Opportunities for Disability-inclusive Energy Access

A White Paper prepared under the Disability Support Service (DSS) for the Transforming Energy Access (TEA) platform

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About the Transforming Energy Access (TEA) Platform

Transforming Energy Access (TEA) is the flagship Foreign, Commonwealth and Development Office (FCDO) research and innovation platform supporting early-stage testing and scale-up of innovative technologies and business models that accelerate access to affordable, clean and modern energy, enabling sustainable, and inclusive growth in Sub-Saharan Africa, South Asia, and the Indo-Pacific region. This includes clean energy supply technologies (e.g. next generation solar), super-efficient demand solutions (e.g. efficient appliances, sustainable cooling, modern cooking) and smart delivery solutions (e.g. energy storage, green grids, hydrogen). It targets people and enterprises who have no or limited access to clean, modern energy services and limited opportunities to participate in, or benefit from, the energy sector through employment and income generation opportunities. TEA leads on several Ayrton Challenges including 'Next Generation Solar', 'Zero Emissions Generators', 'Energy Storage', 'Clean Hydrogen', 'Inclusive Energy and Leave No One Behind', 'Sustainable Cooling for All' and 'Energy Efficiency' (via the LEIA programme) and supports 'Clean Transport' and 'Smart Energy Systems'.

About the Global Disability Innovation Hub (GDI Hub)

Global Disability Innovation (GDI) Hub accelerates ideas into impact for a more just world — for disabled people, and all people. We are a world leading delivery and practice centre, an Academic Research Centre at University College London (UCL) and the first World Health Organization (WHO) Global Collaborating Centre on Assistive Technology. As an Academic Research Centre and Community Interest Company, our diverse portfolio and unique structure enables rapid translation of research into practice. GDI Hub is also home to the UK aid funded AT2030 programme which tests 'what works' to improve access to life-changing Assistive Technology (AT) for all.

Launched in 2016 as a legacy of the London 2012 Paralympic Games, our office and research lab continue to be based on the Queen Elizabeth Olympic Park, at UCL's East London campus. GDI Hub works in 40+ countries, with a reach of more than 64 million people since 2016, developing homegrown technologies alongside new knowledge and research. In collaboration with global partners, we deliver accelerators and market shaping initiatives—building disability innovation ecosystems with a focus on Low-and Middle-Income Countries (LMICs).

Abbreviations

AT – Assistive Technology

CRPD – Convention on the Rights of Persons with Disabilities

DPOs – Disabled People's Organisation (also called Organisations of Persons with Disabilities or OPDs)

DSS – Disability Support Service

FCDO – Foreign, Commonwealth and Development Office

GEDSI – Gender Equality, Disability, and Social Inclusion

ICE – Internal Combustion Engine

LEZ – Low Emission Zone

LMICs – Low- and Middle-Income Countries

PMV – Private Motorised Vehicle

SDG – Sustainable Development Goal

TEA – Transforming Energy Access

WAV – Wheelchair Accessible Vehicle

WHO – World Health Organization

Definitions

Approaches to and understandings of disability inclusion are constantly—and importantly — evolving. To support the integration of disability inclusion and energy access innovation under the TEA platform, the following definitions are adopted.

People with disabilities or persons with disabilities or disabled people

As defined by the United Nations Convention on the Rights of Persons with Disabilities (CRPD) "persons with disabilities include those who have long-term physical, mental, intellectual, or sensory impairments which in interaction with various barriers, may hinder their full and effective participation in society on an equal basis with others[1]."

Note that there are different preferences regarding terminology, with disabled people used more commonly in the United Kingdom (UK) and people with disabilities used more commonly internationally. Terms can be chosen on a case-by-case basis and, if possible, in consultation with disabled people in the context within which work is taking place. This document adopts 'people with disabilities,' unless referring to a quote.

Accessibility

Refers to enabling access to infrastructure, products, services, and facilities for all people with disabilities. Accessibility is driven by technical standards or design guidelines for the physical and digital infrastructure. Accessibility delivers access to equal participation, whereas inclusive design goes beyond access and delivers systemic inclusion.

Assistive product

Physical products (e.g., hearing aids) and digital products (e.g., screen reading software), specifically developed to advance individuals' functioning and independence.

Assistive technology

Assistive technology (AT) is the application of organised knowledge and skills related to assistive products, systems, and services designed to maintain or improve an individual's functioning and independence and thereby promote their well-being[2].

Disability

Disability is an evolving concept and results from the interaction between people with impairments and attitudinal and environmental barriers that hinder their full and effective

participation in society on an equal basis with others[3].

Disability-disaggregated data

Information on programme objectives, performance indicators, impact measurements, and other characteristics as disaggregated according to disability.

Disabled People's Organisations (DPOs) or Organisations of Persons with Disabilities (OPDs)

A Disabled People's Organisations (DPO), sometimes called, Organisation of Persons with Disabilities (OPD), is "a representative organisation or group of persons with disabilities, where persons with disabilities constitute a majority of the overall staff, board, and volunteers in all levels of the organisation"[4].

Exclusion

Restricted participation in, access to, or benefit from material, financial, or social activities or outcomes.

