ANNEX 1: OFFSET PROJECT TYPES AND RELATIVE QUALITY RISKS

Some types of carbon offset projects have an easier time meeting essential carbon offset criteria than others. In the following tables, we distinguish between "lower risk" project types, where individual projects will frequently meet all offset quality criteria, and other project types, where more caution may often be necessary. For each project type, we indicate in the tables whether meeting a particular criterion could be relatively difficult and may therefore be of particular concern when considering an offset credit purchase. In Tables 3-5, if a cell is left blank, then the criterion is not a major concern for that project type.

Table 2. Relative offset quality risk for different project types

Lower risk	Medium risk	Higher risk
• CO_2 usage • Methane destruction (w/o utilization) • N_2O avoidance from nitric acid production • N_2O – adipic acid* • Ozone-depleting substance (ODS) destruction	• Methane capture and utilization • Methane avoidance • Energy distribution • Energy efficiency, household demand side • PFCs & SF_6 avoidance/ reuse • Renewable energy, small scale	• Agriculture • Biomass energy • Cement production • Energy efficiency, industrial demand side • Energy efficiency -- supply side • Forestry & land use • Fossil fuel switching • Fugitive gas capture or avoidance • Low-carbon transportation measures • Renewable energy, large scale

* Studies have found potential concerns with N_2O avoidance projects at adipic acid plants. In principle, however, these could be lower risk projects if appropriate methodologies are applied.

Table 3. Lower risk project types

Project Type	Sub-Types Included	Additionality	Quantification & Leakage	Other (Ownership/ Double Counting, Permanence)	Co-benefits/ harms
CO_2 usage	Use of CO_2 from biomass or industrial tail gases to replace fossil or mineral CO2 in industrial applications				
Methane destruction	Coalmine ventilation air methane (VAM) destruction				Harms: Could be seen as supporting coal industry and therefore not a project type consistent with long-term climate goals.
	Landfill gas flaring	Varies by location. Projects are likely additional in most parts of the developing world. In developed countries, including the United States, some projects are pursued to avoid triggering regulatory requirements.	Some potential for baseline uncertainties (e.g., how much methane would have been generated in the absence of a project), but most are addressed through program quantification & eligibility rules.		Benefit: May reduce odor issues for communities near landfills.
N_2O avoidance from nitric acid production	Various process improvements in nitric acid production		The baseline can be overestimated, as N_2O measurement is technically complex.		Harms: Could be seen as supporting the manufacture of synthetic fertilizer and therefore not consistent with long-term climate goals

Project Type	Sub-Types Included	Additionality	Quantification & Leakage	Other (Ownership/ Double Counting, Permanence)	Co-benefits/ harms
N_2O destruction in adipic acid production	Destruction or reuse/recycling of N_2O by-product from adipic acid production		Studies have found evidence of plants increasing their acid production to generate more N_2O to destroy for carbon offset credits. Current methodologies may correct for this tendency.		
Destruction of ozone depleting substances (ODS)	Collection and destruction of ODS used in insulating foams and refrigeration equipment		Some uncertainties may exist regarding baseline emission rates (e.g., how quickly ODS would leak if reused in old equipment). The high GWP for ODS gases can amplify quantification errors.		Benefit: Destruction of ODS helps to accelerate recovery of stratospheric ozone.
Direct Air Carbon capture and storage[1]				Must use well-selected, designed, and managed carbon capture and storage sites to reduce non-permanence risk.	
Enhanced weathering	Spreading finely ground olivine or basalt over farmland or seawater or in use for landscaping				Benefits: can be used as replacement for synthetic fertilizers to promote crop yields, can reduce ocean acidification. Harms: may cause soil contamination and disturb ecosystems, risks relating to increased mining. Potential human health risks from grinding minerals to very fine sizes.

