Sustainable Production and Consumption 46 (2024) 119–131

Contents lists available at ScienceDirect

Sustainable Production and Consumption

journal homepage: www.elsevier.com/locate/spc

The transition of Ghana's cooling appliance sector to a circular economy via a small wins governance framework

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ARTICLE INFO

Editor: Prof. Konstantinos Tsagarakis

Keywords:
Cooling
Greenhouse gas emissions
Circular economy
Socio-technical transition
Air-conditioner

ABSTRACT

Air conditioning poses environmental, socioeconomic, and political challenges, especially in sub-Saharan countries such as Ghana, where almost all devices are imported. Thus far, socio-economically feasible pathways for a cooling transition to a circular economy are unclear. Drawing on qualitative interviews, field observations and survey data, this study analyses the potential of small wins governance as a pathway to sweeping system change along Ghana's air-conditioners' lifecycle. The research analyses the status quo and identifies potential small wins that could lead to transformative shifts in the cooling sector. Through a mixed-methods approach encompassing interviews, surveys, and field assessments, the study uncovers small wins at four stages of the air conditioner lifecycle, from (1) import, (2) retail & purchase, (3) usage & service, and (4) end-of-life management practices. For policymakers and practitioners, our results imply that they should (a) systematically encourage and reap small wins in public-private spaces in the short-term, e.g. changing the incentive structure for staff controlling imports of air conditioners, (b) adjust supporting policies as learning dynamics unfold over time (e.g., energy and refrigerant standards and labels, tax system), but (c) also keep pushing for big wins in the mid-term (e.g., constructions of a recycling plant for refrigerants in West Africa). The findings emphasize the need for a behavioural, consumer-oriented perspective for the pragmatic potential of small wins towards a circular economy. Overall, the study addresses significant gaps in the literature and suggests that bottom-up approaches may offer more success than attempting broad top-down system changes. The paper contributes to the wider discourse on social-ecological transitions and offers valuable insights for policymakers, industry stakeholders, and researchers aiming to foster sustainable practices in the cooling sector.

1. Introduction

Space cooling fuels a vicious circle: Whereas more and more people will require space cooling in the upcoming years to adapt to global warming, cooling will become one of the largest contributors to the warming of the planet. On the one hand, cooling helps mitigate high temperatures that can adversely affect people's well-being and health (Green et al., 2019). Cooling is essential to sustain cold chains for food and medications (Alam et al., 2021; James and James, 2010). It provides thermal comfort in commercial facilities, private homes, and offices, enabling productive work and well-being (Flouris et al., 2018). However, it arguably only makes human life possible in the world's hottest regions. With the current climate and socioeconomic developments, it is estimated that globally between two to four billion people will require domestic space cooling to cope with increasing heat (Mastrucci et al., 2019). Over the next 30 years, the global electricity demand for cooling is set to triple – which amounts to 10 new air conditioners (ACs) sold every second – driving the sector to be the second largest energy growth sector after the industry sector (International Energy Agency, 2018). In sub-Saharan Africa in particular, the demand for cooling appliances is increasing, not only due to increasing temperatures but also due to population growth, urbanization, and rising income levels of its middle- and upper-class (Never et al., 2022; Opoku et al., 2019; Senadza et al., 2020). Despite the daunting projections and its relevance for achieving SDG 3 (Health), SDG 12 (Sustainable Production and Consumption, SDG 13 (Climate Action), and SDG 7.3 (Energy Efficiency), cooling is still a

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https://doi.org/10.1016/j.spc.2024.02.016
Received 26 October 2023; Received in revised form 13 February 2024; Accepted 13 February 2024
Available online 18 February 2024
2352-5509/

blind spot in today's sustainability debates (Khosla et al., 2021).

Particularly for middle-income countries such as Ghana, the cooling trajectory poses environmental, socioeconomic, and political challenges. It is estimated that 60 to 80 % of energy used in most public and commercial buildings in Ghana is for air-conditioning (Opoku et al., 2018). About 17 % of the national energy electricity consumption was used for cooling appliances in 2017, with an estimated annual increase of 10.5 % in air conditioner sales until 2030 (Ghana, 2017; Opoku et al., 2019). Beyond indirect emissions from energy consumption, roughly 25–40 % of total cooling emissions are made up of direct emissions by refrigerants in room air-conditioners (Gloel et al., 2008). Imported cooling devices to sub-Saharan Africa often have low energy efficiency ratings and usually contain refrigerants with a high global warming potential (CLASP and IGSD, 2020). Total emissions (consisting of indirect and direct emissions) from the cooling sector in Ghana were predicted to increase from 5.05 Mt CO2eq in 2015 to as high as 12.8 Mt CO2eq in 2050 (Gloel et al., 2008). With Ghana's total emissions across all sectors reaching around 60 million tonnes in 2019, the cooling sector accounts for 10–20 % of the country's overall emissions (Ghana, 2022). In addition, e-waste management in the sub-region is relatively poor, with many appliances left at unregulated dumpsites after their end-of-life.

The transition of the space cooling sector into a circular economy (CE) could break the vicious cycle if balanced policies that reduce the negative environmental impacts of cooling along the lifecycle are developed while maintaining its positive benefits. There is a clear literature gap on how to turn CE from a sweeping, system-wide concept into a feasible bottom-up approach across governance levels in the context of low- and middle-income countries. The CE concept has been criticized for its "muddle" of meanings (Kirchherr et al., 2017, S. 222; see Corvellec et al., 2022; Korhonen, Honkasalo, and Seppälä, 2018a; Korhonen, Nuur, et al., 2018b), currently giving rise to more theoretical papers (e.g. Ahmed et al., 2022; Palafox-Alcantar et al., 2022), systematic reviews (Zhang et al., 2022; Zhu et al., 2022) and reviews of reviews (Kirchherr, 2023), in the social sciences rather than empirical case studies. It has been argued that the current literature on circular economy focuses mainly on the economy, the practical and technical levels of the actual physical flows, disregarding societal structures, cultures, and underlying world-views (Corvellec et al., 2022; Korhonen, Nuur, et al., 2018b). Furthermore, socioeconomic empirical analyses of the cooling sector in the transition to a CE in low- and middle-income countries are largely missing (Khosla et al., 2021). Centering the socio-political implications and behavioural practices that incorporate the lived experiences and aspirations of the involved people can support bottom-up efforts for justice and equity in the CE discourse (see Ashton et al., 2022).

This contribution addresses these gaps by asking the research question: What is the potential of the small wins governance framework (Termeer and Metze, 2019) as a bottom-up innovation approach to understand and foster an incremental shift towards a CE in Ghana's cooling sector? The framework focuses on multiple small, concrete, completed, and in-depth steps that could accumulate into transformative change through various non-linear propelling mechanisms (Termeer and Dewulf, 2019; Weick, 1984; Weick and Quinn, 1999). Small wins are promising for a CE transition, as the framework enables continuous change through test, learn and adapt cycles and circular systemic thinking (Termeer and Metze, 2019). The concept has not been applied to the cooling sector thus far.

The novelty and contribution of our paper are three-fold: Taking the example of Ghana's cooling sector, we provide an understanding of (1) how the cooling sector works "on the ground" from a CE and low-carbon governance perspective, following the lifecycle from the import of air-conditioners to the end-of-life stage, and (2) which small wins exist and how they could be fostered. Finally, (3) we aim to conceptually and empirically complement the small-wins framework and broader CE research by adding a stronger focus on user behaviour of appliances along the lifecycle. We thus contribute to recent literature on the cooling transition and connect socio-technical systems research to circular economy debates (Sovacool et al., 2023; Bours et al., 2021; Palafox-Alcantar et al., 2022; Sovacool et al., 2021; Khosla et al., 2021). Many current CE efforts globally focus on recycling programs, product designs (e.g., efficiency standards), and extended producer responsibility. Concerning cooling appliances, sustainable consumer behaviours could immensely increase energy efficiency, reduce refrigerant leakage, and extend the average product lifetime.

The following sections discuss the small-wins governance framework in light of the literature. We then present the conceptual approach and our mixed-methods design before turning to the results of our empirical study.