Inclusive design

Inclusive design is a mindset and a methodology that embraces diversity to create a world that is more intuitive, elegant, and usable for all of us. Inclusive design can help all human beings experience the world around them in a fair and equal way, by creating safe and accessible environments, products, and services for all members of the community.

Just transition

A just transition means greening the economy in a way that is as fair and inclusive as possible to everyone concerned, creating decent work opportunities and leaving no one behind. It involves maximising the social and economic opportunities of climate action, while minimising and carefully managing any challenges – including through effective social dialogue among all groups impacted[5].

Participation

People with disabilities effectively and fully engaging in political and public life on an equal basis with others, directly or through freely chosen representatives.

Reasonable accommodation

The necessary and appropriate modification and adjustments not imposing a disproportionate or undue burden, where needed in a particular case, to ensure to persons with disabilities the enjoyment or exercise on an equal basis with others of all human rights and fundamental freedoms[6].

The Washington Group questions

Standardised questions designed to globally identify individuals who might be considered to have a disability by asking respondents to what extent they have trouble performing different activities.
Access question sets here: www.washingtongroup-disability.com/question-sets/

Executive Summary

This white paper outlines, **why** disability inclusion is critical for just transition, **what** opportunities are available for disability-inclusive energy access innovation, and **how** energy sector practitioners can implement transformative actions.

This paper is prepared through a flexible and iterative qualitative desk review and compilation of insights from GDI Hub's expertise.

The diversity of disability

Globally, 1 in 6 people experience disability (16%), 80% of whom live in LMICs[7] [8]. Disability occurs when people with impairments lose the opportunity to take an equal part in society because of social and environmental barriers. Disability is diverse, encompassing physical, sensory, and intellectual disabilities, and the prevalence of disability increases with age[9]. The experiences of people with disabilities are also very diverse, including the barriers that are experienced, how these are overcome and a person's requirements to exercise their human rights under the CRPD. Marginalisation and discrimination of people with disabilities is reinforced with experiences related to sex, gender, sexual orientation, race, age, and other individual and personal identities[10].

For example, a woman with a disability is more likely to be economically inactive compared to a man with similar impairment and household background[11]. This might be due to social norms that limit women's role to household responsibilities and do not create an enabling environment for education and employment. Notably, lack of reproductive healthcare, poor working conditions, low wages, violence and harassment, and unsupportive care leave policies for women further exacerbate this[10].

While the corroboration outlined in this paper draws on people with disabilities as an evidencing group based on the literature, we encourage readers to recognise the vast diversity within this group throughout.

Why disability-inclusive energy access?

Disability is both a cause and consequence of poverty[12]. **In the context of climate change, disability can be a cause and consequence of energy poverty,** as households of people with disabilities in LMICs are commonly larger, poorer, and in rural areas, where they may require more heating or cooling[13] [14] [15] [16]. Further, energy transition measures without the

explicit inclusion of people with disabilities could cause various risks such as: worsening socio-economic exclusion and discrimination[17]; exacerbating loss of lives[18] [19]; and neglecting opportunities from a diverse consumer bases through inclusive innovation[20] and delivery methodologies.

Towards addressing these and achieving the targets of Sustainable Development Goal 7 (SDG-7)—ensuring access to affordable, reliable, sustainable, and modern energy for all—**it is essential to deliver clean, undisrupted, and affordable energy, and create an enabling energy transition ecosystem for people with disabilities[15].**

The United Nations (UN) Flagship Report on Disability and Development highlights four critical focus areas for disability-inclusive energy access:

1. Access to modern forms of energy that are less polluting for the households where people with disabilities stay for longer periods of time
2. Access to electricity to charge or operate assistive technology (AT)
3. Affordable energy as many people with disabilities live in low-income households
4. Access to energy for development[15].

What are the opportunities to integrate disability inclusion in energy access?

Based on evidence and case studies available globally, this white paper presents opportunities for disability-inclusive energy access under two themes:

1. **Powering AT with clean energy:** Affordable, sustainable, and clean energy-based adaptations or alternatives for the twenty-two energy-based, WHO-listed priority assistive products could be a high-impact entry-point.
2. **Creating accessible and inclusive clean energy products, services, and jobs:** Towards enabling independent living for people with disabilities and including them as part of just transition,[21] creating accessible and inclusive clean energy products, services, and jobs has impact potential across eight sectors, including: 1) home appliances and information and communication technologies (ICTs); 2) built environment and cities; 3) transportation; 4) healthcare; 5) education; 6) green jobs; 7) humanitarian sector and reconstruction; and 8) energy infrastructure.

GDI Hub, through the delivery of DSS, is supporting and enabling the TEA partners to leverage some of these opportunities, test new ideas, and document learnings.

How to implement transformative actions for disability-inclusive energy access?

A three-pronged framework could guide the pathway to translating these opportunities as impactful actions:

1. A **do-no-harm approach** to ensure people with disabilities are not actively excluded.
2. A **proactive, targeted disability inclusion approach** to cater to the diversity of needs among people with disabilities.
3. An **intersectional prioritisation approach** to consciously reduce compounding inequalities due to other individual identities, including sex, gender, sexual orientation, race, caste, and age[15] [18].