1 Oxfam, 2020. Removing Carbon Now: How can companies and individuals fund negative emissions technologies in a safe and effective way to help solve the climate crisis? Oxfam discussion papers. Oxfam.org. Available: https://oxfamilibrary.openrepository.com/bitstream/handle/10546/621034/bp-carbon-removal-now-190820-en.pdf?sequence=4&isAllowed=y

Table 4. Medium risk project types

Project type	Sub-types included	Additionality	Quantification	Other (Ownership/ Double Counting, Permanence)	Co-benefits / harms
Methane capture and utilization for energy	Coal mine methane, coal bed methane	Carbon offset revenue can make up a large portion of return on capital investment; however, technical hurdles for these projects are no longer substantial and there are significant levels of business-as-usual methane usage at mines in some countries	Some projects may incentivize increased drainage of methane, leading to more methane destroyed than would have been released in the baseline. Most protocols control for this, however. Where methane is utilized for energy generation, some uncertainties can arise regarding the baseline for displaced emissions.	Ownership: Projects that generate energy using captured methane may result in indirect emission reductions (e.g., at grid-connected power plants).	Benefits: May have air pollution benefits if captured methane is used to displace coal. Harms: Could be seen as supporting coal industry and therefore not a project type consistent with long-term climate goals.
	Livestock methane, manure management, biogas utilization	For some projects in some locations, it is important to evaluate whether other revenue streams and funding sources would enable implementation without carbon revenues.	Some potential for baseline uncertainties, but most can be addressed through quantification & eligibility rules. Where methane is utilized for energy generation, some uncertainties can arise regarding the baseline for displaced emissions.	Ownership: Projects that generate energy using captured methane may result in indirect emission reductions (e.g., at grid-connected power plants).	Benefits: Offset projects at industrial livestock operations may mitigate local environmental impacts. Similarly, biodigesters can provide energy families use for cooking, saving money on fuel and reducing the sanitary issues associated with burning of animal and human waste. A lower dependence on firewood due to biogas use reduces fuel wood use.

Project type	Sub-types included	Additionality	Quantification	Other (Ownership/ Double Counting, Permanence)	Co-benefits / harms
Methane capture and utilization for energy (cont.)	Other (waste water, industrial solid waste methane capture & utilization)	Regulatory drivers should be examined for many of these projects. For some projects in some locations, it is important to evaluate whether other revenue streams and funding sources would enable implementation without carbon revenues.	Some potential for baseline uncertainties, but most can be addressed through quantification & eligibility rules. Where methane is utilized for energy generation, some uncertainties can arise regarding the baseline for displaced emissions.	Ownership: Projects that generate energy using captured methane may result in indirect emission reductions (e.g., at grid-connected power plants).	Benefit: May reduce odor issues for communities near facilities.
	Landfill gas utilization (for energy, electricity)	Varies by location. Projects are likely additional in most parts of the developing world. In developed countries, including the United States, some projects are pursued to avoid triggering regulatory requirements, and projects that generate energy can be economical without carbon revenue.	Some potential for baseline uncertainties (e.g., how much methane would have been generated in the absence of a project), but most are addressed through program quantification & eligibility rules. Where methane is utilized for energy generation, some uncertainties can arise regarding the baseline for displaced emissions.	Ownership: Projects that generate energy using captured methane may result in indirect emission reductions (e.g., at grid-connected power plants).	Benefit: May reduce odor issues for communities near landfills.

Project type	Sub-types included	Additionality	Quantification	Other (Ownership/ Double Counting, Permanence)	Co-benefits / harms
Methane emission avoidance	Composting; aerobic treatment of waste or wastewater; palm oil waste management / utilization	For composting and aerobic waste treatment, regulatory drivers should be carefully examined. For some projects in some locations, it is important to evaluate whether other revenue streams and funding sources would enable implementation without carbon revenues.	Some potential for baseline uncertainties, but most can be addressed through quantification & eligibility rules. If palm oil (or other) waste is used for energy generation, uncertainties can arise regarding baseline for displaced emissions.	Ownership: Projects that generate energy (e.g., from palm oil waste) may result in indirect emission reductions (e.g., at grid-connected power plants).	Benefits: Composting projects help reduce food waste, promote the environmental and health benefits of organic farming and reduce fossil-based fertilizer demand.
Energy distribution	District heating, connection of isolated grids, microgrid development, other	Additionality may be unclear in many cases; projects may be capital intensive and it is not clear that carbon revenues would be decisive for investment decisions.	May be some uncertainty about avoided baseline emissions; quantification protocols will generally address this concern with sufficient conservativeness.	Ownership/double counting: Often results in indirect emission reductions. Where distribution displaces electricity applications (e.g., fewer space heaters used as a result of a district heating project), electricity generators could double count reductions.	Benefits: Can lead to significant air quality benefits where displacing inefficient distributed combustion (e.g., in home coal or peat stoves). Connecting isolated grids or microgrid development, provides more reliable energy access.

