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Local Capacity for Energy Transition in Northern and Indigenous Communities: Analysis of Gwich'in Communities in Northwest Territories, Canada

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ABSTRACT: Introducing local renewable energy solutions into the fossil fuel–dominated energy mix of many northern and off-grid Indigenous communities has the potential to create new socio-economic opportunities and address historical energy injustices. However, energy systems are comprised not only of technology and infrastructure, but also the communities who generate, use, and benefit from energy. The design of community-appropriate local energy systems must thus be based on an understanding of, first, a community's socio-technical capacity; second, the social processes that stimulate and sustain transition; and third, the longer-term, desired outcomes from local energy. This paper explores the socio-technical capacity for renewable energy transitions in northern and Indigenous communities based on a case study of four Gwich'in communities in the Northwest Territories, Canada. Results show that the foundational attributes of socio-technical capacity for energy transition in northern communities are interconnected, and strengths or challenges in one area often reflect strengths or challenges in another. Several positive community features, or "capacity strengths," already exist to support energy transition. These include community energy values, which include a community vision; embedded and transferable community skillsets; and "next generation" leaders. In turn, capacity building is needed to provide supports for local energy champions and inter-local energy networks. Results also demonstrate that recent scholarly literature regarding local capacity for community energy does not tightly align with, or reflect the nuances of, energy transition needs in northern and Indigenous communities.

Keywords: energy transition; renewable energy; northern communities; Indigenous; energy security

RÉSUMÉ. L'introduction de solutions énergétiques renouvelables locales dans le mix énergétique dominé par les combustibles fossiles de nombreuses communautés nordiques et autochtones hors réseau pourrait donner lieu à la création de nouvelles possibilités socioéconomiques et rajuster les injustices énergétiques de longue date. Cependant, les systèmes énergétiques sont composés non seulement de technologies et d'infrastructures, mais aussi de communautés qui produisent de l'énergie, la consomment et en bénéficient. Par conséquent, la conception de systèmes énergétiques locaux convenant aux communautés doit reposer, en premier lieu, sur la compréhension de la capacité sociotechnique d'une communauté; en deuxième lieu, sur les processus sociaux qui stimulent et soutiennent la transition; et en troisième lieu, sur les résultats escomptés à plus long terme en matière d'énergie locale. Cet article examine la capacité sociotechnique des transitions énergétiques renouvelables des communautés nordiques et des communautés autochtones en se fondant sur une étude de cas de quatre communautés Gwich'in des Territoires du Nord-Ouest, au Canada. Les résultats montrent que les attributs fondamentaux de la capacité sociotechnique de la transition énergétique des communautés nordiques sont interreliés et que souvent, les forces et les défis d'un secteur particulier reflètent les forces ou les défis d'un autre secteur. Il existe déjà plusieurs caractéristiques communautaires positives, ou « points forts en matière de capacités », pour soutenir la transition énergétique. Cela comprend les valeurs énergétiques communautaires, dont la vision de la communauté; des ensembles de compétences intégrées et transférables; et les leaders de la « prochaine génération ». En revanche, il faut renforcer les capacités afin d'offrir du soutien aux promoteurs de l'énergie locale et aux réseaux énergétiques inter-locaux. Les résultats démontrent également que la documentation érudite récente au sujet de la capacité locale en énergie communautaire ne s'aligne pas étroitement avec les besoins en transition énergétique des communautés nordiques et autochtones ou ne tiennent pas compte de leurs nuances.

Mots-clés: transition énergétique; énergie renouvelable; communautés nordiques; autochtone; sécurité énergétique

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INTRODUCTION

Community-driven renewable energy projects are playing an increasingly important role in decentralizing the traditional, fossil fuel–dominated energy market (Leonhardt et al., 2022). Yet, the transition to renewables is uneven across the globe, particularly in northern and remote communities that are not connected to major electricity grids (Holdmann et al., 2022). Across Canada's North, for example, there are more than 170 diesel-dependent Indigenous communities facing daily energy security challenges (Rakshit et al., 2018). Community renewable energy is high on the agenda for many rural and remote regions, especially in the circumpolar North (Holdmann et al., 2019).

Energy systems are made up of tightly coupled social and technical systems (Miller et al., 2015) that include not only energy infrastructure and technologies, but also the communities that use energy and either benefit from the social and economic opportunities of secure energy, or suffer from energy inequalities and injustices (Hossain et al., 2016; Urmee and Md, 2016). Transitions in energy systems are thus largely social transitions: they require changes not only in infrastructure and technologies, but in the broader social fabric of how a community interacts with energy production and consumption (Miller and Richter, 2014; Newell et al., 2017). The quality of this socio-technical relationship depends on a community's capacity to recognize, pursue, incorporate, and govern complex and dynamic social transitions (Miller et al., 2015; Gui and MacGill, 2018). Building capacity for energy transition starts with people, not technology (Simpson et al., 2003), especially in rural and remote regions where community energy opportunities must align with local resources, values, aspirations, and current and future capacities.