The overall vision is to **include people with disabilities throughout the energy value chain as leaders, employees, consumers, entrepreneurs, and community members.**

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1. Introduction

"Sustainable energy means opportunity.
Opportunity means hope for a better future."
Ahmad Alhendawi, United Nations Secretary General's Envoy on Youth[22]

Transition to clean energy through emissions reduction, energy efficiency, and sustainable development is a must for our desirable, shared future. Removing all existing structural barriers and social inequalities in the transition is not, however, guaranteed[23]. **Targeted interventions are crucial to leave no one behind, particularly the 16% of people with disabilities in the global population, for achieving the 'United Nations 2030 Sustainable Development Goal 7: Ensure access to affordable, reliable, sustainable, and modern energy for all (SDG-7).'** More specifically, to meet Target 7.1 through Indicator 7.1.2, which emphasises the need for universal access to clean energy services[24] [7].

> **Target 7.1:** By 2030, ensure universal access to affordable, reliable, and modern energy services.
> **Indicator 7.1.2:** Proportion of population with primary reliance on clean fuels and technology.

Renewables and electrification are the two primary drivers of the global low-carbon, clean energy transition movement that aspires to change the way we produce, supply, and consume energy[25]. From that context and guided by the multi-tier framework for energy access (MTF), energy sector programmes commonly focus on electricity for households, economic activities, and public services[21]. However, **it is also important to meet the energy needs for accessibility and usage of assistive products.** For example, a person with a mobility impairment might require reliable clean energy to charge their electric wheelchair, operate their electric-wheelchair accessible vehicle (e-WAV), and power any other assistive technology (AT) or products that are essential for their everyday life.

If energy access programmes are to deliver energy for all, distribute benefits equitably, and address the rights of people with disabilities, it is critical to adopt disability-inclusive approaches for energy transition, in line with inclusive climate action commitments of the UK FCDO's Disability Inclusion and Rights Strategy 2022-2030.

2. Energy Access Needs for People with Disabilities

The five broad areas of energy needs for people with disabilities include wellbeing and hygiene, food preparation, mobility, life support, and communication, as various structural barriers impede their independent living[26]. As the UN finds in its flagship Disability and Development Report 2018, the main barriers for disability inclusion and thus meet the needs of people with disabilities are:

- disability related discrimination and stigma;
- lack of accessibility to physical and virtual environments;
- lack of access to AT; access to essential services, and rehabilitation; and
- lack of support for independent living that are critical for the full and equal participation of persons with disabilities as agents of change and beneficiaries of development.

For example, the inaccessible built environment, public transport, and information and communication systems, along with social stigma may force some people with disabilities to spend more time indoors[27] causing higher energy consumption (for temperature control, appliance usage), and therefore higher energy bills than households of people without disabilities[21]. Also, there is a short supply of accessible and affordable social housing, which can lead to people with disabilities living in non-adapted housing units with poor or low energy efficiency standards, leading to even higher energy costs[28]. On the other hand, a higher monthly medical expense due to lack of targeted, subsidised, and reliable healthcare services for people with disabilities could directly reduce the monthly budget available for energy needs, including for the usage of AT[28 29].

Clean, undisrupted, and affordable energy, and an enabling energy ecosystem are beneficial for all and are basic needs for people with disabilities with the current status quo of compounding barriers[30]. Multiple recent studies also build an argument that **disability in the context of climate change could be a cause and consequence of energy poverty**[12 13 14 15 31]. The sections that follow exemplify the potential role and impact of energy access in enabling the lives and livelihoods of people with disabilities.

2.1. Clean energy

Access to clean energy will support the energy needs of people with disabilities and

contribute to their health protection. People with disabilities who may be reliant on spending more time indoors, are at risk for high-level household air pollution, particularly in sub-Saharan Africa and Southeast Asia, where solid fuels are prevalent for cooking and heating [21] [13] [15]. In LMICs with limited building regulations and enforcement, dwelling units with poor ventilation could further exacerbate high-level concentrations of pollutant particles and increase the risk of indoor smoke traps [15]. Environments such as rural areas, refugee camps, and habitats of displaced communities, where access to modern cooking fuels and appliances is limited, may have even higher risk [15].

2.2. Undisrupted energy

Undisrupted energy supply is not only essential for powering personal assistive products but also to support other critical medical equipment, built environment accessibility infrastructure, household energy systems and appliances, and communication devices[32]. Energy disruptions could disempower and demobilise people with disabilities, as recent estimates suggest more than one billion people need at least one form of AT, and more than a quarter of the WHO-listed priority AT products require electricity[33] [15].

Electricity-dependent tools, including wheelchairs, gesture-to-voice technology, personal digital assistants, screen readers, Braille displays, hearing aids, and fall detectors, are basic requirements for many[28] [15]. In addition, mobility scooters, stairlifts, hospital-style beds, electric doors, personal lifts, and wheelchair lifts can also be essential to ensure accessibility within houses and public facilities[32]. People with certain impairments could be highly sensitive to temperature changes and may require heating and cooling systems to run regularly[28]. Electrically powered medical equipment, including air ionisers, nebulisers, ventilators, continuous positive airway pressure machines (CPAP), oxygen systems, infusion pumps, and dialysis machines, are also essential devices for people with disabilities, who report seeking more medical attention than people without disabilities[1] [2]. For some people, electronic communication devices can be vital in life-threatening situations, such as during medical emergencies or for receiving early warnings and preparatory information during climate emergencies[26].