Project type	Sub-types included	Additionality	Quantification	Other (Ownership/ Double Counting, Permanence)	Co-benefits / harms
Energy efficiency, household demand side	Improved cookstoves		Significant uncertainty and potential for over-crediting due to approaches used to estimate reduction in biomass fuel used with improved stoves, fraction of non-renewable biomass (i.e., emissions associated with land-use change impacts), emission factors for wood-fuel used in baseline, inclusion of "suppressed demand" for fossil fuels, and underestimation of stove abandonment or stove stacking.	Permanence: Where project includes accounting for avoided deforestation (i.e., increase in forest carbon stocks due to decreased use of biomass), carbon storage could be reversed.	Benefits: Can lead to significant air quality benefits where replacing inefficient distributed combustion (e.g., in home wood, coal, charcoal or peat stoves) and therefore significant health benefits for families using improved cookstoves. Can lead to creation of new employment through market for stoves. Can reduce time and expenditures on fuel by rural families.
	More efficient lighting, insulation, & appliances; HVAC systems; air conditioning; street lighting; water pumping and purification; etc.	For some projects, it may be hard to show that carbon revenues were a decisive factor, e.g. where energy cost savings exceed offset credit revenues. In many places, improved efficiency is already common practice with national and local support schemes.	Often there can be uncertainty about avoided baseline emissions, actual adoption rates for new equipment, and/or baseline usage patterns. Baselines are sometimes linked to estimates of "suppressed demand" for fossil fuels, which run the risk of overestimating baseline emissions.	Ownership/double counting: Energy efficiency measures will often lead to indirect emission reductions, meaning greater potential for double counting.	Benefits: Can lead to cost savings for end users, and meaningful public health improvements for communities and families in low income areas.

Project type	Sub-types included	Additionality	Quantification	Other (Ownership/ Double Counting, Permanence)	Co-benefits / harms
PFC & SF_6 avoidance & reuse	PFC & SF_6 emission avoidance; SF_6 capture & re-use	Additionality depends on specific project activity and facilities involved. In some contexts, measures for reducing emissions may be cost-effective without carbon revenues. In addition, PFCs and SF_6 are increasingly being regulated by governments, and so some projects could be mandated in some jurisdictions. Some projects may be pursued in anticipation of these regulations, prior to them taking effect.			

