Health in the green economy

Co-benefits to health of climate change mitigation

OCCUPATIONAL HEALTH *Initial findings – discussion draft*

Key messages

- **Health and safety at work are among the fundamental pillars of decent work[1]; these are also essential for a green economy.** Those values must therefore be given high priority and visibility as core components of just transition. Transition to a green economy has the potential to reduce many aspects of workers' exposures to workplace hazards and pollution risks. But "green jobs" are not automatically or necessarily decent, safe or healthy unless clear policies, programmes and actions support social sustainability in a given workplace, enterprise, and sector.[1,2,3]

Potential health gains for workers in a green economy

- **Occupational health and environmental protection measures can be mutually reinforcing.** The reduction of environmental pollution as result of green technologies may also improve the quality of the work environment. Conversely, certain measures that improve the work environment, such as encapsulation, automatization, and substitution of hazardous materials, would also improve the environmental performance of the enterprise. For example, converting vehicles in underground mines from fossil fuels to electricity, low-emission biofuels or fuel cells may improve not only air quality but productivity.[4]
- **Many green production strategies can generate a dual public health and occupational health benefit for workers.** Presently many workers suffer a double burden of exposure to pollutants, both in the workplace and at home. For instance, increased cancer incidence in Africa has been attributed to the combination of occupational and environmental exposure to industrial and agricultural toxic chemicals, air pollution and hazardous waste. Cleaner production methods would reduce the risk of cancer particularly among workers but also among consumers.[5] Transition to renewable energy production may also generate a dual benefit, reducing occupational respiratory diseases and cancers related to fossil fuel extraction and use (coal mining, oil refining, etc.) as well as urban air pollution-related cardiopulmonary disease (cardiovascular diseases, bronchial obstruction, asthma and other respiratory conditions).[6]
- **Greener, more energy-efficient building and transport infrastructure also can produce co-benefits for workers´ health.** For example, low-energy office buildings and workplaces that offer good daylighting and natural ventilation can often improve workers' productivity as well as their health. Prioritizing public transport systems and promotion of non-motorized transport (cycling, walking, etc.) contribute to commuters' health by improving road safety and providing more opportunities for physical exercise, which is especially important for sedentary workers. Organized workplace transport plans and incentives may further enhance these dimensions of health for reduced morbidity, disability and mortality.[7,8,9]
- **Certain low-carbon technologies benefit workers' health by improving work machinery and working environments.** For example, the design, manufacture and use of chemicals, processes and products that are safer for human health and the environment, often described as "green chemistry", can provide many opportunities to improve health and safety at work. [10]
- **The green economy also can benefit health through social policies supporting job creation and enrichment as well as greater economic security.** Decent work and fair employment are critical social determinants of health and equity, while unemployment and underemployment are related to disease, disability and premature death. To be sustainable and ethically acceptable, green economies should generate new and enriched employment opportunities.[11,12,13,14,15,16] National and local policies need to pursue a two-track policy to ensure that green industries and innovations provide better health and greater economic security for workers and their families.

[1] "Decent work," as defined by the International Labor Organization and endorsed by the international community, is: "productive and delivers a fair income; provides security in the workplace and social protection for workers and their families; offers prospects for personal development and encourages social integration; gives people the freedom to express their concerns, and to organize and participate in decisions that affect their lives; and guarantees equal opportunities and equal treatment for all."

World Health Organization

KEY MESSAGES *(continued)*

Health risks in a green economy – mitigation and management

- **Occupational hazards and risks associated with "green technologies" are often similar to those in conventional industries. Known measures can be employed to reduce such risks.** These include: design and protective gear against falls from height; local exhaust encapsulation and exhaust ventilation for protection from excessive exposure to toxic chemicals and indoor particulates; ergonomic devices (e.g. for lifting and carrying); training of workers and improved employment terms.[17] Clear policies and actions are needed to help governments, employers, workers and other social actors address these known problems.
- **Some green economic strategies may draw more employment to sectors with known hazards; these need to be managed and mitigated.** For instance, retrofitting homes and recycling materials are both "green strategies." But these also have known health risks to workers who may be obliged to work in close proximity sorting or removing materials contaminated by unknown toxics, chemicals or bacteria. Particularly in developing countries, the informal sector also is responsible for much of the materials recycling. And while recycling is of great value in resource conservation, jobs may entail dirty, undesirable and even dangerous and unhealthy work, for which people are often poorly paid. Occupational health measures targeted at the informal sector are thus of particular importance.
- **Some green technologies also may generate new or increased exposures to air pollution hazards.** For instance, workers may be exposed to nano-particles or hazardous chemicals in certain types of solar panel production which need to be mitigated.[18] Incineration, or "co-processing" of waste materials (tires, plastics, used oils and solvents, sewerage sludge, etc.) to generate energy for steel and cement production and other industries can conserve energy and replace fossil fuels while reducing waste volumes. However, poorly designed and managed technologies may generate toxic emissions (like dibenzo-p-dioxins, dibenzo-p-furans and PCBs) that can affect workers and people who live close to industrial facilities. Waste-to-energy schemes thus require oversight and monitoring policies that are currently lacking or inconsistently applied.[19,20]
- **Some green technologies require further attention to workers´ ergonomic risks.** For example, production of renewable energy can also involve hazards, e.g. falls from wind power installations, exposure to nano-particles or hazardous chemicals in solar panel production, which need to be mitigated. Using waste materials for "co-processing" of energy (tires, plastics, used oils and solvents, sewerage sludge, etc.) in steel and cement/clinker industries promotes recycling and energy conservation (even replacing fossil combustibles) while eliminating toxic residues. However, poorly designed and managed reuse technologies may generate toxic emissions (e.g. dibenzo-p-dioxins, dibenzo-p-furans and PCBs); excessive exposures can increase risks of cancer, and reproductive/immune disorders for workers and people who live close to industrial facilities. This requires oversight and monitoring that is often inconsistent or lacking. [21]
- **Some climate mitigation measures and green technologies present new hazards or risks to worker health.** When a technology raises threats of harm to human health, precautionary measures should be employed, even before final scientific proof of cause-and-effect relationships. For example, a Precautionary Principle policy adopted by the city of San Francisco (USA) with regards to chemical use notes that *"… early warning signs of harm"* should trigger an occupational health response that uses the *"best available science to identify safer alternatives."* This policy has encouraged the use of measures such as: financial incentives through procurement contracts; certification and promotion of safer business practices; requirements for information disclosure; and outright bans and restrictions on the sale of products when safer alternatives are readily available.[22]

IMPROVING HEALTH EQUITY

- **Adoption of certain green technologies and climate change mitigation measures may reduce gaps in access to basic services and goods necessary for workers´ health.** Substantial worker health co-benefits may be produced by enhanced and equitable access to electricity generated from renewable and clean sources like solar energy and wind. Electricity allows increased illumination of workplaces, resulting in ergonomic gains in comfort, health and productivity. Illumination also helps prevent work-related injuries. Access to light can also help facilitate the use of some tools and machinery. And access to renewable power sources can, in some settings, help curtail productivity losses due to fuel shortages or grid breakdowns. These factors are especially important to small, domestic workplaces and for informal workers, either in small urban areas or in rural villages, farms and small workshops.[23] Electricity also makes possible water pumping for irrigation as well as mechanizing agricultural processing, tilling and cottage industries.[24] Other benefits from enhanced electricity and lighting include better access to communications (important to workers, particularly farmers marketing products and services) and education,

as well as improved housing conditions, health care, and community services – all of which support health and sustainable production.