2. Literature review

The small wins governance framework addresses the intersection of three – in some cases overlapping – sets of literature: sustainability transition models, innovation policy research, and social science contributions to the CE transition, namely how to implement the ladder of circularity in various socio-economic contexts. Publications from these three strands target the implementation of SDG 12 from different angles. They can be differentiated into up to 88 different theories targeting decarbonization (Sovacool et al., 2023). We can only briefly reflect on the three strands that matter most to our approach. The small-wins governance framework belongs to the tradition of sustainability tradition model research but speaks more directly to innovation policy and – as a bottom-up approach – to strategic niche management. Applying a transition to circular cooling requires a reflection of socio-economic analyses in this empirical field.

Sustainability transition models typically adopt a multi-level perspective (MLP), taking a sweeping approach to socio-technical change under SDG 12 that is comprehensive across actors and governance levels. A long-term time horizon is also inherent to these approaches, often tracing the evolution of socio-technical changes over decades. The MLP has been applied to a large number of sectors and countries, e.g., energy, mobility, housing and agro-food systems (Belaïd and Al-Sarihi, 2024; Cheng, 2023; Wu et al., 2021; Geels, 2019; Köhler et al., 2019). While the MLP has been widely adopted as a convincing conceptualization, it has been criticized for a lack of operationalization and direct usefulness for policymakers (Geels, 2019). The small-wins framework addresses this and reduces the complexity of system-wide policy challenges like CE and a low-carbon economy (Termeer and Metze, 2019). Small wins can accumulate and reduce drawbacks, paving the way for extensive transformative reforms, for example, for Finland's sustainable development policy (Salo et al., 2022). Small-wins governance decomposes these immense challenges into governable steps on purpose. The concept also more explicitly acknowledges and deals with the limited reach of state-driven policies in a mix of formal and informal governance situations (Termeer and Metze, 2019) than sweeping sustainability transition models, allowing for some flexibility on how to reach a policy goal and deeper societal change. With its acknowledgment of the limits of the state in driving transitions, the concept differs from strategic niche management and innovation policy approaches such as mission-oriented innovation.

Strategic niche management (Kemp et al., 1998) somewhat bridges the sustainability transitions and innovation policy research communities. Niches are shielded, experimental spaces where (potentially radical) technical and societal innovations emerge. They are protected from mainstream market selection by the state, which also provides a vision for change, orienting future innovations, for example, in Iran's solar PV market (Fartash and Ghorbani, 2023) or the concentrated solar power markets in South Africa and the United States (Mirzania et al., 2020). Niche innovations develop through interactions between learning processes (on various dimensions), social networks, and visions and expectations (Kemp et al., 1998). Strategic niche management also emphasizes the relevance of learning and bottom-up experimentation with actor networks. The emphasis on vision, learning and network perspectives aligns with the small-wins governance framework - such a vision, hand in hand with dynamic public policies, can contribute to a steady transformation (Urpelainen, 2013). Similar to strategic niche management, small wins incorporate the idea of continuously testing, learning, adapting, and cherishing emerging spontaneous change, which also resonates with the general conceptual idea of CE (Termeer and Dewulf, 2019). For governance, this implies creating and allowing several protected policy niches and various bottom-up strategies to accumulate to deeper change over time. Strategic niche management, however, does not have an answer for situations where niche protection or market up-scaling does not happen as expected due to overriding market distortions, limited governance reaches or consumer behaviour.

The innovation policy literature conceptualizes the emergence of technological innovations, their effect on economic development and the most suitable combination of policy instruments to foster them (Radosevic, 2012). Evolutionary innovation research is concerned with the emergence of innovations as outcomes of systemic interactions (Freeman, 1981; Lundvall, 1985). It shows how institutions and technologies co-evolve (Nelson, 1996), giving rise to technological trajectories and technological paradigms. These approaches typically highlight the importance of technological learning and market failures, rejecting simplistic notions of functioning markets with seamless technology transfer. In this tradition, scholars have increasingly focused on sustainability innovations (Chaparro-Banegas et al., 2023; Hermundsdottir and Aspelund, 2021; Altenburg and Pegels, 2012).

Sustainability innovations research can be differentiated into contributions that propagate the state's vital role, thus a top-down approach, and grassroots innovation studies that trace bottom-up processes with less public intervention. Among the first group, mission-oriented innovation scholars argue for targeted but large-scale state-driven investments in innovation, pushing for specific R&D and supporting the up-scaling of these technologies in the market (Kirchherr et al., 2023; Hekkert, 2023; Mazzucato, 2018). Sustainability-oriented innovation systems take a slightly more comprehensive view with high demands on governance (Chaparro-Banegas et al., 2023; Hermundsdottir and Aspelund, 2021; Adams et al., 2016; Altenburg and Pegels, 2012). The shift to such innovation systems requires disruptive policies integrating environmental costs and aligning national innovation systems with international policies without losing stakeholder interest and engagement (Altenburg and Pegels, 2012). Both approaches require substantial financial resources, state planning capacities and government effectiveness in local political economy set-ups. Compared to general innovation systems debates, sustainability-oriented innovation systems emphasize the state's increased role in addressing environmental externalities. However, all underemphasise and ignore the consumer side. Grassroots innovations stem from "*a network of activists and organizations generating novel bottom-up solutions for sustainable development and sustainable consumption; solutions that respond to the local situation and the interests and values of the communities involved*" (Seyfang and Longhurst, 2016, S. 585). Research on these grassroots innovations has had little impact thus far (Hossain, 2016), despite its resonance among sustainable consumer behaviour scholars and community-level initiatives (Roysen et al., 2024; Smith, 2017).

Finally, analyses of the CE transition this far tend to focus more on products, materials and general classification of transition steps in the ladder of circularity, such as the 3-Rs (reduce, reuse, recycle) rather than people and places as in SDG-oriented studies (Ortiz-de-Montellano et al., 2023). Cooling has links to all SDGs in some way, as a recent systematic review has shown (Khosla et al., 2021). Khosla et al. (2021) suggest four interventions to foster the transition: developing cooling as a service business models (SDGs 7, 8, 9, 12, 13), embedding passive, energy efficient and sustainable cooling in urban infrastructures (SDGs 3, 7, 9, 11, 13), explicitly linking cooling to climate action and refrigerant phase down (SDGs 7, 12, 13), and changing lifestyles and behaviours to increase resilience (SDGs 3, 11, 12). Specific patterns of global production networks in the cooling sector shape long-term interactions between cooling macro-drivers and the various stages of the cooling lifecycle (Palafox-Alcantar et al., 2022), reflected in these suggestions. More case studies are required on the F-gas phase-out sociopolitical processes under the Kigali Amendment to the Montreal Protocol (Sovacool et al., 2021). For the cooling transition in buildings, it has already become clear that a combination of active cooling, passive cooling and interactions with users, including addressing thermal comfort norms, are needed to achieve circularity and lower carbon footprints (Bhamare et al., 2019; Mazzone and Khosla, 2021; Palafox-Alcantar et al., 2022). So far, it is still unclear how a suitable socio-economic governance approach can meet the specific challenges of making the cooling sector circular in a non-Western country such as Ghana.

3. Research methodology

The study uses a social science mixed-method approach, including qualitative interviews, quantitative surveys and field observations. The insights gained by each method were triangulated in one interpretation phase (Creswell et al., 2008). Triangulation provides complementary information and increases overall validity; it is prevalent in qualitative social science research (Hammersley, 2008). Our methodological approach is similar to Bours et al. (2021) and Agyemang et al. (2019). The following section presents our conceptual framework with indicators for applying it to empirical data and describes our methods and analysis.

3.1. Conceptual framework

This study adopts the small-wins governance framework based on Termeer and Dewulf (2019) and Termeer and Metze (2019). The framework outlines the characteristics, indicators, and contra-indicators of small wins. Inherent in this framework are the three guiding steps 1) identifying and valuing small wins; 2) analysing whether the suitable propelling mechanisms are activated to accumulate into transformative change; and 3) feeding results back into the policy process where they, in turn, activate new small wins (Termeer and Dewulf, 2019). This paper focuses on the first step, primarily concentrating on potential future small wins, to give guidance for the second and third steps.

Small wins share five characteristics (see Table 1; adapted from Termeer and Metze, 2019).