2.3. Affordable energy:

Affordable energy is key for safeguarding households of people with disabilities from energy poverty, meeting their required energy consumption needs, and adopting new products and services[16]. People with disabilities are three times less likely to get

employed. When employed, they get paid less than people without disabilities, and face poor progression prospects[1 2 27]. When considering energy prices and price policies, failing to account for those facing barriers to accessing employment could exacerbate both poverty and energy poverty.

The need for undisrupted energy supply for mobility, healthcare, and indoor temperature regulation, as discussed in Section 2.2, reflects potential higher energy needs, which often translates into higher energy bills. Dynamic energy pricing instruments that mandate a higher rate for peak-hour or -season usage pose an additional threat for people with disabilities who may not have the choice to restrict their usage of assistive products and medical equipment only to low-priced hours or seasons[26]. With comparatively low income but high healthcare and personal care needs, people with disabilities are likely to hit energy poverty with even a small increase in energy prices[35]. Therefore, people with disabilities could rarely become early adopters of the emerging new clean energy systems, services, or products, if they require high upfront capital investment and operational costs.

Disability-inclusive energy access is not limited to delivering easy, flexible, accessible, and adaptable energy products or appliances. It refers to creating an enabling energy ecosystem that offers inclusive interface with product information, market, finance, demonstration, delivery, service, and feedback mechanism. It also refers to **including people with disabilities as consumers and co-designers of new energy products and services**[28]**.** For the energy sector practitioners to deliver such holistic outcomes, Chapters 3 and 4 present two high-impact opportunity areas.

3. Powering Assistive Technology with Clean Energy

Energy transition programmes in LMICs offer an immense opportunity to expand the market for and reach of assistive products[36]**.** Assistive technology and products directly improve all five areas of energy needs for people with disabilities—wellbeing and hygiene, food preparation, mobility, life support, and communication—enhancing participation, and supporting CRPD obligations[26 2]. However, across the world, only around 10% of people with disabilities who need an assistive product have access to them[2].

In addition to the 26% of WHO-listed priority AT that require electricity, 18% of them,

including hearing aids, deafblind communicators, and digital hand-held magnifiers, need either rechargeable or disposable batteries, which come with high operating costs for people with disabilities[15]. While high capital costs hinder adoption, high operational costs lead to discontinued use, particularly in low-income households.[13]. For AT like hearing aids that use non-rechargeable zinc-air batteries, an added concern is high electric waste (e-waste) generation. A recent estimate suggests that more than 200 million people from LMICs have hearing impairments[37]. Given a future where all of them have access to disposable battery-powered hearing aids, 7.3 billion batteries will be generated as e-waste per year, assuming 5-10 days as the average life time per battery[13]. **This emphasises the need for affordable, sustainable, and clean-energy based adaptations or alternatives for the 22 energy-based, priority assistive products** (Table 01).

The following strategies or interventions could bring together disability innovation and energy access innovation and directly include people with disabilities as part of the just transition[21] [38]:

a. Integrating energy needs of assistive products and accessibility equipment within existing solar-powered home systems or community-level mini-grids, particularly in off- and weak-grid regions across sub-Saharan Africa[13]
b. Designing and testing solar-based, affordable powering mechanisms for assistive products, which could increase their reach and ownership
c. Prioritising and/or subsidising access to clean energy services for people with disabilities
d. Manufacturing assistive products locally in an energy-efficient manner and reducing the carbon footprint across the product life cycle[39]
e. Offering repair services or training people with disabilities to handle regular maintenance of clean energy-based AT[39] [36]
f. Mainstreaming energy efficiency rating systems for AT to support well-informed purchases[38]
g. Integrating energy monitoring systems as part of AT to track consumption and ration energy usage[38]
h. Exploring new marketing and financing models and subsidies for people with disabilities to access clean energy-based AT.

No.	Energy-based Priority Assistive Products List (WHO)
1.	Alarm signallers with light/sound/vibration
2.	Audio players with DAISY capability
3.	Braille displays (note takers)

No.	Energy-based Priority Assistive Products List (WHO)
4.	Closed captioning displays
5.	Communication software
6.	Deafblind electronic communicators
7.	Fall detectors
8.	Gesture-to-voice technology
9.	Global positioning system (GPS) locators
10.	Hearing aids (digital) and batteries
11.	Hearing loops/FM systems
12.	Keyboard and mouse emulation software
13.	Magnifiers, digital hand-held
14.	Personal digital assistant (PDA)
15.	Personal emergency alarm systems
16.	Prostheses, lower limb (not all)
17.	Recorders
18.	Screen readers
19.	Simplified mobile phones
20.	Video communication devices
21.	Watches, talking/touching
22.	Wheelchairs, electrically powered

Table 01: The 22 assistive products identified from the WHO's 50 priority AT list that either need electricity or batteries for operation.