- **Equity in reducing occupational health risks and enhancing benefits associated with green technologies can be promoted through "life cycle" or "supply chain" approaches**. Many green technologies involve multi-country supply chains, with different hazards associated with production, use and disposal. For example, the production of low-energy compact fluorescent lightbulbs (CFLs) in one country was associated with mercury poisoning among workers, while the lightbulbs later were shipped abroad. A third group of workers may suffer occupational and environmental poisoning from processing and discharge of electronics waste.[25] Occupational health experts should be involved in all phases, as recommended by international norms.[26, 27]
- **The supply chain also provides opportunities for better distribution of occupational health benefits of green economies among diverse enterprises and countries.** Adherence to codes of conduct, fair trade and ethical practices among suppliers, vendors and contractors is a core expression of social responsibility and ethics to which green industries can commit. Importers and consumers can require evidence of compliance with sustainable and socially responsible practices through independent certification. For example, the "fair trade" certification of agricultural produce marketed in North America and Europe is one example of a process that has supported improvements in the health and conditions of many agricultural workers in developing countries.[2] Standards for "decent work" are now increasingly being set for other types of certified (green-seal) products such as biofuels (bioethanol, biodiesel). These specifications and requirements link sustainability issues and occupational health so as to produce "win-win" results for all stakeholders.[28, 29, 30]
- **Standards and requirements for "decent" work go beyond day-to-day working conditions and include combating slavery and slavery-like practices.** This includes eliminating child labour, improving working conditions, the right of free association and the possibility of social dialogue.[31]
- **Countries that promote green economy policies have an unprecedented opportunity to develop more inclusive health and occupational policies concerning workers with vulnerable employment conditions.** Many expanding green technologies are likely to involve large groups of previously unskilled and informal workers who have until now been excluded from most forms of occupational and social protection. Greater promotion of these technologies by countries and policy-makers can, and should, go hand in hand with better occupational health protection and safety measures for these same groups. For example, in many developing countries, collection and recycling work is often performed by the most marginalized groups in the population, known as waste pickers or scavengers. Children, women and the elderly are often engaged. Basic occupational health services and primary health care may play an important role in reducing inequity and promoting just transition towards green economies.[32]
- **In a green and sustainable economy, workers must be active participants who propose their own initiatives and advocate their communities' interests.** Because workers play central roles in all economic activities and technological developments, policy-makers and other stakeholders should both prioritize occupational health issues and also involve workers in related decisions. Workers should not be seen primarily as a "high-risk group" or as victims of new technologies and economic development.[33]

BACKGROUND AND RATIONALE

Green technologies are highly varied in scale and job demands, and they are not free of hazards. Workers in these industries will be exposed to risks that may be the same as, less than or elevated compared to conventional technologies. If green technologies are disseminated in ways that present increased risk to worker health, sustainability will be achieved at the cost of inequitably distributed risks and benefits, regardless of the benefit to the global community as a whole. Green technologies that protect or enhance worker health will achieve sustainability not only at the community level but down to the level of families, contributing to sustainability of income security and social equity.

This document seeks to anticipate green technologies' consequences for occupational health and safety, including hazards or risks they may present. The goal is to remove impediments to the dissemination and adoption of green technologies and to reduce avoidable risks for workers. This document identifies remediable hazards and manageable risks as well as the strategies to manage them so green technologies can be implemented without compromising worker health.

[2] *Health and environment. Managing the linkages for sustainable development: A toolkit for decision-makers.* WHO/UNEP Health and Environment Linkages Initiative, Synthesis Report. Geneva. WHO/UNEP, 2008.

SCOPE AND METHODS

The review began with a critical analysis of energy generation alternatives and carbon emissions reduction strategies, focusing on emerging "green technologies" likely to replace conventional technologies with known occupational health implications in a transition to a "green economy". Particular emphasis was given to energy technologies, insofar as energy-related industries are the major sources of climate change and thus central to climate change mitigation. However, green technologies for other areas including transport, agriculture, forestry and waste management also were considered.

Green technologies considered within the scope of the project were primarily those that had already been described and analyzed by the Intergovernmental Panel on Climate Change (IPCC) in the *Fourth Assessment Report of Working Group III*.[34] Other selection criteria included:

1. Stage of technological maturity developed enough to support an evaluation;
2. Sustainability assured or likely in economic, environmental and social dimensions;

Among available energy technologies, geothermal energy was not considered insofar as there are many subsets (geothermal warming, hydrothermal, hydrothermal condensing flash, ocean kinetic), each with different occupational issues and relatively small energy contributions. Ocean engineering technologies remain immature and speculative. Categories such as green chemistry, fuel efficiency and advanced manufacturing were also not addressed, insofar as they were overly broad. Nuclear energy and hydropower through dams were not considered because they are conventional technologies with sustainability issues that have already been well described.

A literature search for known hazards was then carried out with reference to the following criteria:

1. Evidence of benefit to workers' health;
2. Equity and fairness for both producers and users, including distribution and access to benefits;
3. Benefits for general public health;
4. Potential for job creation and "decent work";
5. Mitigation measures required to protect against foreseeable risks that would be acceptable to society.

Since the medical and public health literature on many green technologies is not extensive, many on line proprietary and grey-literature sources were also examined along with peer-reviewed literature. Interpretation of these sources required, in some cases, informed speculation because exposure data was unavailable.

To ensure that the team did not overlook known hazards familiar to the occupational health and safety community, but not widely researched and discussed in the literature, we also posted queries on social media (on LinkedIn.com) to get broader input on occupational health issues emerging in green technologies.

Findings were summarized in a draft table, "Potential Impacts of Selected Mitigation Measures on Health and Safety of Workers." The team then created a 21 x 5 matrix (105 cells, as some among the 10 technologies were subdivided). For each green technology, the following columns were populated based on prior knowledge of the technology and rapid literature searches:

1. Description of the technology (highly condensed);
2. Likely benefits to occupational safety and health (OSH);
3. Impact on OSH of collateral policies and interventions associated with the technology;
4. Potential hazards and risks to workers;
5. Measures to reduce, control, or mitigate risks to workers.

After analysis and review of the first list, a new list was constructed to reflect what was found in the bibliographic search and additional results from inside the team and other actors. From that second analysis, the "scoping" as an initial outcome emerged. This matrix was presented in the interim report.

SUMMARY OF INITIAL FINDINGS

The following green technologies were identified as meeting all or most of the criteria of the review. These are presented in the summary table. Findings in terms of evidence about impacts on workers' health were summarized for three dimensions: jobs and employment; working conditions; and health and health equity impacts.

1. Renewable energy sources: solar (thermal power generation, solar photovoltaic, passive solar heating and cooling), wind, biofuels (multiple sources), innovative biomass resources and bioenergy conversion technologies;
2. Replacement and/or reduction of traditional fossil fuel energy: selected industries and vehicles;
3. Materials recycling, whether "external" raw material scollected for the purpose or generated at the site in selected industries;
4. Energy efficiency in buildings;
5. Transportation: reduced energy consumption and efficiency;
6. Mitigation measures in agriculture: techniques for reduction of carbon emissions;
7. Mitigation measures in forestry: techniques for reduction of carbon emissions and fixation;
8. Waste management;
9. Fuel cells;
10. Carbon dioxide capture and storage (CCS).

