time horizons: 1. technological TH fitting the life cycle of the product, 2. inventory modeling period possibly longer than technological TH if emissions persist longer than product life cycle, 3. impact modeling period for the characterization ➢ they must be harmonized if different assessments should be comparable			➢ time dependent CF should not lead to a circular dependency, the assessed project should not influence the baseline ➢ taking trends like deforestation as given for avoiding circular dependencies is not a good choice because the project and similar projects have direct influence and is not independent from the trend		
46	Schwietzke, Stefan; Griffin, W. Michael; Matthews, H. Scott	2011	Environmental Science & Technology		X	X		X								X	X		➢ important when assessing LUC because of high initial emissions which are marginalized in longer TH			➢ Cumulative Radiative Forcing instead of GWP as time dependent midpoint indicator		
47	Shimako, Allan Hayato; Tiruta-Barna, Ligia; Ahmadi, Aras	2017	Science of the Total Environment		X		X			X											➢ apply time-dependent equations based on fate mechanisms	➢ apply time-dependent equations based on exposure mechanisms - more accurate than simple TH-dependent CF		
48	Shimako, Allan Hayato; Tiruta-Barna, Ligia; de Faria, Ana Barbara Bisinella; Ahmadi, Aras; Spérandio, Mathieu	2018	Science of the Total Environment		X	X	X			X											➢ study shows sensitivity of dyn. LCA to temporal resolution of inventor and dyn. characterization, it depends on the impact category ➢ strong sensitivity for tox., weak for climate indicators				
49	Soimakallio, Sampo; Cowie, Annette; Brandao, Miguel; Finnveden, Goran; Ekvall, Tomas; Erlandsson, Martin; Koponen, Kati; Karlsson, Per-Erik	2015	International Journal of Life Cycle Assessment	X				X									X		➢ if new artificial systems are more efficient than natural systems, long THs lead to conclusion that nature (wood) should be removed (by fast growing biomass) - depends on weighting					
50	Su, Shu; Li, Xiaodong; Zhu, Yimin; Lin, Borong	2017	Energy and Buildings	X		X								X							➢ dynamic inventory considering technological progress (e.g. energy mix) ➢ methods: mathematical methods (demand-supply model, complex adaptive system, Markov-chain) for short term and scenario analysis, query, investigation and estimation for long-term and user behavior (literature review, simulations)		➢ dynamic weighting suggested ➢ weighting could change in the future through monetization (shadow prices, green tax prediction) or distance to target method regarding environmental protection policy	
51	Tiruta-Barna, Ligia; Pigné, Yoann; Navarrete Gutiérrez, Tomás; Benetto, Enrico	2016	Journal of Cleaner Production	X						X								X			➢ "dynamic" or "time-dependent" means in literature to have a sort of future prediction or higher temporal resolution in LCI ➢ literature often addresses either dynamic LCI or dynamic LCIA so that links are missing ➢ building a dynamic inventory is difficult because of interactions of the process and supply dynamics as well as because of loop paths ➢ there are two main challenges in building a dynamic inventory: 1. foreground processes can be modeled or measured precisely but background processes in the supply chain lack in data and adequate temporal assessment - there must be a supply model between foreground and background processes which models the supply schedule and delays between the processes, 2. finding best trade-off between accuracy and feasibility ➢ an algorithm for calculating dyn. LCI based on a process and supply network is proposed			
52	Udo de Haes, Helias A.; Jolliet, Olivier; Finnveden, Göran; Hauschild, Michael; Krewitt, Wolfram; Müller-Wenk, Ruedi	1999	International Journal of Life Cycle Assessment	X						X								X	➢ short (100 yrs.) and long TH (500 yrs.) should both be assessed so that readers can decide on their weight for the farer future for themselves ➢ 500 yrs. is regarded as near infinity if most of the impacts occurs then (10,000 yrs. for radioactive pollution)	➢ discount rates and finite time horizons are both kinds of discounting ➢ reasons: time preference and uncertainty whether future will be avoided				
53	van Zelm, Rosalie; Huijbregts, Mark A. J.; van Jaarsveld, Hans A.; Reinds, Gert Jan; Zwart, Dick de; Struijs, Jaap; van de Meent, Dik	2007	Environmental Science & Technology	X					X									X				➢ TH-dependent CF for AP calculated		
54	Wang, Jingjing; Zhang, Yurong; Wang, Yuanfeng	2018	Journal of Cleaner Production		X					X			X						➢ TH = service life (full life cycle of product)	➢ reason is monetary value of environmental damage, money should be discounted ➢ discount rate = social discount rate which depends on county, for China rather high (5.5% in richer areas - 8% in poorer areas) *(question: damages are global, can Chinese discount rate be applied?)*	➢ statistical functions applied for length of life cycle (Weibull distribution)			
55	Weitzman, Martin L.	1998	Journal of Environmental Economics and Management	X						X								X		➢ exponential discounting does not reflect the real opinion of people about the weight of future emissions from a certain point of time on, e.g. an event in 3 centuries is not less important than an event in 400 years ➢ there are different possibilities for different discount rate, higher discount rates lead to a faster decline, so there is as accumulation of all possibilities (scenarios) a declining discount rate ➢ for long-term impacts scenarios for different discount rates should be calculated, then the lowest discount rate should be applied as final discount rate ➢ discount rate declines from the present rate to the future rate		➢ "carbon-reduction policy should use performance metrics that reflect cumulative warming instead of aggregation of GHG flows" – dyn. impact assessment preferred		
56	Yu, Bin; Sun, Yue; Tian, Xin	2017	Journal of Cleaner Production		X	X								X					➢ There is a TH of the inventory (cut-off in the inventory/life cycle) and a TH of the impact assessment ➢ Both influence the outcome of the assessment and can be addressed by scenario analysis or time dominance principle			➢ Application of TH-adjusted GWP		
57	Yuan, C. Y.; Simon, R.; Mady, N.; Dornfeld, D.	2009	Sustainable Systems and Technology	X									X		X					➢ LCI is discounted with 5% and 10% ➢ discount rates should be conservative - underestimation of impact would be more critical ➢ discounting because of "future emissions may not happen", e.g. because of new technological developments or simply because of an earlier end of life because of accidents	➢ inventory is a path model, different paths for the same product ➢ there are fast and slow paths, some with optimal production circumstances and some with errors, loops because of bad quality ➢ inventory is built on a mean path			
58	Yuan, Chris; Wang, Endong; Zhai, Qiang; Yang, Fan	2015	Environmental Impact Assessment Review	X						X										➢ LCI is discounted, no information on discount rates ➢ scenario- or sensitivity-analysis is suggested because of strong influence of discount rate ➢ aim is not to decrease impact calculations but to have a more accurate business-like decision instrument	➢ is necessary for discounting, should also include fate mechanisms			
59	Zimmermann, B. M.; Dura, H.; Baumann, M. J.; Weil, M. R.	2015	Integrated Environmental Assessment and Management		X	X			X				X		X						➢ scenario analysis using time resolved LCA			
60	Zimmermann, B. M.; Dura, H.; Weil, M.	2014	Metallurgical Research & Technology		X	X			X				X		X				➢ should be included in functional unit		➢ introduction of "time resolved LCA (trlca)" – the temporal resolved LCI is not measured but modeled on basis of historical data or simple simulation ➢ temporal effects can be regarded without the need for complex measurements			

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