The **AT2030 programme led by GDI Hub and funded by UK International Development** focuses on cutting-edge research and delivery for five of the fifty products from the WHO-priority AT list: hearing aids, prostheses, wheelchairs, eyeglasses, and assistive digital products and software. Clean, modern, and affordable energy solutions could potentially improve all these products, and here are some examples:

- Testing the feasibility of solar-powered hearing aids and expanding their reach
- Enabling off-grid energy units for locally producing prosthetics, which can be more fit-for-purpose and often rely on technology such as 3D printing, requiring undisrupted energy supply in remote or humanitarian settings

- Popularising power wheelchairs or electric attachment which can enhance the mobility of wheelchair users, particularly in settings where public transport is inaccessible

Case study 1: SolarEar, Howard Weinstein (2002)

Globally it is estimated that people with hearing impairments make up around 460 million, of which 7% are children from LMICs, who miss their education as they either couldn't access hearing aids and replaceable batteries or afford them (as they typically cost $1 a week). Innovated by people with hearing impairments, Solar Ear was developed as the world's first solar-powered hearing aid with chargeable batteries. The long life of solar-powered batteries (up to three years), along with lower price and maintenance costs, has enabled them to reach 30 countries.

4. Creating Accessible and Inclusive Clean Energy Products, Services, and Jobs

In addition to powering AT, a complete and equal participation of people with disabilities requires leveraging opportunities and embedding disability inclusion across all sectors, as presented in the following sections[13 40].

4.1. Home appliances and ICTs

People with disabilities require accessible appliances for cooking, cleaning, and self-care and hygiene, and also personal devices such as ICTs including screen readers, speech recognition and video communication tools (for sign language communication and video relay interpretation), speech-to-text services (such as open and closed captioning), and visual assistance, which demand energy supply for uninterrupted functioning[21]. **Research shows that, for people with disabilities, lack of access to clean energy products, is commonly due to lower income, lack of awareness, and misalignment in needs and product offerings[14].**

The following strategies could address these concerns:

a. **Popularising solar home systems,** for example stand-alone mini-grid systems capable of powering three to eight devices for up to five hours per day and allowing regular usage of assistive products, provided through solar panel grants or similar financial incentives[41].

b. **Promoting accessible off-grid appliances through OPDs and proactively strengthening customer bases** in order to reduce reliance on expensive fossil fuel-based energy grid and increase reliability on modern energy products [13].
c. **Adopting inclusive design principles and accessibility standards** to ensure the appliances are suitable and adaptive for the diverse needs of consumers with disabilities[21]. For example, including remote control options and distinct visual and audio cues as part of the appliance interface could enhance accessibility for people with varying mobility, vision, and hearing impairments[36]. Notably, the common interface challenges for people with disabilities are physical strain and dependence on others[14].
d. **Recognising mobile phones as part of energy-dependent AT and creating charging facilities** to reduce the barriers to communication and social participation[42] [21]. For example, voice recognition and control features enable hands-free operation for users with limited mobility or dexterity, and screen readers and magnifiers provide visual accessibility for individuals with low vision or blindness. Also, Pay-As-You-Go solar energy solutions that could be accessed through a mobile phone could become an incentive for energy companies to provide mobile charging services through community solar lanterns[36].
e. **Promoting and advertising clean energy appliances** through accessible digital- and print-based content to build awareness on product features and benefits[36]. For example, illustrated and multi-media formats for product manuals and warranty cards could enable people with disabilities to access necessary maintenance services.

Case study 2: Pay-As-You-Go model for Electric Cooking

The Electric Cooking Entrepreneurs Association of Kenya (ELCEAK), in collaboration with PowerPay Africa has introduced a Pay-As-You-Go (PAYGO) model to make electric cooking more accessible and affordable for all, including people with disabilities. Through this model, users can skip the burden of large upfront purchasing costs for electric cooking appliances, and pay in small, manageable instalments. Further, this relieves households of people with disabilities and other marginalised users from the risk of indoor pollution by making the shift to clean cooking fuel

4.2. Built environment and cities

Appliances and products must be accessible, but equally important is an inclusive built environment in which they can be used[36]. The GDI Hub's AT2030 inclusive

infrastructure case studies, conducted in six cities from LMICs, reveal that there is a lack of co-designed and connected infrastructure, which compounds the physical barriers, particularly for people with disabilities living in informal settlements[43].

Below are opportunity areas to reduce these barriers:

a. **Energy adaptation for social housing:** The increasing household heating and cooling needs, in the context of global warming, is a common driver for energy poverty in households of people with disabilities. Retrofitting existing social housing units and care home facilities with better insulation and ventilation features, efficient temperature regulation systems, and clean energy-based appliances could enable more people to meet their energy needs at lower cost[28 44]. The energy adaptation retrofitting process could also be leveraged to upgrade social housing facilities with ramps, elevators, grab handles, and other accessibility-supportive elements.
b. **Energy transition solutions for the private housing sector:** Encouraging, incentivising, or mandating private homeowners and developers to invest in low-cost, accessible, energy-efficient home systems would create more housing options. The integration of disability assistive tools with home automation services would also benefit households with older people and people experiencing temporary mobility limitations, who may face regular or occasional surges in energy needs[33].
c. **Creating community energy hubs:** In low-resource settings, local public institutions like schools, health clinics, and rural administrative offices could be transformed as anchor points to generate and share clean energy. However, it is important to ensure that these institutions are accessible and inclusive[45 44].