CONCLUSIONS

- Benefits to workers should be balanced against risks to workers, and both should be compared to conventional technologies and the status quo as benchmarks.
- Jobs in green technologies are not free of hazard, nor in many cases are they any less hazardous than jobs in conventional technologies.
- The cost of disabling diseases and injuries, should they continue their present trends or rise, could substantially compromise the sustainability of the green economy by creating a dependent burden, reducing per-capita economic productivity and diverting resources from investment.
- The predictable risks of green technologies appear to be manageable and mostly conventional rather than exotic or unfamiliar.
- Some green technologies, especially those that involve centralized facilities for large-scale power generation, share risks with other projects of similar scale in the construction sector.
- The solutions to occupational health and safety risks in green jobs are the same as for conventional technologies and are based on the same principles.
- Employers in green technologies are likely to be responsive to the need for occupational health protection and safety because of the ethic of sustainability and social equity.
- Conventional technologies such as gasoline or diesel fuel for vehicles may coexist for a long time with green technologies such as hydrogen or electric-powered vehicles. During this transition, the workforce of the conventional technology may remain in place while facilities are constructed and employment opportunities are created in the new sector. Opportunities for employment in mitigation and monitoring also are likely to emerge.
- A green economy that does not adequately protect workers will be perceived as exploitive and therefore unsustainable.
- The best guarantee of long-term sustainability is cultural, featuring a strong vision of an equitable and accessible future. Healthy, safe, and decent jobs are part of that vision.

SUMMARY TABLE: APPRAISAL OF OCCUPATIONAL HEALTH IMPLICATIONS OF SELECTED MITIGATION STRATEGIES ASSESSED BY IPCC

MITIGATION STRATEGY	LIKELY CO-BENEFITS FOR WORKER HEALTH	IMPACT OF OCCUPATIONAL HEALTH CO-BENEFITS (20 years horizon)	OCCUPATIONAL HEALTH RISKS AND THEIR CONTROL (in addition to adoption of occupational safety and health general principles and strategies)	IMPACT OF OCCUPATIONAL HEALTH RISKS (20 years horizon)
Concentrating solar power (CSP) technologies	**Jobs and employment** - Provides direct job opportunities for electrical engineers, electricians, industrial machinery mechanics, welders, metal workers, electrical equipment assemblers, construction equipment operators, installation technicians, labourers, construction managers. Indirectly, other economic activities may expand or change technology and productivity with wider access to electricity.	+	• **Occupational accidents** may occur in the manufacturing, construction and transportation phases. • **Reflected light** - Power tower systems have the potential to concentrate light to intensities which could cause eyesight injuries or even blindness if reflected into the eyes of operators. Failure of tracking systems could result in straying beams that could pose a danger to workers near the receiving spot on the power tower. • **Releases of heat transfer medium** - The accidental release of heat transfer fluids (water and oil) from parabolic trough and power tower systems can be a health hazard. The hazard could be substantial in those power tower systems that use liquid sodium or molten salts as the heat transfer medium.	- -
	Working conditions - Operation of CSP stations usually involves "clean" and safe activities, and the benefits of providing electricity may impact numerous workplaces as a clean source of energy, improving illumination and ergonomic conditions to help prevent accidents and increase productivity.	+		
	Health outcomes - Indirect benefits through provision of electricity may be vital for health services, including hospitals, and for medical procedures (diagnosis & therapy).	+		
	Equity impacts - Indirect benefits such as job opportunities, better health services, comfort at home, and other goods, services and facilities that depend on electricity.	+		

MITIGATION STRATEGY	LIKELY CO-BENEFITS FOR WORKER HEALTH	IMPACT OF OCCUPATIONAL HEALTH CO-BENEFITS (20 years horizon)	OCCUPATIONAL HEALTH RISKS AND THEIR CONTROL (in addition to adoption of occupational safety and health general principles and strategies)	IMPACT OF OCCUPATIONAL HEALTH RISKS (20 years horizon)
Photovoltaic (PV) solar technologies	**Jobs and employment** - Provides direct job opportunities in the development of new technologies, production of solar cells, assembly and installation of panels, operation of stations and maintenance. Other economic activities may indirectly expand or change technologies and productivity by obtaining access to electricity.	+++	Potential occupational hazards and risks are mostly associated with the **semiconductor manufacturing** industry phase and/or the **construction industry** phase (for example, falls from rooftops when installing and maintaining solar panels): • **Ergonomic risk factors** have been critical, mostly in production and assembly lines making silicon wafers and semiconductors in some countries. • Possible **reproductive hazards** (birth effects and miscarriage) and cancer risks. • **Chemical hazards and risks** in the production of **crystalline silicon (x-Si) solar cells** include hydrofluoric acid (HF) burns and irritation, gas silane (SiH_4) fires/explosions and lead (Pb) solder/module disposal (decommissioning). • Risks in the production of **amorphous silicon (α-Si) solar cells** include gas silane (SiH_4) and hydrogen (H_2) fires/explosions and leaks of toxic doping-gases (AsH_3, PH_3, GeH_4). • Risks in the production of **cadmium telluride (CdTe) solar cells** include cadmium (Cd) toxicity, carcinogenicity, module disposal. • Risks in the production of **copper indium selenide (CIS) solar cells** include hydrogen selenite (H_2Se) toxicity and module disposal (decommissioning). • Risks in the production of **gallium arsenide (GaAs) high-efficiency solar cells** include: arsine (AsH_3) toxicity, phosphine (PH_3) irritation and fire risks, arsenide carcinogenicity and H_2 flammability.	- - - -
	Working conditions - Provides electricity to numerous workplaces as a clean source of energy, improving illumination and ergonomic conditions contributing to accident prevention and productivity.	+		
	Health outcomes - Indirect benefits of electricity provision may be vital for health services, including hospitals, and for medical procedures (diagnosis & therapy).	++		
	Equity impacts - Indirect benefits such as job opportunities, better health services, comfort at home, and other goods, services and facilities that depend on electricity.	++		

SUMMARY TABLE *(continued)*

MITIGATION STRATEGY	LIKELY CO-BENEFITS FOR WORKER HEALTH	IMPACT OF OCCUPATIONAL HEALTH CO-BENEFITS (20 years horizon)	OCCUPATIONAL HEALTH RISKS AND THEIR CONTROL (in addition to adoption of occupational safety and health general principles and strategies)	IMPACT OF OCCUPATIONAL HEALTH RISKS (20 years horizon)
Solar hot water and space heating and cooling (installation and use in workplaces)	**Jobs and employment** - Benefits may impact all phases of the life cycle of these technologies, i.e., raw materials -> manufacturing/assembly -> use/ reuse/maintenance -> recycling/waste management. Seen from a supply chain perspective, these benefits can impact suppliers, manufacturers, wholesalers/distributors, retailers and end users.	++	Apparently, there are no specific occupational hazards and risks related to these technologies. However, the following basic and nonspecific OSH concerns must be taken into account: • Use of power tools; • Work with ladders to access equipment and rooftops; • Working at heights during installation, servicing and decommissioning of solar units presents risks requiring fall protection; • Installing and performing maintenance on devices; • Ergonomic conditions.	-
	Working conditions - Comfort and economic gains for workers (homes) and for workers, employers, clients and visitors inside workplaces. Direct ergonomic gains with positive impacts on productivity. Contributes a physical dimension of the "healthy workplace" concept.	++		
	Health outcomes - Comfortable indoor temperatures at homes and workplaces are positive determinants of health, and heating provided by clean/green energy sources may reduce the adverse effects of "dirty" sources and uncomfortable temperature conditions. Indirectly, reduction of upper respiratory disorder incidence is expected.	++		
	Equity impacts - In principle, direct solar energy may be regarded as a "democratic" source of energy, and related technologies should be affordable and increasingly socialized.	+		
Wind energy	**Jobs and employment** - Provides direct job opportunities for environmental engineers, iron and steel workers, millwrights, sheet metal workers, machinists, electrical equipment assemblers, construction equipment operators, installation technicians, labourers, construction managers. Indirectly, other economic activities may expand or change their technology and productivity with access to electricity.	++++	**Onshore wind energy technologies:** • Working at heights (construction activities; assembly of wind tower components; general maintenance) leads to risk of falls.[35] • A variety of proximal nuisance effects are also raised with respect to wind energy development, the most prominent of which is noise. Noise from wind turbines can be a problem especially for those living nearby. Possible impacts are both audible and sub-audible (infrasound). **Near-shore or offshore wind energy technologies:** • Working at heights (construction activities; assembly of wind tower components; general maintenance) leads to risk of falls. • Working over water during these activities presents similar risks.	- - -
	Working conditions - Provides a clean source of electric energy that can impact numerous workplaces by improving illumination and ergonomic conditions, thus aiding accident prevention and productivity.	++++		
	Health outcomes - Indirect benefits of providing electricity which may be vital for health services, including for hospitals and medical procedures (diagnosis and therapy).	++++		
	Equity impacts - In principle, wind energy may be regarded as a "democratic" source of energy, and technologies should be affordable and increasingly socialized.	++++		