Even more complex are energy transitions in remote Indigenous communities, which face unique contemporary and historical circumstances that influence their capacity to pursue community energy initiatives (Krupa, 2012; Beatty et al., 2015; Karanasios and Parker, 2018). Many scholars have argued that historically marginalized Indigenous peoples have considerable potential to lead sustainability transitions and that introducing local energy projects could address many enduring socio-economic challenges in Indigenous communities (Pasqualetti et al., 2016; Karanasios and Parker, 2018). However, Miller et al. (2013) emphasize that the design of community appropriate energy systems requires careful consideration of a community's socio-technical capacity to make a transition, coupled with an understanding of social processes that stimulate and sustain transitions, and longer-term, desired social outcomes of transitions. Ensuring long-term success of renewable energy development in northern or remote regions requires more than building new energy projects. It also means building the local socio-technical capacity to plan for, design, pursue, implement, operate, own, and maintain renewable energy projects (Daley, 2017; Miller et al., 2018).

A major challenge in taking steps towards such community-appropriate energy transitions is the limited research on the necessary and sufficient socio-technical baseline capacities of remote northern Indigenous communities in this area. Holdmann et al. (2022) argue that, notwithstanding the growth in energy scholarship and recognition of the complex socio-technical nature of energy systems, to date, scholars have largely emphasized global trends or disruptive technologies and downplayed the importance of place and context. Most research on local capacity for energy transition in Canada and internationally has focused on urban environments, grid-connected communities, or rural communities in developing regions of the Global South (Middlemiss and Parrish, 2010; Rezaei and Dowlatabadi, 2016; Mühlemeier and Binder, 2017; Leonhardt et al., 2022). Scholars have paid limited attention to the baseline capacity and capacity-building needs of northern and Indigenous communities seeking to embark on such complex socio-technical transitions. Yet, understanding local capacity to support and sustain community energy in northern and Indigenous communities is foundational to planning for, initiating, and achieving long-term transitions. This means tapping into existing community capacities and identifying the needs and opportunities for capacity development.

The purpose of this paper is to better understand the socio-technical capacity for renewable energy transitions in northern and Indigenous communities. While we focus on energy transition in four Gwich'in communities in Canada's Northwest Territories (NWT), the lessons learned are broadly applicable to northern communities globally.

STUDY AREA

Gwich'in are among the most northerly Indigenous peoples in North America, save for the Inuit. Traditional Gwich'in lands extend from the Mackenzie Valley of the Northwest Territories through the Yukon and into Interior Alaska. This study focuses on the traditional lands of the Teetł'it Gwich'in and Gwichya Gwich'in, which span the Richardson Mountains to the west, beyond Nagwichoonjik (Mackenzie River) to the east, and north to the Mackenzie Delta. The Gwich'in Tribal Council (GTC), operating under the Gwich'in Comprehensive Land Claim Agreement (Gwich'in Tribal Council, 2022a), represents the Gwich'in people in the Gwich'in Settlement Area (GSA). The GTC vision statement characterizes the Gwich'in as a "culturally vibrant and independent Nation that is environmentally responsible and socially, economically and politically self-reliant" (Gwich'in Tribal Council, 2022b).

The focus of this research is on the four communities of Aklavik, Fort McPherson, Inuvik, and Tsiigehtchic (Fig. 1). All four are off-grid communities and part of the Community Appropriate Sustainable Energy Security Partnership (CASES), an initiative led by the University of Saskatchewan in partnership with northern and Indigenous

communities, public- and private-sector enterprise, and researchers from Canada, Alaska, Sweden, and Norway (https://renewableenergy.usask.ca/index.php). The Northwest Territories Power Corporation (NTPC), a crown corporation of the Government of Northwest Territories (GNWT), generates and distributes electricity in all four communities using diesel-based generation. Electricity rates in Aklavik, Fort McPherson, Inuvik, and Tsiigehtchic are highly subsidized: the residential electricity rate is $0.306/kilowatt-hour (kWh) for the first 1,000 kilowatt hours per month from September to March, and for the first 600 kilowatt hours per month from April to August; actual costs are $0.702/ kWh (NTPC, 2022a).

Aklavik is powered by variable-speed diesel-based generation, which delivers electricity to approximately 300 households and other (e.g., commercial, school, recreational complex) buildings, and an integrated 55 kW solar photovoltaic (PV) system that was installed in 2017 (Table 1). Approximately 51% of annual energy use in Aklavik is based on heating, specifically heating oil, followed by use for electricity (31%) and transportation (19%) (Arctic Energy Alliance, 2020a). Aklavik has a community energy plan that emphasizes the importance of providing residents with the information they need to make wise choices about their energy use, using energy and water in harmony with the land, and making clean, affordable, and reliable energy the everyday norm (Arctic Energy Alliance et al., 2017; Arctic Energy Alliance, 2020a). The hamlet's key energy goals and priorities include achieving a sustainable energy future, encouraging youth involvement in energy planning, and introducing skills training and development opportunities for community members (Arctic Energy Alliance et al., 2017).

Fort McPherson's diesel-based system is supplemented by a waste heat recovery system, which gathers 1,160,000 megajoules (MJ) from the diesel generator, and an 85 kW biomass project (Cherniak et al., 2015; Arctic Energy Alliance, 2020b). The biomass project was installed in 2013 to simultaneously heat the band office and community health centre using a single system. Transportation comprises the majority of annual energy use in Fort McPherson (55%), followed by heating (29%) and electricity (17%) (Arctic Energy Alliance, 2020b). Fort McPherson does not have an energy plan. The community engaged in a climate change adaptation planning project in 2011, which was funded by Indigenous and Northern Affairs Canada. Included in that plan is a vision that, by 2050, the community will be "a resilient, self-sufficient community which celebrates and practices its culture and promotes renewable economic development within our traditional lands" (Ecology North, 2011).