Firstly, small wins should relate to concrete results of moderate importance. They should translate to practical actions beyond vaguely framed notions and promises. They are most likely found at a micro

Table 1
Characteristics and indicators of small wins.

Characteristic	Indicator	Contra-indicator
Concrete outcome of moderate importance	Visible results and lived experiences; intermediate results; micro or local level	Promise and ideas only; fixed best practices; large scale
Contribute to a CE Macro level	Clear context-specific narrative of current and potential contribution; partly linked indicators or the ladder of CE	No clue; small losses for many actors
In-depth changes	Second-order change; radical new practices	More of the same; quick wins; low hanging fruit
Overcome resistance and barriers	Overcome technical, financial/and or regulative barriers; faced resistance	Mentioning barriers only; (too) easily achieved
Connecting technical, societal, structural and behavioural change	Various modes of synergies	Technological innovations only; societal innovation only

Source: Authors' own adaption based on Termeer and Metze (2019).

level, where people effectively deal with uncertainties and suspense (Vermaak, 2013). Educational initiatives, that is, educating consumers, technicians or retailers on energy efficiency, are all potential small wins with concrete results. *Secondly,* a small win should have a clear and shared narrative aimed at circularity. The small win should be identifiable to contribute to a set goal or ambition, for example, reducing the amount of recovered refrigerant and e-waste or extending the lifespan of electronic appliances. *Thirdly*, small wins are in-depth and differ from quick wins or low-hanging fruits, which are simple and blatantly easy to change (Vermaak, 2013; Weick, 1984). They are more than changing interpretations and narratives that only twist the status quo. *Fourthly*, small wins should tackle and resolve barriers inherently constrained by institutionalised linear economy, upheld and protected by prevailing power structures (Fischer and Pascucci, 2017). Activities must overcome resistance, resolve tension between predominant actors, and change incentive structures. For example, negative incentives can exist for actors to keep up with current import practices of inefficient, used goods or for technicians to sell and refill new refrigerants rather than recover and recycle refrigerants. Those would need to be addressed and changed. *Finally*, yet importantly, small wins should combine and account for technical, societal and behavioural change. While new technical solutions are warranted to transition to a CE, new processes and relations must be developed (Fischer and Pascucci, 2017). Innovative new technological development can only be enabled by adaptive social practices. For example, introducing cooling devices into the market using natural refrigerants such as propane (R290) requires technicians to acquire new skills to handle these flammable refrigerants. Socio-institutional change can use and upscale existing technologies or processes, such as refrigerant recovery. New technologies can enable behavioural change (e.g., smart meters that regulate room temperatures).

Small wins and CE concepts could become a solution for the cooling appliance market, releasing the tension between environmental deprivation and economic prosperity (Geissdoerfer et al., 2017; Lieder and Rashid, 2016). After identifying opportunities for change, new practices must be implemented into prevailing systems and given value over old practices (Reay et al., 2006). In this study, we will focus on identifying opportunities for change and present for the first time how implementing a small-wins framework can give entry points to a low-carbon CE in the cooling appliance sector in Ghana.

When applying the framework to the cooling sector, we will also follow the "ladder of circularity" (Kirchherr et al., 2017; Potting et al., 2017) as a guiding principle to differentiate gradients and priority levels of circularity in the following order: refuse, reduce, reuse, repair, refurbish, remanufacture, repurpose, recycle, recover resources and goods. Reusing and repairing used ACs should be given priority over recycling. The respective priority and balancing of different policy goals (circularity/reuse vs. energy efficiency/climate mitigation) impact the ideal lifetime time for used ACs in the market (Never, 2023).

3.2. Data collection and analysis

Data was collected in Accra and Kumasi, the two major cities of Ghana, in 2020. This study was part of a larger project which determined the time of data collection. The COVID-19 pandemic and the end of the larger research project made additional data collection at a later point in time impossible. The sampled cities are the predominant economic centres for cooling appliances business operations. The majority of Ghanaian middle-class individuals live in these cities.

Twenty semi-structured expert interviews were conducted in Accra and Kumasi on the challenges in the cooling sector and how to transform the sector towards a CE. Interviewees included (see complete list of questions asked in Section S2, Supplementary Information):

- Government agencies such as the Environmental Protection Agency (EPA), the Energy Commission (EC), Ghana Revenue Authority (GRA), Ghana Standard Authority (GSA), and the Ministry of Environment, Science, Technology and Innovation (MESTI).
- Local and international civil society groups such as the Energy Foundation (EF), Caritas Ghana, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ, engl. German Agency for International Cooperation), Kreditanstalt für Wiederaufbau (KfW), and the United States Agency for International Development (USAID).
- Private sector firms and organizations, including the National Air-conditioning and Refrigeration Workshops Owners' Association (NARWOA), as well as local electronic shops and workshops
- Academic institutions such as the University of Ghana, Accra, and Kwame Nkrumah University of Science and Technology, Kumasi.

After the 20 interviews, the saturation point regarding content and experts named for further interviewing (snowballing) was reached (Mayring, 2014). Interviews were recorded or notes taken, dependent on respondents' consent. Eight interviews were recorded with the assurance of anonymity; responses were extensively documented via note-taking for the remaining interviews. Transcriptions and notes were coded using atlas.ti, employing qualitative content analysis after Mayring (2014, 2015). Through code generation, the data collection and analysis brought out four emerging themes and entry points for change: "Import Practices," "Retail and Purchase Practices," "Usage & Service Practices," and "End-of-Life Practices." These are also used to structure the rest of the paper.

Additionally, two quantitative pen-and-paper survey questionnaires were administered to gain further insights and triangulate the interviews (S3 and S4, Supplementary Information). The pen and paper survey was done to reach a larger sample and obtain more task-specific information. It enabled us to reach more reliable conclusions. One set of survey questionnaires was given to sales personnel of electronic goods in local stores in Accra and Kumasi. In total, 31 submissions of retail surveys were collected. The second survey was comprised of technicians and servicing refrigeration and air-conditioning equipment personnel in Accra and Kumasi. In total, 38 submissions of technician surveys were collected. A convenience and snowball sampling approach was adopted for the pen and paper surveys (Gile and Handcock, 2010). The data was analysed using R's statistical software (R Core Team, 2021). Visual field assessment was also carried out, including visits to the Tema port in Accra, retail stores in Accra & Kumasi, mechanical stores of cooling appliance service technicians, as well as the informal e-waste dumpsite at Agbogbloshie in Accra.

4. Results & discussion

In Ghana, four main steps along the life cycle of an AC appliance exist that impact a product's circularity and carbon creation. Small wins can be found in each step as entry points for transformation towards CE: *Import, Retail & Purchase, Usage & Servicing and End-of-life Practices*. Preceding these steps, the Ghanaian vision for the sector requires reflection.

The Ghanaian government has subscribed to a low-carbon economy vision and has engaged extensively in electronic waste governance since 2005 but has not yet developed a strong CE vision or strategy. Termeer and Metze (2019) argue that setting a provocative ambition is a prerequisite for small wins to accumulate to deeper change by giving self-organized processes motivation and direction, thus connecting their approach to mission-oriented innovation policy to some extent (Bours et al., 2021). We question whether using the same overarching CE vision for stakeholders is required as the concept is unclear to many stakeholders in Ghana under this label (Hemkhaus et al., 2020). Instead, drawing on overlapping visions (low-carbon economy) and ongoing governance efforts (sustainable e-waste governance) may be sufficient to allow for a bottom-up development of small wins. The Ghanaian government has introduced several policies and laws seeking to increase energy efficiency for cooling appliances, to phase out

Hydrochlorofluorocarbon (aka. HCFC such as R-22) and Hydrofluorocarbon (aka. HFC such as R-410A) refrigerants, and to create environmentally and socially sound waste management systems (see Suppl. Information, Table S1). The current waste management policies are part of a circular economy. Apart from import regulations for electronic appliances and e-waste (see Section 4.1; the "Reduce" in the ladder of circularity), they focus on the end-of-life stage, namely to reduce and manage e-waste ("Reduce" and "Recycle" in the 9-R ladder of circularity; Kirchherr et al., 2017). The energy-efficient cooling appliance policies were prepared to implement the Kigali amendment to the Montreal Protocol (signed in 2019). At the same time, efforts are being made to phase in so-called natural refrigerants, which are propane-based refrigerants (such as R-290). The existing standards and labelling laws regulating the production and importation of cooling appliances have been reviewed and strengthened, effective November 2023, to ensure that only environmentally friendly cooling appliances are imported into Ghana (Ghana Energy Commission, 2023). Natural refrigerants hardly negatively impact the environment but come with the downside of being flammable. Given this policy background, we now consider the four entry points for small wins.