Project type	Sub-types included	Additionality	Quantification	Other (Ownership/ Double Counting, Permanence)	Co-benefits/ harms
Renewable energy, small scale (under 15 MW)	Electricity generation from small-scale (run of river) hydropower plants	Can face greater investment hurdles than large hydro projects, but it is often not clear whether carbon revenues would materially affect investment decisions	May be some uncertainty about avoided baseline emissions; quantification protocols will generally (though not always) address this concern conservatively.	Ownership/double counting: If grid-connected or otherwise displacing fossil fuel energy, these projects will result in indirect emission reductions; electricity generators could double count reductions. If RECs or GoOs are also sold from project then another entity may functionally double count reduction.	Benefits: Reduced air pollution where fossil generation is displaced. Rural electrification. Harms: Displaced ecosystem services and communities that relied on previous river resources (this is less of a concern for smaller projects).
	Electricity generation from solar, wind, geothermal, other renewable power sources	For many of these projects, it is not clear that carbon revenues can decisively influence investment decisions.	May be some uncertainty about avoided baseline emissions; quantification protocols will generally (though not always) address conservatively.	Ownership/double counting: If grid-connected or otherwise displacing fossil fuel energy, these projects will result in indirect emission reductions; electricity generators could double count reductions. If RECs or GoOs are also sold from project, then another entity may functionally double count reduction.	Benefits: Reduced air pollution where fossil generation is displaced. Rural electrification.
	Gasification and/or combustion of municipal solid waste	For many of these projects, it is not clear that carbon revenues can decisively influence investment decisions.	Potential uncertainties related to methane emissions avoided in baseline. Potential uncertainties related to displaced energy emissions (similar to other renewable energy projects)	Ownership/double counting: If grid-connected or otherwise displacing fossil fuel energy, these projects will result in indirect emission reductions; electricity generators could double count reductions. If RECs or GoOs are also sold from project then another entity may functionally double count reduction..	Benefits: Better local solid waste management. Harm: Air pollution, if advanced emission controls not part of project.

Table 5. Higher risk project types

Project type	Sub-types included	Additionality	Quantification	Other (Ownership/ Double Counting, Permanence	Co-benefits/ harms
Agriculture	Low-till/no-till soil carbon sequestration; use of biochar	Additionality is context-specific. In U.S., for example, low-till/ no-till is increasingly common practice. Frequently, for individual landowners, carbon revenues for these project types are too low to play a decisive role in changing practice. Programmatic approaches (where many landowners are aggregated together under a single project) are more likely to be additional.	Quantification of net GHG reductions in biological systems is inherently more uncertain than for many other project types; diverse and uncontrolled implementation environments make measurement, monitoring, and verification more difficult. Leakage risk can be a significant issue for tillage projects (to the extent crop yields are affected).	Permanence: Risk of reversal (i.e., non-permanent reductions) is a concern for all carbon storage projects.	Benefits: Both biochar and tillage projects can enhance soil productivity and reduce erosion, increasing farmers' yields and reducing impact on aquatic ecosystems.
	Rice cultivation methane avoidance, improved fertilizer management, etc.	Improved fertilizer management can often pay for itself (without carbon revenue), although barriers may prevent efficient investments in some cases. Conversely, carbon revenues for these project types (rice methane, nutrient management) are often too low to play a decisive role in changing practice. Programmatic approaches (where many landowners are aggregated together under a single project) are more likely to be additional.	Quantification of net GHG reductions in biological systems is inherently more uncertain than for many other project types; diverse and uncontrolled implementation environments make measurement, monitoring, and verification more difficult. Leakage risk can be a significant issue to the extent crop yields are affected (shifting production to lands where mitigation actions are not practiced).		Benefits: Improved fertilizer management can help reduce nutrient runoff. Harms: Effects of alternative rice cultivation methods may vary depending on context. (In California, for example, reduced flooding of fields may negatively impact waterfowl habitat.)

Project type	Sub-types included	Additionality	Quantification	Other (Ownership/ Double Counting, Permanence)	Co-benefits/ harms
Biomass energy	Industrial waste: Bagasse power, palm oil solid waste, black liquor, forest residues, sawmill waste, industrial waste, biodiesel from waste oil	Regulatory incentives frequently make biomass power competitive with fossil fuels, even without carbon revenues. Some studies have questioned the application of barrier and investment analyses to assess the additionality of these projects.	Some risk of exaggerated claims of avoided methane emissions associated with anaerobic decay of biomass.	Ownership/double counting: Often results in indirect emission reductions; other energy suppliers or electricity generators could double count reductions.	Benefits: Supports a beneficial use of waste from agricultural industries, diverting waste from landfills and providing revenue in return for environmental benefit. A source of renewable and environmentally-improved energy by generating electricity from waste. Accordingly, creates more sustainable patterns of production.
	Agricultural farm residue, forest residue, and dedicated energy crop	Regulatory incentives frequently make biomass power competitive with fossil fuels, even without carbon revenues. Some studies have questioned the application of barrier and investment analyses to assess the additionality of these projects.	Significant risks of over-crediting concern due to lack of assessment of land use, as well as direct and indirect land use change from collection of biomass feedstocks (leakage risk). Some protocols may better address these concerns than others.	Ownership/double counting: Often results in indirect emission reductions; other energy suppliers or electricity generators could double count reductions.	Benefits: Promotes renewable energy development. If land-use risks are properly dealt with, creates more sustainable patterns of production. Harms: Risks competing with other land-uses, primarily agriculture for food and reforestation/ afforestation.