MITIGATION STRATEGY	LIKELY CO-BENEFITS FOR WORKER HEALTH	IMPACT OF OCCUPATIONAL HEALTH CO-BENEFITS (20 years horizon)	OCCUPATIONAL HEALTH RISKS AND THEIR CONTROL (in addition to adoption of occupational safety and health general principles and strategies)	IMPACT OF OCCUPATIONAL HEALTH RISKS (20 years horizon)
Biofuels: bioethanol from sugarcane	**Jobs and employment** - Provides direct jobs either for unskilled and unqualified workers (manual cultivation) or for more skilled and qualified workers (mechanized cultivation). Indirect impact along the supply chain of bioethanol.	+++	**Sugarcane cultivation, harvesting and transportation ("old pattern"):** • Migrant and seasonal work; • Frequently poor working, housing and sanitary conditions; • Overload of heavy work and associated health effects (dehydration, heat cramps, heat stroke); • Inhumane working conditions even resembling slavery persist in some parts of the world; • Children and other vulnerable groups may be part of labor force; • Exposure to solar radiation (UV) raises skin cancer risks; • In manual harvesting, exposure to trauma and work injuries caused by manual tools (knives), exposure to smoke from pre-harvest fires; • Exposure to toxic chemicals (pesticides and herbicides); • Exposure to venomous snake, scorpion and insect bites; • In mechanized harvesting, exposure to whole-body vibration leading to low back pain; • Risk of accidents.[36,37,38] **Bioethanol production**: general risk topics similar to bioethanol from corn (below). In addition to the general OSH prevention principles, the following measures should be taken: • Prioritization of local recruitment/hiring of workers; • Prioritization of continuous cycles of cultivation and/or complementary phases of the productive process to avoid seasonal cycles of recruitment/ dismissal; • Replacement of manual cultivation and cutting of sugarcane by mechanized processes to improve working and ergonomic conditions; • Qualification and requalification programmes to improve workers´ skills, and opportunities for diversified and better occupational challenges. • Worker participation and empowerment. • Enlargement of the concepts and practice of green economy and green jobs to foster decent work. • Promotion of the concept and practice of healthy workplaces in sugarcane cultivation and biofuels production.	- - - -
	Working conditions - Several models of sugarcane cultivation generate a large arc of possibilities, from very primitive and unacceptable working conditions for migrant and seasonal workers (mainly in manual cultivation and harvesting) to more advanced models based on mechanization and other ergonomic interventions.	+++		
	Health outcomes - Health benefits for workers depend on work organization, ergonomic conditions and general sanitary, housing and environmental conditions. Health may be promoted at the workplace and health care may become more readily available. Conversely, working conditions are determinants of fatigue, injuries and work-related diseases.	++		
	Equity impacts - Sugarcane cultivation and processing for ethanol (or sugar) production are labour-intensive and may offer equitable opportunities for thousands of workers even in distant and remote areas.[39,40,41]	+++		

SUMMARY TABLE *(continued)*

MITIGATION STRATEGY	LIKELY CO-BENEFITS FOR WORKER HEALTH	IMPACT OF OCCUPATIONAL HEALTH CO-BENEFITS (20 years horizon)	OCCUPATIONAL HEALTH RISKS AND THEIR CONTROL (in addition to adoption of occupational safety and health general principles and strategies)	IMPACT OF OCCUPATIONAL HEALTH RISKS (20 years horizon)
Biofuels: bioethanol from corn, wheat and other crops	**Jobs and employment** - Provides direct job opportunities in agriculture and industry and along bioethanol supply chain of suppliers, manufacturers, wholesalers/distributors, retailers and end users.	++++	**Corn cultivation, transport and storage:** • Traditional hazards and risks found in agricultural activities (corn, wheat, etc.): fires and explosions from grain dust; suffocation from engulfment and entrapment in grain bins; falls from heights; crushing injuries from grain handling equipment (augers and conveyors); exposure to fumigants and other toxic chemicals. **Bioethanol production:** • Potential exposure to cereal dust (in ethanol production from sugarcane, risk of inhalation of dust leading to extrinsic allergic alveolitis or bagassosis); • Potential exposure to hazardous chemicals (caustic cleaners, acid waste, natural gas, propane coolants, solvents, pesticide residues); • Potential hazards and risks caused by pressurized tanks (fermentation vessels, CO_2 tanks); • Potential hazards and risks related to ethanol storage (fires and explosions caused by different ignition sources).	- -
	Working conditions - No relevant and reliable information has addressed specific aspects of this dimension.	++++		
	Health outcomes - No relevant and reliable information has addressed specific aspects of this dimension.	++++		
	Equity impacts - No relevant and reliable information has addressed specific aspects of this dimension.	++++		
Biofuels: biodiesel from castor beans, soybeans, palm oil and non-edible plant oils	**Jobs and employment** - Provides direct job opportunities in agriculture and industry and along the biodiesel supply chain of suppliers, manufacturers, wholesalers/ distributors, retailers and end users.[31]	++	Technologies and processes are divided into agricultural activities (cultivation and transportation of biological feedstock as castor bean oil, soybean oil, etc.) and their respective hazards and risks, and industrial and manufacturing activities for biodiesel production hazards and risks, such as: • Fire and explosion (spontaneous combustion in some situations); • Exposure to methanol and sodium hydroxide (lye) in extracting oil; • Exposure to respiratory allergens and endotoxins (proteins); • Exposure to oil mist leads to respiratory irritation, asthma and dermatitis.	- -
	Working conditions - No relevant and reliable information has addressed specific aspects of this dimension.	++		
	Health outcomes - No relevant and reliable information has addressed specific aspects of this dimension.	++		
	Equity impacts - Castor beans and other crop cultivation as well as the full process for biodiesel production are labour-intensive and may offer equitable opportunities for thousands of workers even in remote areas.	++		
"Modern" biomass resources and bioenergy conversion technologies	**Jobs and employment** - Provides direct job opportunities for chemical engineers, chemists, chemical equipment operators, chemical technicians, mixing and blending machine operators, agricultural workers, industrial truck drivers, farm product purchasers, agricultural and forestry supervisors and agricultural inspectors.	++	No specific occupational hazards or risks have been described beyond those involved in more traditional and well-known technologies and processes.	-
	Working conditions - No relevant and reliable information has addressed specific aspects of this dimension.	++		
	Health outcomes - No relevant and reliable information has addressed specific aspects of this dimension.	++		
	Equity impacts - No relevant and reliable information has addressed specific aspects of this dimension.	+++		