In Tsiigehtchic, the smallest of the four communities, approximately 47% of annual energy use is based on heating, followed by electricity (32%) and transportation (22%) (Arctic Energy Alliance, 2020d). Tsiigehtchic has a climate change adaptation plan, developed in 2010 under the same Indigenous and Northern Affairs Canada program

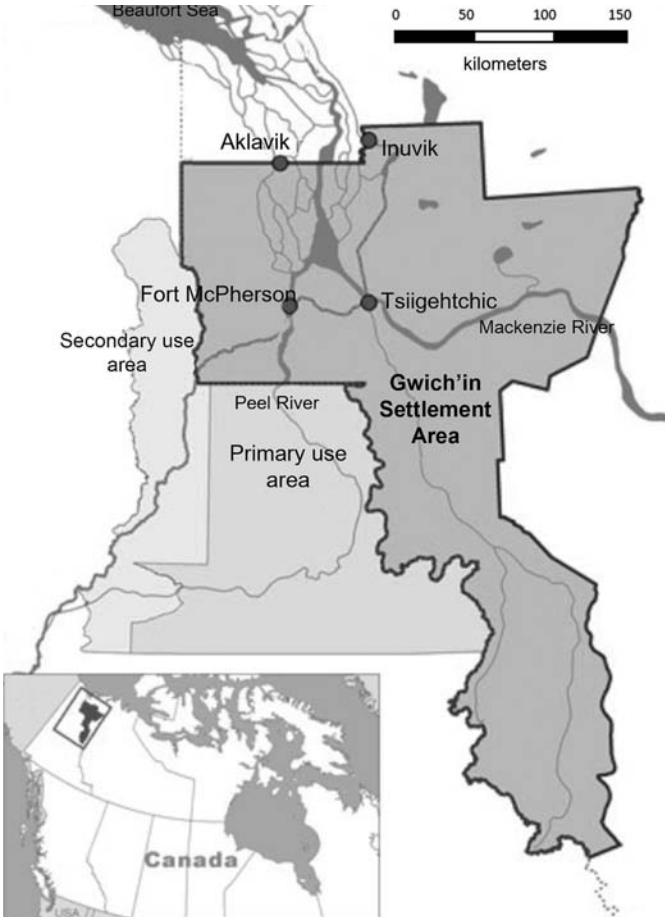

FIG. 1. Gwich'in Settlement Area (Gwich'in Renewable Resources Board, 2022).

used in Fort McPherson, and shares the same vision for community resiliency and self-sufficiency by 2050 (Ecology North, 2010).

The primary energy sources in Inuvik, in contrast, are synthetic natural gas and diesel-based generation. Inuvik's gas power plant is comprised of three generators with a total installed capacity of 7.7 megawatts (MW). Liquefied natural gas is trucked in from southern Canada. The community's diesel power plant has a total installed capacity of 6.2 MW. A waste recovery unit on the power plant's natural gas-fired generator gathers 2,510,000 MJ. Approximately 40% of annual energy use in Inuvik is based on heating, followed by transportation (32%) and electricity (29%) (Arctic Energy Alliance, 2020c). Inuvik has a community energy plan, established in 2010, that outlines five long-term goals, including increasing the community's energy efficiency and opportunities for renewable energy supply (Kavik-AXYS, 2010).

METHODS

We collected data using semi-structured interviews with community members, Gwich'in leadership, and representatives of the energy sector and intermediary

TABLE 1. Community socio-economic and energy profiles: Aklavik, Fort McPherson, Tsiigehtchic, Inuvik.[1]

Community	Socio-economic profile[2]	Energy profile[3]
Aklavik	• Population: 684 [24% < 15 yrs; 14% > 60 yrs] • Employment: 41.2% • Average family income: $92,467 • Residential tenure: 222	• Diesel-based generation: four 320 kw generators • 55 kw solar PV system • Residential heating: heating oil, firewood • Renewable energy: 4.2% – 4% firewood (190 cords) – 0.2 % (59,900 kilowatts-hours) solar PV
Fort McPherson	• Population: 737 [15% < 15 yrs; 22% > 60 yrs] • Employment: 39.5% • Average family income: $81,700 • Residential tenure: 242	• Diesel-based generation: 1.83 MW plant • Biomass district heating: 85 kw facility for community buildings • Residential heating: heating oil, firewood • Renewable energy: 4.01% – 2% (236 tonnes) wood pellets – 2% (196 cords) firewood – 0.01% (4100 kilowatt-hours) solar PV • Waste heat recovery system: 1,160,000 MJ
Tsiigehtchic	• Population: 190 [16% < 15 yrs; 15% > 60 yrs] • Employment: 53.4% • Average family income: $110,500 • Residential tenure: 60	• Diesel-based generation: three diesel units, 510 kw • Residential heating: heating oil, firewood • Renewable energy: 5% – 100% firewood (68 cords)
Inuvik	• Population: 3303 [22% < 15 yrs; 14% > 60 yrs] • Employment: 68.3% • Average family income: $126,832 • Residential tenure: 1180	• Diesel-based generation: installed capacity 6.2 megawatts • Gas power plant – 3 LNG-fueled generators (7.7 MW) – trucked-in LNG fuel • Residential heating: natural gas, firewood • Renewable energy: 3.4% – 2% (787) cords from firewood – 1.3% (600) tonnes from wood pellets – 0.1% (180,000 kilowatt-hours) solar PV • Waste heat recovery system: 2,510,000 MJ

[1] Sources: (Arctic Energy Alliance, 2020a, b, c, d; Cherniak et al., 2015; NTPC, 2022a, b, c, d; NWT Bureau of Statistics, 2022a, b, c, d).