Case study 3: Tackle energy poverty in households of people with disabilities and support social integration (2021 – 26), Cyprus Energy Agency

The Cyprus Energy Agency, in collaboration with the Union of Cyprus Communities, is implementing a project to reduce energy poverty in around 300 households of people with disabilities. This initiative is part of the European Union's broader effort to ensure a fair low-carbon transition, addressing the unique energy needs of people with disabilities. The project covers small-scale renovations for improving energy efficiency (for example, adding thermal insulation, providing modern appliances, and delivering specialised equipment), financial support, and household-level guidance on energy use.

4.3. Transport

GDI Hub's AT2030 inclusive infrastructure case studies from six cities also show that public transport systems in LMICs are mostly inaccessible[43]. **This status quo often leads to people with disabilities either reducing or restricting their trips, becoming captive users of poor public transport systems, or opting for high-cost, polluting, private motorised vehicles**[17].

As more cities are now promoting mixed-use neighbourhood planning and regeneration through concepts such as '15-minute cities', disability-inclusive pedestrian infrastructure may reduce reliance on energy-intensive private motorised vehicles (PMVs) for shorter trips[17]. However, active travel modes and interventions for low-traffic neighborhoods have faced criticism from disability activists, as active travel may not always be accessible despite efforts to improve infrastructure[46]. Efforts to decarbonize transport sector through electric vehicles also need to be delivered with accessibility and inclusion in mind. The following list offers entry-points:

a. **Disability-inclusive and -responsive Low Emission Zones (LEZs):** Cities across the world are now actively implementing LEZs as a spatial enforcement measure to persuade usage of clean energy-based private motorised vehicles (PMVs)[47]. A combination of inaccessible public transport infrastructure and high emission charges for using PMVs could be a double penalty on people with disabilities[48]. Below outlines measures for implementing LEZs that work for all[49]:
    I. Providing short- to medium-term exemptions or grace periods from emission charges for vehicles of people with disabilities and wheelchair accessible vehicles (WAV).
    II. Offering trade-in bonuses and transition allowances for people with disabilities and charities operating WAVs to enable a shift from polluting internal combustion engine (ICE) vehicles to electric vehicles with zero tailpipe emissions.
    III. Encouraging demand-based taxi aggregator services to operate clean energy-based WAVs with a regulated tariff.
    IV. Providing priority access in low-traffic neighbourhoods for people with disabilities to be able to reach their homes if a private vehicle is their only practical mode of transport.
b. **Innovation for accessible micromobility:** As car-free and car-lite zones are emerging as new-age urban redevelopment practices, inclusive clean energy-based micromobility options suitable for the needs of people with disabilities are critical[50]. These options, however, may only benefit people with certain impairments. The low

noise levels, unregulated speed restrictions, unpredictable rider behaviour, and haphazard parking practices of electric scooters and other micromobility options could also create a challenging environment for many people with disabilities to freely navigate shared public spaces[48].

c. **Design and delivery of accessibility-customisable electric vehicles:** The challenges in accommodating disability-responsive vehicle modification requirements for electric-WAVs commonly leave people with disabilities with a compromise in internal space and travel comfort[51] [48]. Hence, innovation in design is key to expand options.
d. **Accessible vehicle charging infrastructure:** In LMICs, a household garage or allocated parking space is commonly absent, leading to parking vehicles overnight at driveways. The presence of personal and accessible parking space nearby determines the possibility for installing home charging facilities and shifting to electric vehicles[52]. While community charging infrastructure can support in most cases, people with disabilities may face challenges such as the inconvenience of travelling between home and charging stations, lack of priority access, or overcrowded overnight charging options, which could hinder their purchase choices and usage[32].

Affordability is an influential criterion for enabling energy transition in the transport sector, as buying a new electric vehicle comes with a high upfront capital investment or significant monthly instalment. **People with disabilities often at the risk of energy poverty would require additional financial support or innovative purchase or ownership models to access new, clean, modes of transport**[53].

4.4. Healthcare

Accessible and affordable healthcare facilities are key for the well-being of all including people with disabilities requiring both standard and specialised care[28] [15]. In sub-Saharan African countries, only around a quarter of existing health facilities have reliable electricity supply, and a quarter of them do not have access to any form of energy[36]. Electrifying healthcare infrastructure offers a range of distributional benefits; however, two direct high-impact areas are:

a. **Reliable localised healthcare system** through solar-powered mobile clinics and ambulances, which could help reaching communities, including people with disabilities, who are traditionally excluded from preventive care services[54] [55].
b. **Reliable portable off-grid medical devices** including solar-powered refrigerators for vaccines, solar-powered ventilators, smart phone-based ultrasound, and solar

autoclaves to serve low-resource settings with high disability prevalence rates[36 56 57 58 59].

Synchronising these larger healthcare innovations with the operations and charging requirements of clean energy-based ATs could also be an opportunity to improve people's access to and use of affordable and reliable assistive products in remote settings. For example, solar-powered ambulances could be leveraged to also act as mobile charging infrastructure, for people living in refugee camps, displaced communities, and countries with conflicts, where reliable grid-based electricity continues to be a challenge.