MITIGATION STRATEGY	LIKELY CO-BENEFITS FOR WORKER HEALTH	IMPACT OF OCCUPATIONAL HEALTH CO-BENEFITS (20 years horizon)	OCCUPATIONAL HEALTH RISKS AND THEIR CONTROL (in addition to adoption of occupational safety and health general principles and strategies)	IMPACT OF OCCUPATIONAL HEALTH RISKS (20 years horizon)
Fuel cells	**Jobs and employment** - Benefits may impact all phases of the life cycle of these technologies, i.e., raw materials -> manufacturing/assembly -> use/ reuse/maintenance -> recycling/waste management. Seen from a supply chain perspective, these benefits can impact suppliers, manufacturers, wholesalers/distributors, retailers and end users.	++	• Fire and explosion: Hydrogen used in fuel cells is a very flammable gas and can cause fires and explosions if it is not handled properly. Hydrogen fires are invisible and if a worker believes there is a hydrogen leak, it should always be presumed that a flame is present. • Freeze burns: Workers may also be exposed to freeze burns when liquid hydrogen comes into contact with skin. • Electrical hazards: Hydrogen fuel cell workers are exposed to potential electrical hazards present in their work environment, increasing electrocution and arc flash risks. • Exposure to hazardous chemicals: methanol.	-
	Working conditions - Indirect benefit by providing alternative clean and "green" sources of energy for other workers (drivers, for example) and to other indoor and outdoor co-workers and bystanders.	++		
	Health outcomes - Indirect benefits by reducing the total burden of unpleasant and toxic emissions (produced by fossil fuels like diesel, for example), thus impacting positively on the incidence and prognosis of respiratory disorders among workers.	++++		
	Equity impacts - No relevant and reliable information has addressed specific aspects of this dimension.	+++		
Replacement and/ or reduction of traditional fossil sources of energy (selected industries and vehicles)	**Jobs and employment** – By creating jobs for technical, operational and administrative tasks related to: switching from "dirty" conventional fossil fuels to cleaner ones (e.g. replacing coal with natural gas); to renewable energy (e.g. use of bagasse of sugar cane and other biomass residues); to co-processed energy from waste materials in selected industries (e.g. cement, steel).	++++	**Switching from fossil fuels to other selected fossil fuels or to renewable energy:** • There are no specific occupational hazards and risks in the operation of switching fuels, except those generated by the new fuel and those related to the required technological changes and adjustments. **Using waste materials for co-processing of energy:** • Potential exposure to multiple and unknown chemical hazards (solvents, heavy metals, pesticides, toxic residues). • Risk of reactions and synergy among different chemicals producing new toxic hazards. • Toxic emissions such as VOC, PCDDs, PCDFs, HCl, CO, CO_2, HF, ammonia (NH_3), benzene, toluene, ethylbenzene, xylene, polycyclic aromatic hydrocarbons (PAH), heavy metals and their compounds may contaminate air, water or soil resources, posing health risks for communities and/or workers.[17] • Section D, items 76 to 93, of *UNEP Technical Guidelines on the Environmentally Sound Co-processing of Hazardous Wastes in Cement Kilns* recommends measures for management of occupational health and safety issues.[42]	0
	Working conditions - Indirect benefits from reducing old, "dirty" and traditional sources of CO_2 emissions and other pollutants (both gases and particulates) in workplaces.	++++		- - - -
	Health outcomes - Indirect benefits from reducing the burden of unpleasant and toxic emissions (produced by fossil fuels like diesel, for example), thus changing the incidence and prognosis of respiratory disorders among workers.	++++		
	Equity impacts - Replacement of or reductions in traditional fossil sources may occur in virtually all sectors, involving workers with different profiles who are geographically scattered.	++++		

SUMMARY TABLE *(continued)*

MITIGATION STRATEGY	LIKELY CO-BENEFITS FOR WORKER HEALTH	IMPACT OF OCCUPATIONAL HEALTH CO-BENEFITS (20 years horizon)	OCCUPATIONAL HEALTH RISKS AND THEIR CONTROL (in addition to adoption of occupational safety and health general principles and strategies)	IMPACT OF OCCUPATIONAL HEALTH RISKS (20 years horizon)
Materials recycling of both "external" raw materials or materials generated on site of selected industries	**Jobs and employment** – Direct positive impact by enlarging the size, scale and dispersion of populations economically involved along supply chains in all phases of material life cycles.	++++	While recycling is of great value in terms of resource conservation, it can entail dirty, undesirable, dangerous and unhealthy work, and it is often poorly paid. In many developing countries recycling work is performed by an informal network of scrap collectors, also known as "waste pickers" or scavengers, who collect recycled materials for revenue. Vulnerable groups like children, women and the elderly are usually engaged in this work.[21] A prominent example of dangerous recycling work is ship dismantling ("ship scrapping" or "ship breaking"), a major employer mostly in South Asia. Worldwide, between 200 and 600 large ships annually are broken up after having reached the end of their useful life. Many thousands of people, often migrant workers, are employed in this sector. But this is an industry marked by environmental and human health hazards, high accident rates and lack of protection for workers. The ships contain valuable steel and other scrap metal, but also many hazardous materials, including asbestos and PCBs.[22] Information on environmentally sound management of ship recycling is available on the Basel Convention website: http://www.basel.int/ships/index.html In addition to the general OSH prevention principles, the following measures should be taken: • Special legal and technical provisions to regulate the recycling world in connection with environmental regulatory agencies; • Special policies and programmes for/with workers in the informal sector, who usually are not covered by llabour inspections and other formal structures related to OSH. • These policies and programmes should work closely with NGOs and other organizations such as cooperatives and networks organized by informal workers or workers in small and micro-enterprises. • Special primary health care (PHC) policies and programmes for "waste pickers" or scavengers should be developed, using PHC and family health strategies and approaches, including health and workplace surveillance.	- - - -
	Working conditions - Often inadequate (informal workers, small plants, engagement of children and women) unless clear policies and appropriate enforcement are adopted. Indirect benefits for sectors and workers with reduced use of "dirty" energy sources.	+		
	Health outcomes - Not always beneficial for workers directly involved unless clear policies and appropriate enforcement are adopted.	+		
	Equity impacts - Direct positive impact as a clearly inclusive policy closely related to behavioral changes of ample target groups directly and indirectly involved.	+++		

MITIGATION STRATEGY	LIKELY CO-BENEFITS FOR WORKER HEALTH	IMPACT OF OCCUPATIONAL HEALTH CO-BENEFITS (20 years horizon)	OCCUPATIONAL HEALTH RISKS AND THEIR CONTROL (in addition to adoption of occupational safety and health general principles and strategies)	IMPACT OF OCCUPATIONAL HEALTH RISKS (20 years horizon)
Energy efficiency of buildings	**Jobs and employment** - Job creation and employment under a life-cycle approach: building design; manufacturing supplies; construction processes; building operation and maintenance; disposal, recycling and reuse of buildings; construction and demolition waste.	+++	While some researchers and occupational safety and health organizations have begun compiling lists of hazards associated with green construction, very few formal studies analyze such hazards. It is important to note that many green construction hazards are not entirely new and that some of the above hazards substitute for hazards that workers would encounter in traditional construction industries. Other workplace hazards are not new but are found in new contexts: • Increased risk of existing hazards: lead and asbestos in weatherization. • Hazards associated with new technologies and products: exposure to isocyanate (insulation) and to nanomaterials.[43]	- -
	Working conditions - No clear evidence of positive impacts on working conditions in performing tasks of construction or refitting. Indirect benefit for workers by improving air quality and "liveability" of homes and workplaces (commercial buildings, offices). Air quality indoors may be improved under a chemical/ toxicological perspective or under a biological perspective (e.g. fungi).	++		
	Health outcomes - No clear evidence of objective health indicators of morbidity is available so far. However, evidence is available on the seriousness of "sick building syndrome," which may be prevented.	++		
	Equity impacts - Positive effects, taking into account the high number and geographical dispersion of buildings that will adopt these measures. Everything within this scope has universal-dimensions, thus favoring equity concerns.	++		