[2] Population based on 2021 data; employment and residential tenure based on 2019 data.

[3] Renewables as % of energy mix based on most current (2018) data.

organizations. The COVID-19 pandemic impacted data collection plans tremendously due to travel restrictions prohibiting outside researchers from visiting the community. As a result, we conducted interviews with Gwich'in leadership and representatives of the energy sector and intermediary organizations remotely, via videoconference. For community member interviews, however, the research team, in collaboration with the Gwich'in Tribal Council, hired and trained local Indigenous youth to work as community-based researchers. The youth researchers, one per community, conducted the interviews both in person and over the phone with members of their own community. The participation of youth researchers was significant factor in the successes of the research, especially in resolving any potential limitations of community members not wanting to speak with "outsider" researchers about their community energy experiences.

Youth researchers used snowball sampling (Lewis-Beck et al., 2004) to identify community-member participants. Then, in collaboration with the Gwich'in Tribal Council, we used the same sampling approach to select participants for the key informant interviews (leadership and other representatives). The research team conducted a total of 20 interviews with Gwich'in leadership, energy sector representatives, and intermediary organizations, and 74 interviews with community members (Table 2). Interviews lasted 60 to 90 minutes and were audio recorded and transcribed. We received research ethics approval from the University of Saskatchewan Behavioural Research Ethics Board (Beh-REB 1616) and secured a northern research license (No. 4707) from the Aurora Research Institute, the organization responsible for licensing research in the Northwest Territories. The University of Saskatchewan and the Gwich'in Tribal Council Board of Directors also signed a partnership letter of understanding.

Because the interviews took part in a larger research agenda under the CASES initiative, our questions explored several topics, including: the importance of energy for everyday life in the community; challenges in, and opportunities for, pursuing local energy initiatives; relationships between communities, utilities, and intermediaries that might support energy initiatives; energy affordability and reliability; community energy needs and future opportunities from secure and sustainable energy systems; types of local investments required to ensure a secure energy future; knowledge about the community's energy supply and energy security; human resources and expertise needed to develop and maintain local energy

TABLE 2. Research participants.

Participant group	Participants	Number
Aklavik	Community members	14
Fort McPherson	Community members	20
Inuvik	Community members	25
Tsiigehtchic	Community members	15
Gwich'in leadership	Gwich'in Tribal Council leadership	10
Energy sector	Utility representatives	2
Intermediaries	Intermediary organizations	8
Total		94

systems; what blend of energy sources will be preferable or needed in the future; and energy system regulations; and barriers to and opportunities for local energy.

Thus, to focus on local capacity, we adopted a conceptual framework developed by McMaster (2022) that proposes eight foundational attributes for the appraisal of a community's baseline socio-technical capacity for sustainable energy transitions (Table 3). We define capacity simply as the collective ability of a community to create and seize opportunities to meet community needs, thus providing for greater self-sufficiency and control over social and economic future (Smith et al., 2001). McMaster (2022) cautions that the eight attributes defined in their frameworks are not predictive of energy transition success, or explanatory of why some community energy projects succeed while others fail; rather, they offer conceptual guidance for exploring fundamental baseline capacities of a community prior to embarking on local energy initiatives. McMaster (2022) developed the attributes based on literature that explores community energy and planning in Indigenous communities (e.g., Pasqualetti et al., 2016; Rezaei and Dowlatabadi, 2016; Karanasios and Parker, 2018; Stefanelli et al., 2019; Mercer et al., 2020); energy transition and community development literature focused on the Circumpolar North (e.g., St. Denis and Parker, 2009; Rosenbloom and Meadowcroft, 2014; Cherniak et al., 2015; Poelzer et al., 2016; Mortensen et al., 2017); and research exploring socio-technical capacity in rural and remote regions of developing countries in the Global South (e.g., Middlemiss and Parrish, 2010; Schäfer et al., 2011; Miller and Richter, 2014; Sovacool et al., 2020). The attributes may not be comprehensive of all factors influencing transition capacity (Vallecha et al., 2021), but McMaster (2022) argues that they capture the minimum socio-technical attributes needed at the community level to initiate and sustain community appropriate socio-technical energy transitions.

Using the conceptual framework as guidance, we coded interviews thematically using NVivo 12 qualitative data analysis software and used subsequent rounds of coding to identify whether each attribute discussed by participant was referred to as an existing strength or capacity challenge or limitation in the community or region. We also recorded the number of participants, across all interviews, who identified a given attribute. This allowed us to analyze the data to represent the frequency of occurrence across all participants versus the frequency of repeated occurrences within conversations. The perspective of the first author, an Indigenous female scholar, is of importance to our analysis. Because interview questions explored other topics, including those related to individual household energy use, the sufficiency of local government and intermediary supports for energy security initiatives, and community relationships with the energy utility and other communities, we assured participants that results would not be linked to any particular participant's name in research reports unless they indicated otherwise. We asked all participants for permission to be acknowledged in separate documentation and project materials for their contributions to the larger partnership initiative.