4.1. Import practices

Import practices pose an entry point for cooling devices and present opportunities for small wins towards CE in the cooling appliance market in Ghana and sub-Saharan Africa at large, especially for achieving SDGs 7.3, 12 and 13. Ghana relies on foreign/imported air-conditioners and other cooling devices. The type of imported goods shapes the domestic market, making this a crucial step in the lifecycle. A radical, systemic shift towards importing only cooling appliances of the highest standards - in line with the low-carbon economy and CE goals - is challenging due to various current practices by stakeholders involved in the import process, as discussed below.

According to the United Nations COMTRADE database on international trade, Ghana's import of electric equipment was US$685.02 million in 2019. About 80 % of the imported goods in Ghana are handled by the Tema port (Gyebi-Donkor, 2006). At the port, every imported good has to pass through clearance procedures, where appropriate taxes are charged, and compliance with import bans and regulations is verified. The port is managed and operated by several different agencies. The Ghana Revenue Authority is the main body in charge of customs, the verification and clearance of goods. The Energy Commission and the Environmental Protection Agency are two crucial agencies for the import of cooling appliances. The Energy Commission ensures the appropriate labeling of electronics by efficiency standards and the detection and confiscation of illegal secondhand or unlabelled goods. The Environmental Protection Agency checks for environmentally hazardous materials, such as illegal refrigerants. The Ghana Revenue Authority's primary mandate is to collect import tax; the agency thus looks for insufficient declarations. The mandate of the Environmental Protection Agency and the Energy Commission is to detect illegal imports and misclassifications. The specific activities and functions of the institutions and agents involved are not always explicit, which can lead to duplication of roles and efforts and an uncertainty of responsibility.

> "It takes a lot of tact, strategy and maneuvering to be able to do the enforcement because many of the customs personnel (of the Ghana Revenue Authority) think that it is not their formal mandate, so they don't care. Originally, the Energy Commission does not have to be at the port; well, they are forced under circumstances to be there to ensure that the enforcement is actually done".
>
> (respondent 17)

At the beginning of the clearance process, importers must obtain an array of certificates, permits and licenses (e.g., Final Classification and Valuation Report, Tax Clearance Certificate, Taxpayers Identification Number, and Import Declaration Form) that must be registered. An importer's clearing agent does a self-assessment of duties and taxes involved, which poses an opportunity for insufficient declaration or misclassification. The Ghana Revenue Authority is in charge of validating the declaration and has to decide whether further examination is required. A small win was the introduction of scanners in 2011 that allowed screening containers comparable to an X-ray. A directive was given in 2018 to scan all containers that leave the port. In that way, misclassified products can more easily be detected. Goods declared or identified by scanners as electronic equipment are always subject to a physical examination. According to data from the Energy Commission, nearly 50.000 used fridges and more than 10.000 used ACs were seized between 2013 and 2020. Despite these protocols and many confiscated appliances, a large unknown number of illegal goods still manage to enter the country (respondents 8, 9, 16, 17).

The Ghana Revenue Authority customs officers are usually the first in line at the port to examine imported containers, followed by the Environmental Protection Agency and Energy Commission, in line with Ghana's waste management policies, such as the Hazardous and Electronic Waste Control and Management Act (ACT, 917 see Table S1 for further relevant policies, Supplementary Information). Both rely on the Ghana Revenue Authority for notifications. Every institution examines each container separately, which can lead to undue delay in the clearance process. While this is a crucial component in the goods clearance process, it is an arduous and time-consuming task that takes between 2 and 4 h from unpacking to the actual inspection and at times, wares can be put entirely on hold (respondent 11). In some instances, the Energy Commission is notified about a suspicious container. However, upon the arrival of their staff, the container was found to have already been cleared by the Ghana Revenue Authority (respondent 16). Not rarely there is tension between the Energy Commission and Ghana Revenue Authority (respondent 9). Thorough checks take time and can lead to frustration and additional tension with importers, who are often on tight schedules.

> "It is dangerous for the staff when they confiscate goods. I have escaped lynching on three occasions (…). The importers were not happy."
>
> (respondent 15)

Imports by diplomatic missions and other specified government agencies, privileged persons, and organizations/institutions are exempted from physical examination, and these could be possible pathways for abuse. Furthermore, importers could potentially try to misclassify a container to avoid an examination. Illegal products are often well hidden within containers or other items and rarely carry fake labels or packaging (e.g., old refrigerators in new boxes, respondents 8, 9, 16, 17). Due to congestion and time constraints, the products cannot always be unboxed and checked in detail.

Another challenge is the lack of space to store confiscated goods. Even though the Energy Commission is responsible for handling the final destruction of second hand electronics (e.g., refrigerators and ACs), goods are stored in warehouses under the jurisdiction of the Ghana Revenue Authority. Cases were reported where confiscated goods that contain valuable fractions (e.g., compressors) disappear overnight from the warehouse, while fractions that are costly to recycle are left behind (respondents 9 and 15). In some instances, confiscated goods pile up at the port, putting much pressure on the responsible agency (respondent 17). It could be a disincentive for the agency to confiscate too many illegal goods.

Although many regulations and legislations relating to the import of cooling appliances exist, their implementation is insufficient, with many loopholes for illegal practices. Waste management and circular economy are de facto already connected in these policies with the aim of reducing the entry of inefficient devices and e-waste into the country (9-R ladder of circularity). However, the contribution to a CE is still limited at this point. Even though the legal basis for banning the import of second hand cooling appliances has existed since 2008 (with the LI 1932 EE regulation, see Table S1 for further relevant policies, Supplementary Information), the current practices only entail confiscating illegally imported goods, but offenders are not legally prosecuted. The outlined ongoing practices, therefore, hamper a widespread, transformative change. Small wins that can help to address some of these issues related to imports are highlighted in Table 2. A first action for small wins would be creating clear task descriptions and dialogues between agencies to reduce tensions and increase efficient collaborations. Changed incentive structures for port personnel from all agencies could increase the effectiveness of bans. Stricter enforcement seems possible by implementing stronger jurisdictional procedures, supported by capacity building of import staff on anti-corruption and safe conflict management.

Table 2
Small wins in the domain of import practices.

Challenge	Action for small wins	Small win characteristic
Overlap of responsibilities and duplication of roles and efforts between agencies	Improve coordination between agencies with clear task description	Connecting technical, societal, structural and behavioural change
Incentive structures	Change of incentive structures to support stricter enforcement (e.g., awards for officers who detect illegal goods, preferential access of importers with good track records)	Overcome resistance and barriers
Corruption and favouritism by involved personnel	Anonymous and confidential procedure to report misconduct to higher authorities	In-depth change, Overcome resistance and barriers
Infrastructural shortfalls and procedural challenges	Additional warehouse for confiscated secondhand electronics under the jurisdiction of the Energy Commission	Concrete outcome of moderate importance
Illegal practices outweigh the risks and costs	Increasing funding is necessary for the Energy Commission to confiscate goods and identify offenders. Followed by jurisdictional law enforcement and investigations against large scale illegal importers	Overcome resistance and barriers
Political interferences with official regulations or approved practices	Increase political neutrality by strengthening discourse on core values (integrity, non-interference once government actions are institutionally approved, role model function for society)	Overcome resistance and barriers
Outflow from richer countries	Increasing international pressure on exporting countries to create legal circular paths for used electronics and e-waste, set up backtracking systems of secondhand goods to the point of export, and blacklist specific importers. First, small wins at the international level have been reached due to Ghana's pressure on behalf of Africa in the Montreal Protocol Kigali Amendment negotiations: 1. Decision XXXIV/4: Illegal import of certain refrigeration, air-conditioning and heat pump products and equipment. 2. Draft Decision XXXV/[–]: The import and export of prohibited cooling equipment.	In-depth changes, Contribute to a CE at macro level

> "It has to come from both ends - there also needs to be more efforts to reduce further waste and second hand devices being sent to Ghana. The rest of the world needs to learn that Africa is not their dumping ground (…). Ghana has done a lot compared to other West African countries. But have the rich countries done enough?"
>
> (respondent 9)

Responsibility for the import of illegal goods also lies with exporting countries. Coordination between several countries in sub-Saharan Africa could help to put pressure on North America and Europe to stop the flow of second hand goods, where it embarks. In addition to valuable small wins in Ghana's import sub-sector, a more explicit legal basis for import bans and controls could benefit numerous Sub-Saharan African countries. Amechi and Oni (2019) have criticized the ineffectiveness of the e-waste import ban in Nigeria, including transboundary bans, arguing for a more nuanced socio-economic approach to the issue. A combination of various small wins and a clear regulatory base could be helpful. Table 2 summarizes the results for import practices as they relate to the dimensions of the small wins concept.