SUMMARY TABLE *(continued)*

MITIGATION STRATEGY	LIKELY CO-BENEFITS FOR WORKER HEALTH	IMPACT OF OCCUPATIONAL HEALTH CO-BENEFITS (20 years horizon)	OCCUPATIONAL HEALTH RISKS AND THEIR CONTROL (in addition to adoption of occupational safety and health general principles and strategies)	IMPACT OF OCCUPATIONAL HEALTH RISKS (20 years horizon)
Transportation: energy consumption and efficiency	**Jobs and employment** - Provides direct job opportunities for civil engineers, rail track layers, electricians, welders, metal fabricators, engine assemblers, bus drivers, dispatchers, locomotive engineers, railroad conductors.	++++	No specific occupational hazards or risks to passengers or operators are posed by the adoption of any "green" transportation approach. Occupational hazards and risks associated with energy sources for vehicles are covered above. Note the following: • Electrical hazards: Battery and hydrogen fuel cell workers are exposed to potential high-voltage (300-500 V) electrical hazards in their work environment, thus more vulnerable to electrocution and arc flash hazard risks. • The distribution of exposure to hazard and risk may change depending on transportation policies and technologies chosen. For example, the risk of exposure to high-voltage electrical discharge may occur in battery swap stations as well as maintenance shops. • Emergency responders may face new hazards in dealing with vehicular collisions, rescues and other situations.	0
	Working conditions - Switching from fossil fuels (gasoline/diesel) to biofuels or electric/hybrid vehicles produces improved air quality for drivers, co-workers and the public. Noise reduction is an additional outcome of electric/hybrid vehicle adoption. Reduction of commuting time from home to workplace is good for workers, and most can benefit from using public transport instead of private cars on congested roads.	++++		
	Health outcomes - No formal evidence of positive health outcomes is available, unlike the abundant evidence demonstrating health problems caused by air pollution, noise and congested roads in urban areas. Stress and fatigue are additional problems already epidemiologically analyses and clearly associated with current transportation models.	++++		
	Equity impacts - Everything within this scope has universal dimensions; access to good public transport usually reinforces equity concerns and democratic values.	++++		
Mitigation measures in agriculture: techniques for reduction of carbon emissions	**Jobs and employment** - No relevant and reliable information has addressed specific aspects of this dimension.	++	No specific or new occupational hazards or risks have been described so far, except those involved in more traditional and well-known technologies and processes. A general reference for good practices in terms of occupational safety and health is ILO *Convention 184 on Safety and Health in Agriculture* (2001).[44] This Convention points out "*the need for a coherent approach to agriculture, taking into consideration the wider framework of the principles embodied in other ILO instruments applicable to the sector, in particular the Freedom of Association and Protection of the Right to Organize Convention, 1948; the Right to Organize and Collective Bargaining Convention, 1949; the Minimum Age Convention, 1973; and the Worst Forms of Child Labor Convention, 1999.*"	0/-
	Working conditions - Even without formal evidence, the major approaches adopted for reduction of emissions (CO_2, CH_4, N_2O), enhancement of removals and displacement of emissions are safe and should reduce use of and exposure to hazardous chemicals.	+++		
	Health outcomes - No relevant and reliable information has addressed specific aspects of this dimension.	++		
	Equity impacts - These mitigation measures are in principle labour-intensive, and may be incorporated into current practices that occupy a relevant share of the economically active population worldwide.	++		

MITIGATION STRATEGY	LIKELY CO-BENEFITS FOR WORKER HEALTH	IMPACT OF OCCUPATIONAL HEALTH CO-BENEFITS (20 years horizon)	OCCUPATIONAL HEALTH RISKS AND THEIR CONTROL (in addition to adoption of occupational safety and health general principles and strategies)	IMPACT OF OCCUPATIONAL HEALTH RISKS (20 years horizon)
Mitigation measures in forestry: techniques for reduction of carbon emissions and for carbon fixation	**Jobs and employment** - No relevant and reliable information has addressed specific aspects of this dimension.	+++	No specific or new occupational hazards or risks have been described, except those involved in more traditional and well-known technologies and processes.	0/-
	Working conditions - The major recommended approaches are in principle safe and healthy, and do not add new hazards and risks. They have the merit of introducing different cultures, values and behaviours and do not consist of new "technologies" per se.	+++		
	Health outcomes - No formal information has been found that addresses this dimension. However, improvement of health conditions is expected because of the close relationships between "green" culture, behaviour and practices, and principles of health promotion and health protection.	++		
	Equity impacts - These mitigation measures are in principle labour-intensive and may be incorporated into current practices which occupy a relevant share of the economically active population worldwide.	++		

SUMMARY TABLE *(continued)*

MITIGATION STRATEGY	LIKELY CO-BENEFITS FOR WORKER HEALTH	IMPACT OF OCCUPATIONAL HEALTH CO-BENEFITS (20 years horizon)	OCCUPATIONAL HEALTH RISKS AND THEIR CONTROL (in addition to adoption of occupational safety and health general principles and strategies)	IMPACT OF OCCUPATIONAL HEALTH RISKS (20 years horizon)
Waste management	**Jobs and employment** – Provides job opportunities for different occupational profiles and skills, including workers from small communities and people who used to live and work on untreated garbage deposits. Additional benefits in terms of human resource needs and opportunities under a supply chain perspective: suppliers -> manufacturers-> wholesalers/ distributors ->retailers and end users of biogas and/or solid residues for use in agriculture, horticulture, soil stabilization and soil improvement.	++	**Landfill methane recovery**: • Jobs in this sector are often low-quality and carried out by vulnerable workers. Risks can include handling during collection and sorting, potential exposure to dangerous objects, hazardous chemicals that may become concentrated during processing, biohazards and toxic or flammable gases. • Risk of fire and explosion caused by uncontrolled combustion (largely methane) generated during decomposition. • Exposure to landfill gases (including hydrogen and hydrogen sulfide). • Exposure to other toxic gases and vapors (benzene, vinyl chloride). • Transport hazards (road vehicles, trucks and tractors). **Biological treatment, including composting, anaerobic digestion and mechanical biological treatment (MBT):** • Exposure to enteric organisms usually found in biosolids, such as *Escherichia coli*, *Salmonella*, *Shigella*, *Campylobacter, Cryptosporidium, Giardia* and enteroviruses. Exposure may potentially result in disease (e.g., gastroenteritis), or in a carrier state (e.g., typhoid) where an infection does not clinically manifest in the individual but can be spread to others. These enteric organisms are usually associated with self-limited gastrointestinal illness but can develop into more serious diseases in sensitive populations such as immune-compromised individuals, infants, young children and the elderly (source: NIOSH). **Wastewater and sludge treatment:** • Risk of disease caused by infectious agents (bacteria, viruses, protozoa, helminths and fungi) present in raw domestic wastewater (mainly from human origin) and in agricultural waste. • Risk of diseases caused by insects or rodents proliferating in sludge drying beds. • Risk of chronic poisoning by inhalation or ingestion of chemicals used in wastewater treatment. • Hazards related to entry into confined spaces: suffocation due to oxygen deficiency, poisoning (e.g. by hydrogen sulfide).	- -
	Working conditions - There is an ample spectrum of possibilities from poor working conditions to acceptable working conditions, as occurs in all sectors. Additional and new hazards and risks obviously require safe, healthy and "green" approaches, which in principle are well-known.	+		
	Health outcomes - Specific positive evidence on workers´ health is difficult to characterize. This may be indirectly assessed in terms of health benefits from better living and sanitary conditions where workers and their families are included.	++		
	Equity impacts - Indirect effects from including workers and their families in provision of better living and sanitary conditions.	+		