RESULTS

The sections below present results of the socio-technical capacity assessment for energy transition across the four Gwich'in communities. We present results holistically, describing them in relation to the overall Gwich'in region,

TABLE 3. Core attributes of socio-technical capacity for early-stage planning and assessment of community energy transitions.

Community energy champion(s)	• Individuals or groups (e.g., energy planner) mandated to lead community energy initiatives, and who are sufficiently resourced—financially, logistically, technically, managerially.
Inter-local energy networks	• Local access to a network of professional and technical knowledge about energy technologies and innovations, including formal or informal opportunities for community-to-community learning and mentorship from energy-community frontrunners.
Community energy vision	• A broadly shared vision, focused on longer-term goals and aspirations (e.g., self-determination, socio-economic independence) through which community energy is seen as a pathway to help achieve those goals and aspirations.
Community energy value	• Community energy is understood as adding local value, creating new opportunities for social, cultural, and economic value creation or enhancing existing ones.
Energy literacy	• Foundational knowledge about energy use, energy sources, and energy technologies, coupled with access to energy literacy programs and learning opportunities.
Embedded skills	• Existing and transferable energy-related skill sets in a community to pursue, operate, and maintain local energy systems or technologies.
Skills development opportunities	• Availability of and access to training or mentorship programs across energy skill sets, and an interest in the local workforce to pursue energy-related training and employment.
Next generation leaders	• Energy education is embedded in school curriculum, and community youth are actively engaged in local leadership, community initiatives, or local energy projects and activities.

Source: McMaster (2022).

and we also identify strengths and challenges across communities. Overall, the most discussed attribute by interviewees was community energy values, discussed by 96% of participants and across all participant groups (Table 4). This was followed closely by embedded energy skills, identified by 83% of interviewees, and skills development, discussed by 77% of participants. In sharp contrast, less than one third of participants discussed topics related to inter-local energy networks and energy champions—essential aspects of community energy leadership and local capacity needed to transition energy systems. The largest proportion of interviewees who raised these two attributes were from GTC leadership, followed by intermediary organizations. Participants from the energy sector and from each of the four communities also raised these attributes, but to a lesser extent.

Based on the ratio of strengths to limitations, as identified by participants when speaking about the various attributes of community energy capacity, several important observations emerged that illustrate key strengths and challenges related to energy transition (Fig. 2). At the aggregate scale, across the four communities, we identified the presence of a community vision to guide energy transitions and shared community energy values as essential and existing strengths. Participants often expressed ideas related to these strengths when speaking of cultural, community or social and economic considerations related to energy transition. We also identified an additional strength: the presence of next generation leadership to facilitate long-term community energy transitions and ensure long-term socio-technical capacity. This was usually discussed in terms of the importance of youth involvement in community initiatives in general, but also in terms of youth interest in their energy future. Finally, we identified the strength of embedded skill sets (i.e., a community's existing energy knowledge). These embedded skill sets include energy-relevant skills, such as technical, managerial, or financial skills that existed among retired community members, and the resilience of skills, in terms of people's ability to adapt to new technologies or opportunities.

The two most definitive capacity challenges we identified were intertwined: energy literacy and opportunities for skills development (Fig. 2). Energy literacy considers both existing energy literacy within the partner communities and access among community members to energy literacy training, workshops, and education opportunities, while skills development considers opportunities for training and capacity development, such as access to training, workshops, and education to develop skill sets relevant for energy planning and transition efforts. At the most fundamental level, these two challenges represent a lack of local access to education and training opportunities, whether for enhancing and developing energy literacy, or for specific skills development in areas of expertise, such as technical, financial, or managerial skill sets. Closely following these two challenges were those associated with limited development of inter-local energy networks to facilitate knowledge sharing and support across communities and with communities in other regions, and lack of capacity to support local energy champions to drive community energy initiatives.

TABLE 4. Social capacity attributes as strengths and challenges across four study sites in support of community energy transition.

Social capacity attributes	Perspectives on current capacity[1]	
	Strength	Challenge
Local energy champion(s)	6	12
Inter-local energy networks	9	20
Community energy vision	7	4
Community energy value	83	25
Energy literacy	14	38
Embedded skills	59	29
Skills development opportunities	19	62
Next generation leaders	13	4

[1] Number of interviewees who identified current capacity strengths or challenges. Numbers for any given combination of strengths and challenges (rows and columns) do not add to the total (n = 94) because not all interviewees addressed every attribute. For a given attribute, some individuals identified both strengths and challenges.

However, as a region, results indicate that the four communities have many opportunities, collectively, and exciting prospects to support each other's challenges and share each other's possibilities to further the region's energy planning, transitions, and developments through regional energy networks and support systems. A more nuanced analysis of results, exploring perspectives on each attribute, is presented below.