4.5. Education

On average, one-third of children with disabilities are not enrolled in formal education from primary, early years[60]. The common barriers for their access to education include:

- **Infrastructure inaccessibility:** Almost half (47%) of the existing education facilities mapped (30,000) in LMICs are found to be inaccessible for wheelchair[15].
- **Lack of electricity:** Research from the past decade suggests 80% of primary and secondary schools in Africa did not have electricity[61]. The lack of accessible learning materials poses a challenge, and digital tools that could help may be unaffordable or impractical without reliable electricity.
- **Lack of training and awareness:** Students may experience stigma and discrimination due to pervading cultures, a lack of disability confidence and awareness among both staff and students.

Energy access interventions could address barriers, for example:

a. **Enabling equal classroom participation:** Though designing new accessible classrooms and retrofitting the existing physical infrastructure to be accessible are essential first steps, electrifying education facilities is critical to provide reasonable accommodations. For example, reliable energy can be vital for the education of children with disabilities who may need indoor temperature regulation and adequate lighting for sensory comfort for longer study hours, and active classroom participation[61 62].
b. **Promoting clean energy-based assistive products for education:** There are many and a growing number of assistive ICTs for education, including 'digital-to-Braille technologies, DAISY books, text magnifiers, videos with captioning, audio formats, and video-in-sign language'[15].Solutions range from low-tech to high-tech, for example, solar-powered audio recorders, portable note takers, calculators, and computer-based applications. Within this emerging market and progress towards

inclusive and accessible education for children with disabilities, there lies an opportunity for clean energy assistive ICT products and charging to guarantee inclusive and quality education.

4.6. Green jobs

Globally, "there is disproportionately low representation of persons with disabilities in the labour market with unemployment rates as high as 70 to 80 per cent"[15 27]. Recent studies show that the clean energy sector is expected to create 8-18 million jobs worldwide by 2030[63 64 65], where sub-Saharan Africa is expected to benefit from up to 4 million new jobs across solar, bioenergy, wind, and hydropower sectors[66 67]. These **"good, green jobs" could be made available and accessible for people with disabilities by recognising them as potential leaders, employees, and entrepreneurs in the clean energy sector**[33 18 28].

The following list shares the enabling reasons to include people with disabilities through green jobs:

a. **Sectoral diversity in the energy transition job market:** The energy transition agenda directly accelerates work across multiple sectors, including "renewables research, heating systems to heat pumps, efficient lighting alternatives, electric vehicles, energy-efficient building materials, and battery manufacturing supply chain for various needs[48]." This offers new employment avenues requiring new skills, which could be filled by people with disabilities through training and skill building activities, internships, and apprenticeships.
b. **Skills in demand for green jobs:** The 'Jobs for a Livable Planet' Report suggests that green jobs are being created across the project cycle or supply chain, covering design, construction, commissioning, operation and maintenance, and decommissioning[68]. For example, the momentum for decentralised and community-based energy generation and distribution models requires local talent recruitment for office administration, sales and client relations, and process management. This presents opportunities to hire people with disabilities at a community level in collaboration with OPDs and vocational training centres.
c. **Green entrepreneurship:** Empowering people with disabilities in LMICs to become business owners where the energy access market is growing immensely would also support CRPD's "Article 27-1f: Promote opportunities for self-employment, entrepreneurship, the development of cooperatives and starting one's own business[27 40]." The post-Covid-19 market has accelerated remote working and e-commerce, which could be strengthened as an avenue for people with disabilities to

build, facilitate, and monitor e-commerce platforms for energy products and services[69].

Case study 4: Kerjabilitas.com, Indonesia

A web- and mobile app-based career and social network for people with disabilities to connect with inclusive job providers. Within this application and website, both job seekers (people with disabilities) and job providers can create a profile, view advertisements, match their requirements with suitable listings, and share their applications or offerings. The platform serves as a digital job market for people with disabilities, a communication forum to voice their opinions and needs, and a skill development portal. Overall, it reduces the digital divide for people with disabilities, increases their employability, and offers career advice.

4.7. Humanitarian sector and reconstruction

"Access to sustainable energy can deliver quick returns in humanitarian situations; enhancing safety, security, productivity, and health for camp inhabitants, host countries, camp operators, and the environment. It can also serve as a powerful means for bridging the gap between humanitarian response and development, create opportunities to pursue education, businesses and social enterprises, and spur innovation"

United Nations Coalition for addressing the needs of refugees and displaced people worldwide[22].

An inclusive, equitable, and just transition approach also lends itself to **a rights-based, intersectional lens** that could connect the international human rights treaties and obligations with the required resource mobilisation at the grassroots level[70]. During humanitarian emergencies, energy access could be essential for electricity-powered assistive products, as people with disabilities are considered as some of the most at risk in such contexts, as set out in the Inter-Agency Standing Committee (IASC) guidelines[71]. It is interesting to note that the IASC guidelines do not discuss energy access as an area for intervention, possibly indicating the lack of knowledge at the intersection of these issues. The Sphere Standards for the inclusion of older people and people with disabilities provide practical guidance on inclusive actions, however, they again do not explicitly mention energy access, which would be a critical thread across multiple interventions[72]. **Investment in energy infrastructure and access should be explored as an investment in and for people, partnerships, and societies, essential to post-disaster reconstruction**[73]**.**