MITIGATION STRATEGY	LIKELY CO-BENEFITS FOR WORKER HEALTH	IMPACT OF OCCUPATIONAL HEALTH CO-BENEFITS (20 years horizon)	OCCUPATIONAL HEALTH RISKS AND THEIR CONTROL (in addition to adoption of occupational safety and health general principles and strategies)	IMPACT OF OCCUPATIONAL HEALTH RISKS (20 years horizon)
Carbon dioxide capture & storage (CCS) techniques	**Jobs and employment** - No relevant and reliable information has addressed specific aspects of this dimension.	+	Little bibliographic evidence exists of accumulated experience with OSH hazards and risks.[45] The risk of leakage of CO_2 from pipelines is a major concern. A sudden and large release of CO_2 would pose an immediate danger to human life and health in cases of exposure to concentrations of CO_2 greater than 7–10% by volume in the air. Similar concerns are applicable to the risk of leakage of CO_2 from storage sites.	0/-
	Working conditions - No relevant information has been found addressing gains and benefits from the adoption of these technologies.	+		
	Health outcomes - No relevant information has been found addressing gains and benefits from the adoption of these technologies.	0/+		
	Equity impacts - No relevant and reliable information has addressed specific aspects of this dimension.	+		

SELECTED REFERENCES

1 United Nations Environmental Program. Green jobs: towards decent work in a sustainable, low-carbon world. Washington, UNEP, 2008. http://www.unep.org/labour_environment/PDFs/Greenjobs/UNEP-Green-Jobs-Report.pdf

2 Sanchez AB, Poschen P. The social and decent work dimensions of a new agreement on climate change. Geneva, International Labor Organization, 2009. http://www.ilo.org/wcmsp5/groups/public/---dgreports/---integration/documents/briefingnote/wcms_107814.pdf

3 International Labor Organization. Promoting decent work in a green economy: ILO background note to "Towards a green economy: pathways to sustainable development and poverty eradication." Geneva, ILO, 2011. http://www.ilo.org/wcmsp5/groups/public/@ed_emp/@emp_ent/documents/publication/wcms_152065.pdf

4 Villeneuve PJ, Parent MÉ, Sahni V, Johnson KC, Canadian Cancer Registries Epidemiology Research Group. Occupational exposure to diesel and gasoline emissions and lung cancer in Canadian men. Environmental Research, 2011; 111(5):727-35. http://www.ncbi.nlm.nih.gov/pubmed/21536265

5 McCormack VA, Schüz J. Africa's growing cancer burden: environmental and occupational contributions. Cancer Epidemiology, 2012; 36(1):1-7. http://www.ncbi.nlm.nih.gov/pubmed/21996568

6 Sumner SA, Layde PM. Expansion of Renewable Energy Industries and Implications for Occupational Health. JAMA, August 19, 2009—Vol. 302, No. 7

7 Hosking J, Macmillan A, Connor J, Bullen C, Ameratunga S. Organisational travel plans for improving health. Cochrane Database of Systematic Reviews, 2010; 17(3): CD005575. http://www.ncbi.nlm.nih.gov/pubmed/20238341

8 Morabia A, Mirer FE, Amstislavski TM, Eisl HM, Werbe-Fuentes J, Gorczynski J, Goranson C, Wolff MS, Markowitz SB. Potential health impact of switching from car to public transportation when commuting to work. American Journal of Public Health, 2010; 100(12):2388-91. http://www.ncbi.nlm.nih.gov/pubmed/20966368

9 Brockman R, Fox KR. Physical activity by stealth? The potential health benefits of a workplace transport plan. Public Health, 2011; 125(4):210-6. http://www.ncbi.nlm.nih.gov/pubmed/21458011

10 Wilson MP et al. Green Chemistry: Cornerstone to a Sustainable California. The Centers for Occupational and Environmental Health, University of California, 2008. http://coeh.berkeley.edu/greenchemistry/briefing/ or www.coeh.ucla.edu/greenchemistry.htm

11 United Nations Environmental Program. Green jobs: towards decent work in a sustainable, low-carbon world. Washington, UNEP, 2008. http://www.unep.org/labour_environment/PDFs/Greenjobs/UNEP-Green-Jobs-Report.pdf

12 World Health Organization. Resolution WHA62.14 – Reducing health inequities through action on the social determinants of health. Geneva, WHO, 2009. http://apps.who.int/gb/ebwha/pdf_files/WHA62-REC1/WHA62_REC1-en-P2.pdf

13 Sanchez AB, Poschen P. The social and decent work dimensions of a new agreement on climate change. Geneva, International Labor Organization, 2009. http://www.ilo.org/wcmsp5/groups/public/---dgreports/---integration/documents/briefingnote/wcms_107814.pdf

14 International Labor Organization. Promoting decent work in a green economy: ILO background note to "Towards a green economy: pathways to sustainable development and poverty eradication." Geneva, ILO, 2011. http://www.ilo.org/wcmsp5/groups/public/@ed_emp/@emp_ent/documents/publication/wcms_152065.pdf

15 Puig-Barrachina V, Malmusi D, Marténez JM, Benach J. Monitoring social determinants of health inequalities: the impact of unemployment among vulnerable groups. International Journal of Health Services, 2011; 41(3):459-82.

16 World Health Organization. Rio political declaration on social determinants of health. Rio de Janeiro, WHO, 2011. http://www.who.int/sdhconference/declaration/Rio_political_declaration.pdf

17 ILO. Promoting safety and health in a green economy. Geneva, 2012 http://www.ilo.org/safework/info/publications/WCMS_175600/lang--en/index.htm

18 Ellwood P, Bradbrook S. Foresight of New and Emerging Risks to Occupational Safety and Health Associated with New Technologies in Green Jobs by 2020, PHASE II – Key Technologies. European Agency for Safety and Health at Work, Luxembourg: Publications Office of the European Union, 2011. http://osha.europa.eu/en/publications/reports/foresight-green-jobs-key-technologies

19 Pinto Jr. AG, Braga AMCB. Work and health: the activity of burning toxic waste in cement kilns in Cantagalo, Rio de Janeiro State. Ciência & Saúde Coletiva, 2009; 14(6):2005-2014. http://www.scielo.br/scielo.php?pid=S1413-81232009000600008&script=sci_arttext

20 United Nations Environmental Program. Basel Convention: technical guidelines on the environmentally sound co-processing of hazardous wastes in cement kilns, 2011. Basel Convention 10th meeting 2011, Cartagena, Colombia, Document UNEP/CHW.10/6/Add.3 http://www.basel.int/Portals/4/Basel%20Convention/docs/pub/techguid/cement/tg-cement-e.pdf