Local Energy Champion(s)

Most interviewees who identified the importance of local energy leadership referred to current challenges and specifically to the lack of people resources available to provide local energy leadership. Interviewees from Tsiigehtchic, Aklavik, and Fort McPherson explained that not having designated energy champions, or sufficiently resourced ones, means missed opportunities to pursue renewable energy initiatives. A Tsiigehtchic participant noted the many financial programs available to support community energy, "but we don't have anybody … that can utilize those funding pots to get started … to get that money." GTC leadership echoed these concerns, indicating that challenges to community energy leadership are more capacity-related than related to any lack of prioritization of local energy, and that "we [GTC] just don't have the people and enough manpower to be able to move projects forward … or even go after all the grants that we would like to." The scenario was different in Inuvik, the largest of the communities (Table 1), where interviewees considered the presence of local energy champions, specifically

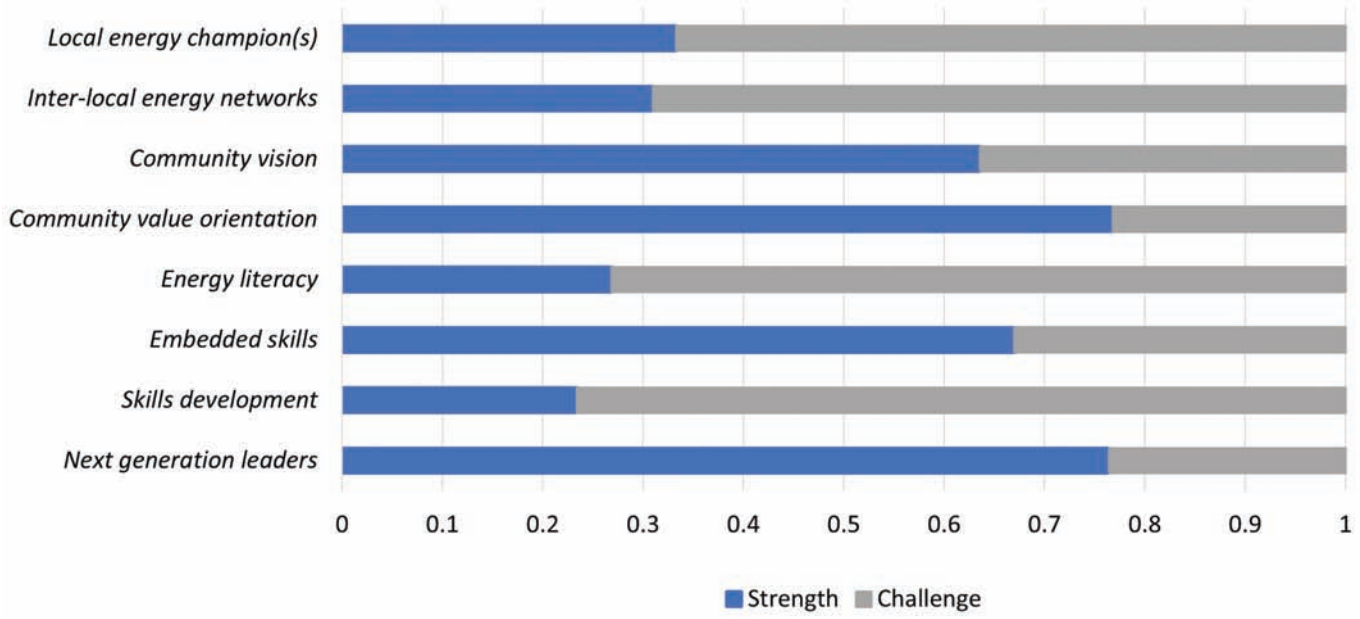

FIG. 2. Ratio of baseline community capacity strengths to limitations for the study region, as derived from interview data. Ratio is based on the number of times an attribute was described as a strength vs. limitation, with some interviewees describing an attribute as both a capacity strength and limitation.

Arctic Energy Alliance (AEA, https://aea.nt.ca/), a key strength for advancing local energy initiatives. An Inuvik participant explained that there is "a staff of four or five in that Arctic Energy Alliance office, locally … those are the key people who deal with those particular issues." Although AEA's mandate is to support all communities, reference to the AEA did not emerge in community discussions outside Inuvik about local energy champions.

Despite these challenges, GTC leadership cautioned that it should not be assumed that the communities have no local leadership to advance community energy. One participant explained that there are "folks in each of the communities who are energy champions in their own way" and that, even though those people may not carry an official title, "in the perspective of the traditional way of life and … what they're doing in the local level, just naturally … sets the example." A Tsiigehtchic resident shared a similar perspective, emphasizing that energy leadership is embedded in the community way of life and that such leadership must not come from outside the community. The interviewee went on to express concern about imposed energy leadership from outside the community, notably the federal government, indicating that "the federal government still treats us like we're in Residential School … it's like, 'We know what's best for you,' even though [they] live in Ottawa … haven't come to our community … haven't seen the geography or the terrain, haven't spoken to our Elders, haven't spoken to our youth."