4.2. *Retail and purchase practices*

The demand side is essential in transforming a linear economy into a circular one, linking sustainable production and consumption (SDG 12). The production of local cooling appliances and stricter import regulations to allow only the import of devices with the highest available energy efficiency is unrealistic at this stage. A gradual shift in retail and consumer choice may have a higher chance of success. Retail and purchase practices, therefore, pose another entry point for small wins. It is essential to consider barriers in sale practices, motives for consumers to purchase environmentally friendly cooling appliances and potential value chain effects of a pro-environmental shift in the cooling market.

In Ghana, energy consumption and ownership of an AC are closely linked to a household's income (Never et al., 2022; Senadza et al., 2020). Motivations to purchase an AC are more common among middle- and upper-class households. Less than 10 % of lower middle-class households, compared to more than 70 % of upper-middle-class households, own an AC (Senadza et al., 2020).

> "99% of households in Ghana by now have lights, nearly 90% have a fridge, less than 5% have an AC. Yet if owned, an AC consumes about half of a households' electricity. This is madness!"
>
> (respondent 19)

Consumers are gradually getting used to and demanding more space cooling. For most consumers, energy efficiency is subordinate to other attributes when buying cooling appliances (respondent 7). It is essential for retailers to promote and for consumers to purchase products that create little to no emissions during their lifetime. For ACs, this refers to devices that produce low indirect emissions from energy consumption and low direct emissions through refrigerant usage. The availability of affordable green devices with natural refrigerants, such as R290, poses a small win. As of now, not many R290 devices exist in the market. Those that may be available are not the most energy-efficient. A device that fulfills both sustainability goals is currently unavailable in the market. It would come at a high price that not many Ghanians could afford and is therefore economically of interest to producers and importers.

If households can afford an AC, financial constraints are still a decisive factor, impeding households from investing in higher energy-efficient devices (respondent 8). In the public sector, procurement regulations that motivate the purchase of equipment with the least cost also impede higher-efficiency cooling appliances. According to retailers, most customers buy ACs with the lowest energy efficiency rating (1-star rating). Based on our paper & pen survey, an efficient AC costs a minimum of GHS 2200 (≈320€), whereas a conventional AC costs around 1400 GHS (≈200€) for 12,000–14,000 BTU/h capacity AC. It is estimated that there is a yearly price increase of about 7 % for ACs. The additional investments needed for higher energy-efficient ACs are a considerable margin for many consumers (respondent 11). Most consumers are unaware of the environmental impact of refrigerants and the difference between them (respondents 7 & 11). Often, consumers choose an overpowered AC that is inefficiently cooling the area (respondent 15).

Even though sensitivity to the energy efficiency of electronic devices is still low among Ghanaian consumers, it is slowly rising for those who can afford it. It is expected to increase dramatically in the next ten years (respondents 2 &11). The needs and beliefs of consumers start to play a role in purchase decisions of efficient devices, in addition to finances and availability. Cooling is considered a driver of modernity and comfortable lifestyles and is linked with upward mobility and status presentation (respondent 7). Psychological factors such as status and social norms play an important role and are essential in purchasing decisions. A recent study finds that the preference of the Ghanaian consumer for energy-efficient ACs can be enhanced by highlighting the social benefit of sustainable consumption (Kuhn et al., 2022). Adapting narratives of policy and marketing campaigns to reasons that are predominant in a country context, such as appealing to people's aspirations and values, can encourage energy-efficient choices.

> "For the climate-friendly technologies, many would purchase them if it highlights their status in life, but not necessarily because they care for the environment"
>
> (respondent 7)

Promoting energy efficiency is challenging for retailers and public stakeholders, making achieving SDG 7.3 difficult. Awareness and informational campaigns have tried to promote energy efficiency and educate consumers on its environmental relevance and individual financial benefits with mixed results. Unawareness of the relevance and benefits of energy efficiency is still common. More effort should be made by local policy and marketing as well as international initiatives.

From a value chain perspective, energy-efficient ACs and ACs with environmentally friendly refrigerants such as R290 add value to the product, increasing sales prices. Sales volumes may be lower initially, with potential negative effects on retailers. This could be countered by two strategies: First, adding quality guarantees with free servicing and maintenance for a limited time, followed by maintenance contracts (consumer incentive and potential positive value chain effect on technician employment). Second, public subsidies or green credit schemes that retailers could advertise jointly with banks or public agencies, lowering purchase barriers and positively creating market demand, which, in turn will enable economies of scale for manufacturers and retailers at a later point in time. Engaging stakeholders pro-actively in the design and decision-making process for such support schemes would be key to increase acceptance and to create the ground for small wins in the market transition.

It is a small win to increase consumer awareness about the environmental impact of cooling and to foster a critical reflection on the need to cool. Through movies and advertisements, cooling is often portrayed as a status symbol. It would be a small win to counter this narrative to foster a reflective consideration of the need for cooling. The counter-narrative should portray behaving environmentally friendly and purchasing energy-efficient products as a status symbol.

Other cooling appliances, such as refrigerators or deep freezers, are commonly sold as used products on the street. Based on field observations by the authors and respondents, this seems less common for ACs. To some extent, this is due to the minimal price difference between secondhand ACs and new ACs (respondent 9). High installation and maintenance costs of used ACs are the main reason for the small margin between new and used devices. Repairs on ACs usually tend to be more difficult and expensive than for other white goods (e.g., refrigerators or washing machines). Consumers are aware of the technological sensitivity of ACs and are therefore more sceptical of used ACs compared to plug-in electronic devices such as refrigerators.

> "Nobody trusts used ACs that are sold on the street. The dust is everywhere, and when they break down completely, you cannot get your money back. Then, even if they would be half the price of a new one, you still lost a lot."
>
> (respondent 6)

There is the fear that used ACs are unhealthy and could carry bacteria (respondent 12). Mainly, due to the fear of disease during a pandemic, people are suspicious of buying used ACs. It is, however, common for used devices to be directly passed on to family and friends (respondent 7). A small win would be to guarantee that devices are passed on in a manner that is well serviced, cleaned and checked that no refrigerant leaks once devices change owners. It is also where consumer awareness is decisive (see for further elaboration Section 4.3).

In summary, as far as retail and purchasing practices are concerned, the two main barriers are the high upfront capital costs of higher energy-efficient cooling devices and the unwillingness of customers to pay for cleaner refrigerants. These are similar to barriers identified for other energy-efficient appliances (Agyarko et al., 2020). Overcoming these barriers could be a small win, reducing indirect and direct emissions and having an in-depth change for a low carbon CE. In 2014, a feasibility analysis by Serengeti Capital and Atlantic International determined that establishing a refrigerator assembly plant in Ghana could be both technically and financially viable (Agyarko et al., 2021; Owusu-Achaw, 2015). Increasing the demand for devices with hydrocarbon refrigerants such as R290 would promote technical, societal, and behavioural change for clean cooling. Ways that make it easier and, more attractive for customers to buy the right products would be a small-win. Financing options that allow for payment by installment could help consumers afford expensive energy-efficient devices. Even though the Ghanaian banking sector is not as experienced with small individual loans, it should be encouraged and supported to do so. Small wins related to end-of-life practices are outlined in Table 3.