4.8. Energy infrastructure

Energy infrastructure as an umbrella term includes, 'generation, transmission, distribution, and storage infrastructure for electricity, gas, and oil'[74]. As the design and delivery of energy infrastructure is evolving due to clean energy targets, there is an opportunity for a more integrated approach to embedding disability inclusion across the infrastructure lifecycle covering **planning, preparation, procurement, and implementation**[75]. The specific areas of interventions could include:

a. **Disability-inclusive energy planning:** In the context of frequent and high-intensity climate emergencies, centralised energy networks are likely to face increased disruptions, which calls for energy planning for short-term recovery and long-term resilience at the city- and community-levels. Businesses could offer household-level or personal-level energy planning products and tools for people with disabilities, which work in alignment with the city- and community-level systems. For example, an accessible mobile application for notification regarding power disruptions, peak-time usage, and price alerts could help them ration energy. This could specifically benefit people relying on electricity-based assistive products, if provided with energy monitors[26 38].

b. **Preparation for project:** Building the project team's awareness and capacity on disability inclusion through training and engagement with OPDs could prepare staff to become disability confident and competent.

c. **Prioritising accessibility and inclusion through procurement:** Procuring accessible goods and services, making procurement process accessible for people with disabilities, and prioritising sourcing from disability-inclusive suppliers who adhere to accessibility standards are all equally important measures. Energy sector businesses could use the 'Relevance-Spend Matrix', a simple grid-based tool presented as part of the procurement guidelines of the UN Disability Inclusion Strategy, to guide their investment decisions with input from people with disabilities or OPDs[28 76].

d. **Implementation through inclusive design, development, and use:** Fable, an organisation supporting businesses embed accessibility and inclusive design in digital products and tools, recommends the following steps: 1) organising design reviews of prototypes with people with disabilities during design stage, 2) running compatibility tests for all critical task flows of the product, and 3) establishing benchmarks for regular monitoring and collecting user feedback[73]. This shows implementation is never an end and there is always room for improvement through quality feedback.

5. Risks of Excluding People with Disabilities in Energy Transition

While including people with disabilities is key for just energy transition, it could be a challenging global transformation process at levels such as policy, system, product, and personnel.

- At the **policy** level, a lack of representation of people with disabilities in decision-making related to energy access programmes and a lack of disability-disaggregated data monitoring across development outcomes, could pose potential limitations.
- At the **system** level, inaccessible built environment and social stigma, are the key hurdles to reap complete benefits of energy access.
- At the **product** level, lack of inclusive design and user interface, limited choices and autonomy, poor communication, guidance, and assistance could be reasons for lower adoption of clean energy products by people with disabilities[20].
- Further, people with disabilities may have limited familiarity with digital tools, and other learning applications due to the system- and product-level barriers, which could translate as **personal** challenges.

These challenges, if not acknowledged and addressed consciously, risk not meeting the CRPD obligations and leaving behind 16% of the world's population by[7]:

a. **Increasing the percentage of households of people with disabilities in energy poverty**, as they have high energy needs and high vulnerability[16].
b. **Worsening socio-economic exclusion and discrimination,** as absence of affordable energy access could become a systemic barrier to unlock better livelihood opportunities and contribute to the economy[17].
c. **Threatening loss of lives,** as globally, during natural disasters, people with disabilities are up to four times more likely to be impacted[18] [19]. Without reliable energy access, people with disabilities could lose access to ICTs and ATs under climate emergencies.
d. **Missing out on potential customer base,** as people with disabilities are current and prospective consumers for a range of new clean energy technologies and products. Globally, the disability market controls over $13 trillion in disposable income. With minimal but thoughtful redesign and adaptation, the energy market could reach this large and diverse community, reducing their carbon footprint, and maximising benefits[20].

6. Conclusion

The 'Pact for the Future, Global Digital Compact, and Declaration on Future Generations,' adopted at the Summit of the Future, September 2024, emphasises access to energy as a critical area for achieving the SDGs and promoting economic development, and commits to **"seize on opportunities provided by new and emerging technologies to empower and advance equity for persons with disabilities, including through promoting the availability of assistive technologies"** (Action 30 – 54.d)[77].

Disability-Lens Investment Pyramid (IFC, 2024)

To mainstream disability inclusion and innovation lens across energy sector investments and comprehensively integrate people with disabilities as part of the clean energy value chain, it would be useful to adopt the five-tiered 'Disability-Lens Investment Pyramid.' This approach would encourage the inclusion of people with disabilities as leaders championing the change, as employees contributing directly to the energy sector, as consumers of clean energy products and services, as entrepreneurs shaping the energy market, and as community members who play an active role in decision-making.

Figure 1: Disability-Lens Investment Pyramid (Source: IFC, 2024)

A three-pronged approach for disability-inclusive energy access could lead the thinking on this commitment: 1) **a do-no-harm approach** to ensure people with disabilities are not actively excluded from the benefits of energy access programmes, 2) **a proactive, targeted disability inclusion approach** to cater to the diversity of energy access needs among

people with disabilities, and 3) **an intersectional prioritisation approach** to consciously reduce compounded inequalities due to other individual identities, including sex, gender, sexual orientation, race, caste, and age (UN, 2018)[18]. To take action on this thinking and seize the opportunities presented throughout this White Paper, a first step is to include people with disabilities, having diverse needs and impairments, throughout the energy value chain as leaders, employees, consumers, entrepreneurs, and community members[15 78 33].

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