Inter-local Energy Networks

Twenty interviewees described inter-local energy networks, which include communities' access to regional resources and collaborations, as a significant challenge. The nine participants who spoke to strengths referred more to the recognized desire to strengthen community-to-community and regional collaborations, versus the presence of existing networks per se. An intermediary organization suggested that strong community energy relationships do not exist across the region, explaining that "the only time that there's sort of connection in sister communities is really, for instance, if Fort McPherson and Tsiigehtchic—one of them gets solar panels, the other one will be like, I wanna take part in that too." The interviewee described this not as a network, but rather, as an "if it works there, it'll work here" approach. This perspective was echoed by a Fort McPherson participant, who identified a desire in their community for greater collaboration and support networks across communities, but who also noted the limited resources for doing so. Drawing on the example of the community's existing biomass project, the interviewee connected the challenges to collaboration with the constraints to resourcing local energy champions, noting that "if we had a whole department just on biomass, then that department could focus on getting the community running … and then sharing that [knowledge and experience] with the other communities." GTP leadership shared similar perspectives, noting the limited collaborations and knowledge exchanges, largely due to limited capacity to facilitate such networks and, in particular, the lack of a regional energy coordinator. Another interviewee from GTC leadership identified the complexity of working across communities on energy issues, explaining that because community energy goals and projects are locally defined, "[goals] would look different in communities like Aklavik, which is a shared community with Gwich'in and Inuvialuit, as well as Inuvik," than in Fort McPherson or Tsiigehtchic. This interviewee also emphasized the need for regional

coordination in facilitating community-to-community engagement.

Community members identified the importance of sharing energy knowledge and experience across communities, but also noted the importance of drawing on community expertise from outside the Gwich'in region —communities with more experience in local energy and energy transitions. For example, a Tsiigehtchic participant emphasized the importance of collaborations and learning across communities, observing: "We could certainly learn if we visit the two communities of Colville Lake or Old Crow where they have solar energy projects; we can certainly find out from them what kind of funding it took to get to that stage, what kind of training they offer their people." The participant therefore highlighted the importance of learning from community front-runners to inform and support local energy projects. Other participants emphasized the need for improved networks between governments, not only between communities, to facilitate community-to-community learning and to share resources, innovations, and expertise. As expressed by an Inuvik participant, "We have to seek partnership out of our—not only in the—community; maybe out of the country, as well" and "not only our territorial government, but between the Inuvialuit and the Gwich'in … to work together to mutually be beneficial … rather than against each other."

Community Energy Vision

When interviewees discussed the role of a community's energy vision, most referred to the strengths of their community's existing vision for a secure energy future. Across all communities, energy cost savings were a primary focal point. For example, an interviewee from Fort McPherson spoke of viable opportunities that could come from local energy development, particularly biomass, explaining that a small biomass operation for heating the community's grocery supply store could reduce fuel-based heating bills from "$15,000 to $20,000 a month from November to April every year … down to about $7,000 to $10,000." The participant raised the issue of up-front financial investment costs, but explained that for a community's longer-term energy vision, "ten years down the road it's gonna be well worth it; it really is." Interviewees in Tsiigehtchic and Aklavik also addressed the issue of economic drivers, typically emphasizing energy cost savings. As one interviewee from GTC leadership explained, "If you talked to the ordinary person on the street, that's what they're going to be concerned about—paying their bills … cost is going to be the primary driver." However, GTC leadership indicated that energy cost savings are not separate from the longer-term vision of self-determination, in that "everything else flows from that; if you have energy control locally, you can make better decisions about how you spend that energy, and what you do with it."

Only interviewees from the energy sector and intermediary organizations identified limitations or challenges associated with community energy visions. They emphasized a lack of energy vision in the region and a lack of cohesion. When an energy sector participant was asked about community energy vision, they referred to these lacks, indicating that energy transition challenges in the region are rooted in energy vision challenges: "It comes back to that vision … we're not seeing a cohesive group." One intermediary spoke of the benefits of a strong community energy vision, from energy sustainability and security to improved health, but emphasized the "encouraged dependency" that exists as a result of colonization. The interviewee suggested that to expect a community to articulate a clear energy vision is not realistic because: "People have been encouraged to be powerless … to suddenly expect people to turn around and become independent … is not realistic; it takes time."

Community Energy Value

The community energy value attribute relates to community perceptions of whether new or existing energy systems interact with, or add value to, existing local socio-cultural and economic values. Among participants, 83 interviews raised community socio-cultural values as a significant factor in driving energy transitions, whereas 25 individuals spoke of the challenges to supporting community values presented by the existing energy options. Dominant topics of conversation included environmental values, reinvesting in the community, independence, and preserving cultural values and practices. An interviewee from GTC leadership indicated that most community members are environmentally concerned and they "want things done with climate change and global warming, just being stewards of the land … they want to see cleaner sources of fuel that we're using to heat our homes and drive our vehicles and everything." But for most community members the dominant theme was the added value to communities of having secure and affordable energy, which would ensure that more of a community's resources would be available for "going back into the economy and into the schools … there'd be programs and money to fund programs … for the community." For example, an Inuvik participant argued that at the core of community energy is the opportunity to improve community services, such as daycares, schools, and recreational centers, all of which are highly valued, explaining that "If you could lower their operating costs, they could deliver more programs/services." Participants from other communities and GTC leadership echoed this perspective, noting the day-to-day value that local energy developments could bring to communities and the larger opportunities they would create—specifically, greater self-determination and breaking the "long history of colonial policies and colonial approaches telling us how we need to do things."