4.3. Usage & service practices

Integrating users' behaviours in a CE is also crucial (Wastling et al., 2018) for achieving SDGs 3, 12 and 13. Repairing, refurbishing, and repurposing are tied to the consumer and technical experts such as AC technicians. Proper recycling also starts with the consumer, hand in hand with technicians. Beyond purchasing decisions, the usage and maintenance through servicing of devices determines the emissions produced through cooling. Many users tend to leave their ACs turned ON when absent or leave windows or doors open to allow cooled air to escape. Shallow temperature settings have become the norm in public buildings, needlessly exhausting energy resources (respondents 17 & 18).

Environmental considerations play a small role in usage behaviours of cooling appliances, as the vast majority of interviews unveiled (respondents 7, 11, 14 & 17). Most consumers are unaware of the efficacy of their usage behaviours on the environment. Even though the causal impact of AC usage on a building's energy consumption is known to most consumers, the effect of direct and indirect emissions on global warming is rarely apparent. Inefficient usage behaviours seem to be particularly common for public spaces or work environments, where the individual benefiting from cooling is not the one who is paying for it (respondent 17). Therefore, it is essential to consider usage & service practices to overcome such split-incentive problems and to identify small wins to support a transformation to a CE.

The strive for foreign norms and consumption patterns is seen as

Table 3
Small wins in the domain of purchase and retail practices.

Challenge	Potential small win	Small win characteristic
High upfront capital costs of energy-efficient devices	New financial mechanisms such as loans or cooling as a service	Overcome resistance and barriers
Uncertain energy cost savings weaken the appeal of customers to invest in efficient ACs	Awareness raising and pilot demonstrations of the benefits of clean cooling	Overcome resistance and barriers
The unwillingness of customers to pay for cleaner refrigerants	Awareness raising in combination with new financial mechanisms	Overcome resistance and barriers
Brand dominating purchasing decisions by customers	Awareness raising about energy efficiency, Empowering technicians to educate consumers through capacity building	Overcome resistance and barriers
Cooling as a status symbol and means of comfort	Propagation of an alternative narrative that fosters a reflective consideration of cooling needs	In depth-change
Low supply and market share of devices with low global warming potential, such as hydrocarbon refrigerants	Introduction of a supply chain and showcases of devices with low global warming potential refrigerants such as R290 devices, public procurement of R290 ACs to jump-start the market	Concrete outcome of moderate importance
High supply and market share of devices with low energy efficiency standards	Introduction of stricter minimum energy efficiency performance standards of cooling appliances in the public sector, Effort to support local production of cooling devices in West Africa	Contribute to a CE Macro level

problematic on several levels (respondents 9 & 16). Extremely cool environments are becoming a prestigious signal to others, indicating one's status. At the same time, current hospitality norms common in many Ghanaian households demand generosity and caring for the comfort of visitors – this drives energy-intensive cooling behaviours as ACs are turned on for the visitor's benefit. Traditional practices, such as looser and lighter garments aligned with the local climate, are becoming unpopular.

> "You see, isn't it funny that you live in this tropical world, and you go to the office in a three-piece suit, and then you run two or three ACs with the temperature setting at 16 °C. So you create Europe in your office, and then you wear a jacket. Why not wear the kind of dress that is supported by our climate?"
>
> (respondent 16)

Beyond usage behaviours, regular servicing practices can reduce the energy consumption of an AC and prolong its lifetime. The pen and paper survey indicates that most servicing routines incorporate cleaning the inside and outside units of dust and debris, checking for refrigerant leakage and refilling refrigerants, and checking the wiring and functioning of the compressor. A cooling device with too little refrigerant or clogged filters consumes extra energy in the magnitude of an additional 10–15 %. Technicians and retailers recommend quarterly servicing. A highly efficient four-star labeled device that has not been serviced for more than a year consumes as much energy as a standard one-star device that is regularly serviced (respondent 1). Devices not regularly serviced tend to break down faster and are more resource-intensive to fix. In that sense, regular servicing practices can become more important than the actual purchasing decision.

Consumers, however, are not well educated on the servicing issues; ACs can run inefficiently over years without being serviced (respondent 14). Furthermore, consumers often hire the cheapest servicing technician, struggling to differentiate between qualified and unskilled maintenance personnel. Prices for small maintenance works can start at 50GHS (~7€) and go up to 200GHS (~30€). On average, technicians charge 100GHS (~14€) for a basic service that usually includes cleaning of filters and leakage checks. Prices for more extensive repair work can be more costly and depend on replacement parts and refilled refrigerant prices. Our survey identified the most common causes for malfunctioning of ACs as faulty compressors and dirty filters, followed by sensor problems and refrigerant leakage. Users usually only contact technicians for servicing when devices malfunction (respondent 6 and pen & paper survey).

A small win to prolong the lifetime and increase the energy efficiency of devices would be to support consumers and technicians in conducting regular services. For example, implementing regular servicing contracts could profoundly impact the life cycle of devices. These contracts could entail quarterly services by technicians and could be tied to the warranty included in purchasing a new device. Here, enabling a trial-and-error approach for the most successful business model to allow for a market-driven, bottom-up approach via technician associations and retailers rather than governmental legislation may be helpful. These small wins would involve targeted stakeholder engagement, which could be organized via stakeholder engagement workshops, public consultations or participatory visioning workshops. These tools have been used in the past by civil society organizations and development cooperation agencies in other policy fields, e.g., the German development cooperation agency GIZ's multi-stakeholder approach to e-waste management.

Handling refrigerants presents another challenge for both a CE and a low-carbon economy policy goal. Leakages of refrigerants are often difficult to detect and repair (respondent 3). Additionally, refrigerants can leak during repair works or when being de-installed (respondent 13). Technicians often lack the equipment and tools to capture and store the refrigerant, forcing them to vent the environmentally damaging refrigerant into the atmosphere (respondents 7 & 14).

> "Nobody wants to change the process of how to deal with the gas of ACs that are being replaced or taken down. Everyone knows that the gas should be taken out, but nobody knows what to really do with the gas."
>
> (respondent 11)

Due to the profit made with the sale of refrigerants, an incentive exists for technicians to top-up refrigerants. For users, it is difficult to verify the necessity for a top-up (respondent 14). Experts report that it is likely that technicians sometimes refill refrigerant even though it would not be required (respondent 15).

Further challenges regarding service practices exist. Training and skills vary between technicians (respondents 11 & 12). Interviewees report that some technicians can only install, uninstall and clean devices and top up refrigerant; however, minor repair works already pose a challenge (respondents 14 & 6). Handling the different devices with varying refrigerants requires different tools and skills. The environmentally friendly but highly flammable R290 refrigerant - still relatively uncommon and unknown - especially requires specific treatment and handling by technicians. Many stakeholders fear that accidents could become frequent (respondents 12, 13 & 14). Manufacturers and retailers are afraid to be blamed if accidents occur (respondent 1). Sentence code of conduct (see clean manuscript).

Table 4 presents suggested small wins in usage and service practices. The transformation to a CE requires behavioural, societal and technical changes in the usage and servicing domain. Consumers' behaviours can play an essential part in overcoming resistance and barriers. It would be a small win to change existing norms, e.g., too-cold temperature settings, and increase awareness about the efficacy of cooling behaviours on the environment. These measures have been proposed in another study on the cooling sector (Khosla et al., 2022). They could also be transferred to other Sub-Saharan African countries. The amplification

Table 4
Small wins in the domain of usage & service practices.

Challenge	Potential small win	Small win characteristic
Freezing temperature settings as a status symbol	Promotion of sustainable lifestyles by changing default temperatures on ACs and raising awareness/educating consumers, including children, about sustainable behaviours at home	Overcome resistance and barriers
Low environmental awareness and efficacy beliefs of cooling behaviour	Awareness raising with users about the environmental impact of AC usage and the necessity of regular maintenance	Connecting technical, societal, structural and behavioural change
In-efficient building and Neighbourhood architecture	Installation of passive cooling systems, green spaces, better thermal isolation and natural ventilation	In-depth change
Poorly trained and equipped technicians to handle environmentally friendly ACs	Fostering capacity building together with financial support for technicians to acquire equipment to handle clean cooling devices containing natural refrigerants	Connecting technical, societal, structural and behavioural change, Contribute to a CE at macro level
Servicing and maintenance of cooling equipment often does not occur regularly, leading to sub-optimal performance	Servicing contracts between AC owners and technicians would guarantee routine checks and maintenance, which could ensure that devices operate optimally	In-depth change; Contribute to a CE at macro level

and integration of small-win user behaviour in buildings with the more large-scale construction industry and architectural changes will likely lead to transformative change. Combining several passive cooling techniques adapted to the local context is most promising (Bhamare et al., 2019; Ponmurugan et al., 2021). Additionally, servicing cooling systems is crucial to reducing direct and indirect emissions and requires well-trained and equipped technicians. Financial schemes and capacity buildings could support the professionalization of technicians.