21 Ellwood P, Bradbrook S. Foresight of New and Emerging Risks to Occupational Safety and Health Associated with New Technologies in Green Jobs by 2020, PHASE II – Key Technologies. European Agency for Safety and Health at Work, Luxembourg: Publications Office of the European Union, 2011. http://osha.europa.eu/en/publications/reports/foresight-green-jobs-key-technologies

22 Raphael DO, Geiger CA. Precautionary policies in local government: green chemistry and safer alternatives. New Solutions: A Journal of Environmental and Occupational Health Policy, 2011; 21(3):345-58. http://www.netmed.com.br/pubmed/abstract.php?bd=pubmed&submit=y&eword=&ids=22001035

23 Sanchez AB, Poschen P. The social and decent work dimensions of a new agreement on climate change. Geneva, International Labor Organization, 2009. http://www.ilo.org/wcmsp5/groups/public/---dgreports/---integration/documents/briefingnote/wcms_107814.pdf

24 Intergovernmental Panel on Climate Change. Renewable energy sources and climate: special report of the Intergovernmental Panel on Climate Change. New York, Cambridge University Press, 2012. http://srren.ipcc-wg3.de/report/IPCC_SRREN_Ch01.pdf

25 Barratt H. Mercury poisoning of Chinese factory workers making CFLs a concern. Science 2.0, 20 September 2010 http://www.science20.com/make_love_not_war/blog/mercury_poisoning_chinese_factory_workers_making_cfls_concern-71812

26 International Labor Organization. Occupational Safety and Health Convention, 1981 (C155). Geneva, ILO, 1981. http://www.ilo.org/ilolex/cgi-lex/convde.pl?C155

27 International Labor Organization. Occupational Health Services Convention, 1985 (C161). Geneva, ILO, 1985. http://www.ilo.org/ilolex/cgi-lex/convde.pl?C161

28 International Labor Organization. Promoting decent work in a green economy: ILO background note to "Towards a green economy: pathways to sustainable development and poverty eradication." Geneva, ILO, 2011. http://www.ilo.org/wcmsp5/groups/public/@ed_emp/@emp_ent/documents/publication/wcms_152065.pdf

29 Chatterjee P. Health costs of recycling. British Medical Journal, 2008; 337:a296. http://www.bmj.com/content/337/bmj.a296

30 Kumar R. Ship dismantling: a status report on South Asia. Euroconsult Mott MacDonald and WWF India. 2009. http://eeas.europa.eu/delegations/india/documents/eu_india/ship_dismantling_en.pdf

31 ILO, Promoting decent work in a green economy. Geneva, 2011 http://www.ilo.org/employment/Whatwedo/Publications/WCMS_152065/lang--en/index.htm

32 Macedo IC, Seabra JEA. Mitigation of GHC emissions using sugarcane bioethanol. In P Zuurbier & J van de Vooren, eds., Sugarcane ethanol, contributions to climate change mitigation and the environment. 2008, Wageningen, Netherlands: Wageningen Academic Publishers, 95-112.

33 Elgstrand K, Petersson NF. Introduction. In: Elgstrand K, Petersson NF. Occupational safety and health for development. Stockholm, Royal Institute of Technology, 2009; 17-24.

34 Metz, B et al, eds. Climate Change 2007. Mitigation of Climate Change, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge & New York, Cambridge University Press, 2007.

35 International Finance Corporation/World Bank Group. Environmental, health, and safety guidelines – wind energy. Washington, 2007. http://www.ifc.org/ifcext/enviro.nsf/AttachmentsByTitle/gui_EHSGuidelines2007_WindEnergy/$FILE/Final+-+Wind+Energy.pdf

36 Novaes JRP. Champions of productivity: pains and fevers in São Paulo´s sugarcane plantations. Estudos Avançados, 2007; 21(59):167-178.

37 Rocha FLR, Marziale MHP, Robazzi MLCC. Poverty as predisposing factor of illness tendencies in sugar cane workers. Revista Latino-americana de Enfermagem, 2007; 15 (no. especial):736-41. http://www.scielo.br/pdf/rlae/v15nspe/03.pdf

38 Rocha FLR, Marziale MHP, Hong OS. Work and health conditions of sugar cane workers in Brazil. Revista da Escola de Enfermagem da USP, 2010; 44(4):978-83. http://www.scielo.br/pdf/reeusp/v44n4/17.pdf

39 Goldemberg J, Coelho ST, Guardabassi P. The sustainability of ethanol production from sugarcane. Energy Policy, 2008; 35:2086-2097. http://cenbio.iee.usp.br/download/publicacoes/JEPO2750.pdf

40 Galli E. Frame analysis in environmental conflicts: the case of ethanol production in Brazil. Stockholm, 2011. PhD dissertation, KTH (Royal Institute of Technology), School of Industrial Engineering and Management, Division of Industrial Ecology. http://www.europeana.eu/portal/record/9200111/D990328A3E9A4E88873F1CE6B568580211E31A6C.html

41 Macedo IC, Seabra JEA. Mitigation of GHC emissions using sugarcane bioethanol. In P Zuurbier & J van de Vooren, eds., Sugarcane ethanol, contributions to climate change mitigation and the environment. 2008, Wageningen, Netherlands: Wageningen Academic Publishers, 95-112.

42 United Nations Environmental Program. Basel Convention: technical guidelines on the environmentally sound co- processing of hazardous wastes in cement kilns, 2011. Basel Convention 10th meeting 2011, Cartagena, Colombia, Document UNEP/CHW.10/6/Add.3 http://www.basel.int/Portals/4/Basel%20Convention/docs/pub/techguid/cement/tg-cement-e.pdf

43 Chen H. Green and healthy jobs. CPWR (Center for Construction – Research and Training). 2010. http://www.cpwr.com/pdfs/Green-Healthy%20Jobs%20fnl%20for%20posting.pdf

44 International Labor Organization. Safety and Health in Agriculture Convention, 2001 (C184). Geneva, ILO, 2001. http://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:12100:2052608495314308::NO:12100:P12100_ILO_CODE:C184:NO

45 Intergovernmental Panel on Climate Change. IPCC special report: carbon dioxide capture and storage – summary for policymakers. 2005. http://www.ipcc.ch/pdf/special-reports/srccs/srccs_summaryforpolicymakers.pdf

ACKNOWLEDGEMENT

The analysis for this report was carried out by an international team of experts under the leadership of René Mendes (Tee L. Guidotti, Kaj Elgstrand, Ester Galli, Jean Carlo Viterbo, and Guilherme Salgado) and was reviewed by Christine Branche, Peter Ellwood and Muzimkhulu Zungu. The report was edited by Elaine Fletcher and Ivan Ivanov.

The financial support of the US National Institute of Occupational Safety and Health for the production of this document is gratefully acknowledged.

Public Health & Environment Department (PHE)
Health Security & Environment Cluster (HSE)
World Health Organization (WHO)
Avenue Appia 20, CH-1211 Geneva 27, Switzerland
www.who.int/phe/en/
www.who.int/hia/green_economy/en/index.html

Cover photo:
Workers affix a solar hot water heater to the roof of a house in Kuyasa, Cape Town, South Africa, as part of a climate change mitigation housing retrofit initiative financed through the UNFCC Clean Development Mechanism (CDM). Ensuring worker safety with traditional measures, such as the use of protective gear, will be important to enhance workers' health in the transition to a green economy.
Photo: Nic Bothma/Kuyasa CDM Project

Layout by Punto Grafico