Project type	Sub-types included	Additionality	Quantification	Other (Ownership/ Double Counting, Permanence)	Co-benefits/ harms
Cement production	Use of blended cements, process and efficiency improvements	Choice of cement blends is often determined by institutional purchasing or regulatory requirements over which carbon revenues have little influence; higher-blend cements are also often cheaper than standard blends. Additionality for these projects may therefore hinge upon non-financial factors that are more difficult to prove.			
Energy efficiency, industrial demand side	Various forms of Industrial energy use efficiency	Many industrial efficiency projects pay for themselves and are common practice. Carbon revenues are often small relative to energy cost savings, so are seldom a decisive factor in pursuing a project.		Ownership/double counting: Energy efficiency measures will often lead to indirect emission reductions, meaning greater potential for double counting.	Benefits: Increasing industrial energy efficiency decreases the lifecycle emissions – and environmental impact – of products. These projects contribute to private sector participation in decarbonization.

Project type	Sub-types included	Additionality	Quantification	Other (Ownership/ Double Counting, Permanence)	Co-benefits/ harms
Energy efficiency – supply side	Waste heat/ gas recovery; combined heat and power projects; improving energy conversion efficiency at boilers, power plants, etc.	Carbon revenues are often small relative to energy cost savings, so are seldom a decisive factor in pursuing a project. Projects are also common practice in many (though not all) countries and sectors. Some studies have questioned the application of barrier and investment analyses to assess the additionality of these projects.	Baseline determination can be complicated and site-specific. In existing facilities, it can be difficult to assess the actual use of waste heat in the baseline. In new projects, there are high uncertainties in modelling baseline waste heat production. Baselines under some protocols for supply-side efficiency projects have been set too high, resulting in over-crediting.	Ownership/double counting: Projects that displace emissions at other sources (e.g., on electricity grid) will lead to indirect emission reductions, meaning greater potential for double counting.	Harms: Financially supporting energy efficiency improvements in fossil burning energy systems may slow the transition to low-carbon energy systems.
Forestry and land use	Afforestation & reforestation; avoided deforestation; improved forest management; agroforestry; avoided conversion of high-carbon soils	Frequent challenges in determining baseline activity, which may be highly site-specific. Since the baseline determines how much carbon storage is additional, this makes additionality uncertain. In addition, timber and land-use values often exceed carbon revenue value, making it difficult in some cases to determine whether carbon revenues were decisive in changing baseline activities.	There are frequently significant baseline uncertainties for these project types. In addition, diverse and uncontrolled implementation environments make measurement, monitoring, and verification more difficult for these projects. Significant leakage risk can occur from displacement of harvesting or land-use development (i.e., reduced harvest in one area can cause an increase elsewhere)	Permanence: Risk of reversal (i.e., non-permanent reductions) is a concern for all carbon storage projects.	Benefits: Forests provide a range of ecosystem services that forest sector offset projects can maintain and expand. These may include increased local livelihoods, maintaining ecosystems and biodiversity, local farm productivity (pollination and precipitation services), limiting runoff, and water filtration.