4.4. End-of-life practices

The end-of-life treatment of devices primarily differentiates a linear economy from a circular one. An in-depth transformation of the e-waste management practices for cooling devices with the support of the small-wins framework is warranted. Over the last decade, there have been significant efforts to improve e-waste management in Ghana through the formulation of several laws and regulations (see Table S1, Supplementary Information) as well as by donor interventions and plans by the private sector to construct a professional e-waste plant (Akon-Yamga et al., 2021). At the end of the life of a device, waste management and circular economy are strongly linked, even if circular practices are not explicitly mentioned in Ghana's waste management policies for the end-of –life stage yet. Small wins could have been expected to manifest. However, besides intermittent reductions in toxic open fires, not much has changed over the last few years (respondent 20). Currently, there are no persistent improvements, and it seems as if the situation has deteriorated.

Ghana is one of the world's top five secondhand electronics and e-waste importers (Sovacool, 2019). A big chunk of e-waste comes from products close to malfunctioning and at the end of their lifespan. Most e-waste from ACs is generated from public and commercial buildings, but the share of domestically generated e-waste from cooling appliances is growing.

> "I think every [middle class and high income] home has at least one old refrigerator and old deep freezer not in use additional to the ones in use. Multiply that by the number of houses in the country. It tells you a lot about how big the problem is"
>
> (respondent 17)

About 95 % of domestically created e-waste in Accra is handled by the informal e-waste sector (Sovacool, 2019). It has been estimated that about 6300 to 9600 people directly generate income from e-waste in Accra, with a further 121,000 to 201,600 people indirectly depending on it (Prakash et al., 2010). It has been argued that beyond basic income for the poorest populations in Ghana, e-waste provides further societal benefits, such as being a safe space for minorities and a place to learn and acquire skills (see for an overview Sovacool, 2019). From a purely economic perspective, the ongoing informal e-waste reuse and recycling could be a type of CE, as hardly any resources go to waste entirely.

E-waste, however, has adverse environmental and health consequences. Most informal e-waste recyclers follow crude and rudimentary approaches such as open burning of cables and unsound dismantling to recover the valuable materials, also called positive fractions, such as gold, silver, copper, iron, and aluminum, as well as certain plastics (Bucher et al., 2016). Non-valuable and polluting materials, called negative fractions, are disregarded and externalized on the environment and human health (Bucher et al., 2016; Owusu-Sekyere et al., 2022). The people living and working near e-waste scrapyards are constantly exposed to hazardous substances. Inhalation of fumes and transfer of toxins into water and food are common. Health checks with e-waste workers in Ghana show heavy metal traces in blood, urine, and hair (Amankwaa et al., 2017; Feldt et al., 2014). These toxins can cause irritation and permanent eye and skin injury, damage the nervous system, cause blood and brain disorders, and affect fertility (Burns et al., 2019; Kyere et al., 2018; Li and Achal, 2020).

It is incredibly challenging to improve the health conditions in the informal e-waste sector and to set up an economically, socially, and environmentally sustainable system (respondent 20). Environmentally sound but economically viable business models rely on the profits made with positive fractions to account for the costs of negative fractions. By disregarding negative fractions, informal recyclers have an economic advantage over formal recycling firms. An equally diverse array of recycling procedures is necessary for an environmentally sound handling of the vast array of waste components. Each procedure requires a profound knowledge of materials, experience with the local context (e.g., informal market prices), and specific infrastructure and equipment. For example, with the support of the German government, a system to recycle electronic cables was tested, which involved the construction of a trading centre, training of recyclers and collectors and coordination between several stakeholders (Manhart et al., 2020). Collecting cables and installing a machine that strips them of their plastic mantle to obtain valuable copper led to a reduction of hazardous open fires. This practice allowed a higher yield of copper and generated additional revenues from the collected plastics. The centre could be evaluated as a small win, testing innovative solutions by trial and error that can have an in-depth change in technical, societal, structural and behavioural practices. As of now, however, the progress of the centre is uncertain. Also, one system that works for one waste component, such as cables, might be entirely different for another (respondent 14).

The sound recycling of refrigerants is challenging since several costly and arduous steps are necessary (respondents 1 & 14). Firstly, refrigerants need to be recovered from devices; secondly, they need to be transported and stored without leakage; and finally, which is the most challenging, the gases need to be recycled or destroyed. A solution to destroy refrigerants for West African countries would be a tremendous win with in-depth changes, contributing to CE at the macro level with an outcome of high importance. However, the costs of constructing a destruction facility and the financial viability of a procedure present a major barrier. From a cost perspective, converting cement kilns is considered one of the best solutions for developing countries to destroy refrigerants. However, the conversion comes with technological problems that negatively affect the quality of the cement (Heubers et al., 2015). The availability of cement kilns is a precondition that Ghana does not fulfill. For Ghana, other local destruction facilities are either financially not viable or proper operation seems uncertain and risky (UNEP, 2019). Currently, the only realistic option is to export refrigerants to countries with persisting facilities, such as Japan, several EU countries and the US. The Multilateral Fund for the Implementation of the Montreal Protocol provided funding for demonstration projects, including Ghana, where Hydrochlorofluorocarbon was collected and sold via carbon credits to be destroyed abroad (UNEP, 2015). However, the trial was not extended, and continuing without external support does not seem financially viable. Ghana has no structure or procedure to destroy Hydrochlorofluorocarbon and Hydrofluorocarbon refrigerants (respondents 17 & 20).

One of the largest scrapyards, Agbogbloshie, used to be located centrally in Accra. On July 1, 2021 (shortly after the data collection for this paper), the Ghanaian Government cleared the area with bulldozers and armed military. At the time of writing, the informal e-waste sector had decentralized, and various scrap dealers could be observed moving e-waste around Accra but to locations unknown to the government. It is challenging for government agencies to reach this reforming, decentralized scene. Stakeholder engagement has become challenging. It is unlikely that informal practices will stop but instead continue to re-form somewhere else in a decentralized manner, bringing the hazardous recycling practices much closer to people's homes. Without a clear plan, this might exacerbate environmental pollution. To our knowledge, there are currently no plans for the remediation of the contaminated area nor a proposition for a positive perspective of the struggling poor. It is now even more challenging to document health and environmental hazards, understand new emerging informal structures and support a positive change in the sector. The new development, if matured, could become more harmful to the environment and the people than when Agbogbloshie existed as a central location. Further, no formal recycling plant and process is currently in place to compete with informal operations. There have been plans and talks about constructing a large recycling plant for years, but no visible steps have been undertaken (respondent 19). This large change is in contrast to a small-wins approach. Overall, the situation relating to end-of-life practices seems to have deteriorated.

Table 5 summarizes suggested small wins in the domain of end-of-life practices. An infrastructure to collect and store refrigerants in large quantities could support a CE by minimizing waste and avoiding environmental hazards. It would require additional incentives to motivate technicians and recyclers to collect refrigerants. In the long run, a destruction facility in sub-Saharan Africa is paramount to close resource loops. This facility could also help create a business case for technicians and recyclers, incentivizing them by creating additional value along the cooling value chain. Thus, we somewhat oppose the small wins governance literature, arguing for targeted large investments in some areas to enable a positive dynamic. In contrast to the literature on waste management and CE in other sectors, e.g., plastics (Pegels et al., 2022), recycling is not a comparatively easy step to circular cooling.

Table 5
Small wins in the domain of end-of-life-practices.