Project type	Sub-types included	Additionality	Quantification	Other (Ownership/ Double Counting, Permanence)	Co-benefits/ harms
Forestry and land use (cont.)					Avoided conversion of grasslands can yield significant environmental benefits beyond carbon storage, such as preserving landscapes and biodiversity. Harms: Poorly-designed forestry projects that do not sufficiently engage local communities and indigenous peoples can have major negative impacts, including livelihood restrictions and even community displacement.
Fossil fuel switching	Switch from coal to natural gas in boilers or power generation; use of natural gas as a transportation fuel	Carbon revenues are often a small component of total project revenues, so are seldom a decisive factor in pursuing a project. Studies have identified significant uncertainties in assessment of investment barriers to fuel switching, and point to new natural gas projects becoming increasingly common practice and non-additional.	Failure to account for upstream emissions from fossil fuel extraction & transport (e.g., methane leaks at well-head or in transmission & distribution) can lead to over-crediting.		Harms: Supporting adoption or continued use of fossil fuels may slow the transition to low-carbon energy systems. Widespread use of natural gas is incompatible with the temperature goals of the Paris Agreement.

Project type	Sub-types included	Additionality	Quantification	Other (Ownership/ Double Counting, Permanence)	Co-benefits/ harms
Fugitive gases	Waste gas recovery from oil & gas production or other industrial operations; leak prevention in natural gas transmission & distribution systems; other fugitive gas prevention and recovery	Many fugitive emission reduction activities are cost-effective without carbon revenues; the financial value of preventing fugitive emissions (e.g., in terms of reduced fuel losses) often exceeds the carbon revenue value, so carbon revenues are seldom a decisive factor in pursuing a project.	Where waste gas quantities are directly measured, quantification concerns are low. Fugitive emissions, however, can be hard to detect and quantify, creating uncertainties about the effects of leak prevention activities.		Harms: Supporting adoption or continued use of fossil fuels may slow the transition to low-carbon energy systems. Widespread use of natural gas is incompatible with the temperature goals of the Paris Agreement.
Renewable energy, large scale	Geothermal; solar; mixed renewables; tidal energy; other	Unconventional renewables face greater financial hurdles than other technologies, and thus are more likely to be additional. However, carbon revenues are often a small component of total project revenues, so are seldom a decisive factor in pursuing a project.	May be some uncertainty about avoided baseline emissions; quantification protocols will generally (though not always) address conservatively.	Ownership/double counting: Projects that displace emissions at other sources (e.g., on electricity grid) will lead to indirect emission reductions, meaning greater potential for double counting.	Benefits: Reduced air pollution where fossil generation is displaced.

Project type	Sub-types included	Additionality	Quantification	Other (Ownership/ Double Counting, Permanence)	Co-benefits/ harms
Renewable energy, large scale (cont.)	Hydropower and wind projects	Common practice in many countries Carbon revenues are often a small component of total project revenues, so are seldom a decisive factor in pursuing a project. Studies have found documented concerns related to additionality assessment in large-scale hydro and wind projects.	May be some uncertainty about avoided baseline emissions; quantification protocols will generally (though not always) address conservatively. Some studies have identified issues with quantification methodologies for hydro projects, particularly when methane emissions (from plant material that is buried in the dam reservoir) are omitted, leading to over-crediting .	Ownership/double counting: Projects that displace emissions at other sources (e.g., on electricity grid) will lead to indirect emission reductions, meaning greater potential for double counting.	Harms: Some large-scale hydropower projects have well-documented negative social and environmental impacts. These projects can displace local communities and indigenous peoples, degrade forests, harm biodiversity and affect aquatic life and existing food sources for populations.
Low-carbon transportation measures	Public transportation improvements, mode shifting, vehicular fuel efficiency improvements, vehicle scrapping or retirement	In general, the mitigation cost of transportation projects ($/tonne CO2 reduced) is well above current and historical prices for carbon offsets, calling into question whether carbon revenues can be a decisive factor in incentivizing these projects. For transport efficiency projects, fuel cost savings often (substantially) exceed carbon revenues from avoided emissions, raising similar questions about additionality.	High levels of uncertainty in quantifying avoided emissions from public transportation, mode shifting, and vehicle scrapping/retirement projects. Reasonable quantification certainty for efficiency upgrades (notwithstanding baseline/additionality concerns).		Benefits: Transportation emissions reduction projects can improve air quality and the health of those living nearby as well as increase urban liveability.