Challenge	Potential small win	Small-win characteristic
Lack of infrastructure to collect refrigerants	Collection centres where refrigerants can be stored in large quantities	Contribute to a CE at macro level
Technicians lack the skills and necessary equipment to recover refrigerants	Capacity building and resourcing service technicians with the right tools for refrigerant recovery.	Connecting technical, societal, structural and behavioural change
Mainly informal work environment	Capacity building and support to fund legal businesses	Connecting technical, societal, structural and behavioural change
Competition for positive fractions, disregarding negative fractions	Financial schemes such as carbon credits incentivize the collection of negative fractions from cooling devices.	Overcome resistance and barriers
Fear among stakeholders that regulations like the Electric and Electronic Waste Act (Act 917) will actually increase the amount of hazardous waste from abroad	A review of the Act to allay fears of dumping of hazardous waste.	Overcome resistance and barriers
No solution to destruct refrigerants	Cooperation with other countries to construct a destruction facility in sub-Saharan Africa and/or install financially viable procedures to export refrigerants to countries that have destruction facilities (e.g., Japan, US & EU)	In-depth change, contribute to CE at macro level

4.5. Comparison with the literature and limitations of the study

Our findings both confirm and contradict aspects of previous small-wins applications (Bours et al., 2021; Termeer and Dewulf, 2019), sustainability transition models (Belaïd and Al-Sarihi, 2024; Geels, 2019) and sustainability-oriented innovation systems (Chaparro-Banegas et al., 2023). Regarding a vision as a critical factor for sustainability transition models and phase-in processes of clean technologies (Kemp and Never, 2017), we find that CE as a vision is not helpful for Ghanaian stakeholders in the cooling value chain at this point. Implementing the Kigali Amendment is a better candidate for early signaling required changes to stakeholders, as it has more explicit goals with limited scope. Thus, no vision qualifies – the conceptual clarity and grasp of actors and stakeholders along the lifecycle matters for this signaling to work.

Reviewing the role of the state in our results, the majority of the small wins do not require a vital role of the state to be initiated, except for the import of cooling devices and end-of life stage. Stakeholder engagement and value-added along the value chain may be sufficient in areas of limited governance reach in Ghana. This differs from the view of innovation policy scholars and even strategic niche management theory to some extent (e.g., Mazzucato, 2018; Kemp et al., 1998; see Section 2). Since cooling devices are not manufactured in Ghana, the adoption of R290 ACs as innovative technology requires less of a systemic shift in the local innovation system towards sustainability (Hermundsdottir and Aspelund, 2021; Altenburg and Pegels, 2012) but rather a combination of capacity building among technicians, awareness raising and financial market support. Pushing producers (possibly in a West African concreted regulatory approach) could influence the pricing and marketing of centralised manufacturing in the hands of a few producers (Palafox-Alcantar et al., 2022). Unfortunately, we could not analyse and therefore conclude the distribution of power in the global production networks and their impacts on prices and retailers in Ghana in this study,

In line with the literature, small wins such as behaviour changes in Ghana's cooling sector are indeed not perceived as threatening to stakeholders as more sweeping, top-down measures, as Termeer and Dewulf (2019) argue and others have proposed for cooling (Khosla et al., 2022). To advance cooling, a combination of small wins and a few targeted investments, i.e., "big wins," like a recycling plant for refrigerants in West Africa that creates a business case for technicians, is beneficial. In this sense, supporting small wins in the cooling transition alongside large infrastructure investments implies a mixed governance approach.

In contrast to Bours et al. (2021), we did not analyse systematic propelling mechanisms for small wins. However, we focused on the first step, i.e., identifying current and prospective small wins, barriers and how to overcome them. Our findings corroborate theirs on the relevance of organizational and knowledge barriers, especially when it comes to collaboration among institutional actors and along the cooling market's value chain.

Our analysis shows that an empirical application of the small-wins framework is challenging in matching broad conceptual categories and contributing to a macro-level CE in order to very specific problems (e.g., consumers following societal norms and financial limitations in their decisions). Overall, we find that the cooling sector in Ghana is still more linear than it is circular. Recently, other authors have started to question the conception of CE, which has become widely popular among policymakers and businesses. We follow the call for more nuanced and comprehensive approaches to circular practices beyond technical levels of physical material flows (Corvellec et al., 2022; Korhonen, Honkasalo, and Seppälä, 2018a; Korhonen, Nuur, et al., 2018b). While the paper tries to respond to the critique of CE by examining political, societal, and cultural structures, it echoes part of the critique, highlighting the various limitations and challenges that prevail.

Our study has some limitations that apply to all sections of the results discussed here. A challenge that is closely linked and was not the focus of this study was balancing social and environmental goals. Environmental goals such as a quick phase-out of used air conditioners or inefficient devices may harm employment in repair and maintenance services. Further research should look at potential trade-offs and benefits of a CE transition of electronic devices. Methodologically, an alternative approach would have been to dive deeper into one or two identified subsectors and organize focus groups to discuss each small-win and further solutions, prioritizing action-type research. We opted for an analysis of the whole lifecycle instead. Despite our mixed methods approach, the limitations of qualitative case studies regarding context-dependence vs generalizability of results still apply to some extent.

5. Conclusion

This paper applied the small-wins governance framework to the cooling sector in Ghana. Despite a broad policy vision to develop a low-carbon and CE, a quick, radical shift of the complete governance system surrounding the lifecycle of a cooling appliance in Ghana is unlikely. Instead, a series of small wins encouraged by specific stakeholders and supported by learning mechanisms allowing trial and error could provide an alternative pathway to achieve SDG 12 on Responsible Production and Consumption in the cooling sector. Particularly achieving target 12.2 on Sustainable Use and Management of Natural Resources, 12.4 Responsible Management of Chemical Resources and Waste, and target 12.9 Supporting Developing Countries' Scientific and Technical Capacity for Sustainable Consumption and Production could be supported by this approach. Identifying, acknowledging, and encouraging small wins at the stages of import, sales, usage of devices, and end-of-life could accumulate to an acceptable, realistic transition towards a CE over time.

In each stage of the cooling appliance lifecycle, this contribution identified future small wins, each requiring a different actor combination to encourage deeper mechanisms to foster change. Despite long-standing efforts to change the electronic waste and end-of-life sector, deeper change processes accumulating from small wins are uncertain now due to the unclear situation following the enforced clearing of the Agbobloshie e-waste area. Several advances in creating policy frameworks and the legal base for achieving energy efficiency, a low-carbon economy, and implementing the Kigali amendment to the Montreal Protocol have been made or are in progress. Still, we find that a clear legal basis and necessary infrastructure are required for some areas in the cooling sector, especially regarding import bans and recycling plants, thus opposing the view in the literature that complete, small-wins based bottom-up governance is feasible by itself to achieve CE and low-carbon economy goals. One decisive but urgent win that could be considered a large win would be a solution for the destruction of refrigerants in West Africa. Trial-and-error of small wins and feedback loops to policy and private initiatives are likely to be more successful once the enabling conditions are set by infrastructure and legal frameworks to counter some high-risk or illegal practices that are prevalent on the ground.

The broader methodological and managerial implications of our findings concern the importance of balancing between a) an overarching policy goal and feasible, incremental small changes for various stakeholders, also within value chains (this involves trusting that small wins can add up), and b) a stronger focus on bottom-up initiatives while giving enough regulatory guidance, enforcement and space for adjustments over time. Adding c) a behavioural, user-oriented perspective and corresponding evaluation methods is likely beneficial to managers of a cooling transition. Finally, in the multi-level approach to capacity building of international development cooperation, our results imply that focusing more on the micro level to push for a cooling transition in combination with securing multilateral funds for refrigerant recycling plants could prove particularly useful.

We complemented the small-wins framework with a behavioural perspective, showing that stakeholder habits and behavioural biases can impede the accumulation of small wins into long-lasting change. It is questionable whether a CE of the cooling sector in Ghana is feasible and realistic in the way the concept is currently conceived. Still, we carve out how small wins can bring about positive changes that are less harmful to the environment and promote social equity, justice and health benefits for the involved people and, more generally, for society. Finally, we want to emphasize the need to rethink the current economic system.

Acknowledgements

This study was funded by the German Federal Ministry of Education and Research, Grant number 01LN1706A.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.spc.2024.02.016.

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