Closely related to this point, participants across all four communities emphasized preserving the land and maintaining cultural values as prominent aspects of

community values related to energy that must be supported in any energy system. For example, an interviewee in Fort McPherson explained that wood is important for home heating because sometimes some people don't have jobs and can't afford the fuel oil. However, they also pointed out that even community members who use wood as a heat source still need fossil fuels as an affordable fuel for their snowmoblies to harvest that wood, or for generators at cabins or when out on the land. The participant also stressed the importance of fossil fuels for Elders within the communities, noting that "Diesel is important, especially for people that are Elders and people that need heat and … for people that don't have stoves, they need that diesel." Yet, participants across all communities raised a concern about the affordability of fuel to support local ways of life and access to the land. A participant from Inuvik spoke to the effects of energy costs on hunters and trappers, noting that "A lot of our hunters and trappers can't go hunting and that is because the cost of gasoline is too high. I've got a boat, but I don't use it as much as I used to because the price of gas is quite costly. I know a lot of our elderly hunters and trappers that want to get out there, they can't afford to. It's just too expensive."

Interestingly, of the 25 individuals who also referred to concerns or challenges regarding the local value of pursuing renewable energy, 21 were community members. For example, a participant from Aklavik offered a lukewarm perspective on the value of the community's solar array and future investments in renewables: "They set up solar panels a while ago, haven't seen much change though." An intermediary offered an explanation for this criticism, suggesting that some community members were upset after the solar farm development, but that this may have had more to do with a poor project planning process than local values about renewables per se, emphasizing that "the community has to live with it, they need to know about it, they need to want it, they need to approve it or else it's just not right." Yet, in speaking about current energy needs and the value of renewables in Tsiigehtchic, an interviewee commented that "if you're gonna be going hunting, trapping, or fishing, the only energy you're using is your snowmobile, your boat, which is not really energy." This may reflect how participants who are critical of the value added of investing in renewables understand their energy system. They may dissociate the high costs of energy for electricity and home heating from the cost savings potential of renewables and may be skeptical about whether renewables will leave them with more income. All interviewees from Tsiigehtchic, Fort McPherson, and Inuvik who raised concerns about the community value of renewables described negligible impacts, positive or negative, of energy transition on traditional practices.

Energy Literacy

Among interviewees, 38 described energy literacy, inclusive of communities' access to energy literacy programs, as a challenge; 14 spoke to existing strengths. Interestingly, those who spoke to strengths were representatives of either GTC leadership, intermediary organizations, or the energy sector, but even those participants were conservative about the level of energy literacy that exists in communities. An interviewee from GTC leadership explained that most community members understand that diesel is a main fuel source for community heating, but beyond that, most would not understand the details of how the system actually works. Another interviewee referred to Aklavik's integrated solar array, noting that everyone in the community knows that it exists, but "no one knows what they are," and there is limited understanding of the energy supply chain from source to home.

Interviewees pointed to the deficit in energy literacy programming across communities as a major challenge. A GTC leader identified only efforts by the AEA to raise awareness about energy use and emissions, but no broad-scale community energy literacy initiatives. Community members in Aklavik, Fort McPherson, and Tsiigehtchic made similar concerns evident. For example, a community member emphasized how "We can't keep relying on non-renewable energy like oil and gas, it's not good for the planet," but went on to indicate that greater efforts are needed to improve energy literacy: "If we could start having our kids thinking of those, maybe we can not only cut down on the climate change, but I think we could really have a community that thinks energy efficient." Responses were different in Inuvik, where community participants said that there has been a lot of energy literacy programming. This may suggest an imbalance across the Gwich'in communities in terms of access to energy literacy opportunities; as one community member noted: "They've (AEA) done a lot of workshops, but I just don't think the message is getting out there." Participants across all communities criticized the dominate emphasis on energy efficiency in energy literacy programming, rather than also promoting a better understanding energy production, distribution, use, and alternative technologies. This was reinforced by one study participant who explained that "a lot of the energy literacy … tends to focus on how to conserve energy in your house, changing the LED lights, that kind of thing. That kind of energy literacy is good of course, because you're reducing your energy consumption … but it really doesn't help people understand how electric power systems work in the first place."

Embedded Skills

When interviewees referred to embedded skill sets within communities, most identified them as existing capacity strengths. When challenges were raised, it was primarily by interviewees from intermediary organizations. In Aklavik, Fort McPherson, and Tsiigehtchic, multiple interviewees described specific skill sets within the community that could support local energy initiatives, such as technical,

managerial, or retired people's skill sets. In Tsiigehtchic, for example, participants mentioned how one community member had taken solar panel installation training and was passing that knowledge on to other community members. An Aklavik participant spoke to the resilience of technical skill sets, especially for the community's diesel-based generator, in that "we have everything in house … we have our own techs." The interviewee explained that it's not necessary to have such skill sets in every community, and that "it's only on special stuff that we bring in people … like to do the generator re-windings—that goes out every three or four years, so it just wouldn't make sense to hire someone to stay [here]." An interviewee in Fort McPherson noted local technical skills related to biomass (e.g., training on the woodchipper) but emphasized the lack of business development skill sets: "Let's say we wanna do a proposal, then we'd have to get the consultants to help do that." Interestingly, another community member provided an opposite perspective, questioning whether the community had sufficient technical skills, but emphasizing that there are existing and retired business skill sets to manage energy projects: "There are many people that have managed businesses, and lots of people that have qualifications and training to help with that." Participants in Inuvik offered similar observations, identifying retired individuals with electrical and other trades who could provide the skills for simple solar installations: "People who have retired but have certain trade skills like electrical … that would be useful for doing stuff simple as setting up solar panels at a cabin, for instance."

Transferable skills also emerged as a dominant capacity strength, especially skills from the mining and oil and gas sector, with a community member suggesting that, "There are a lot of people with a lot of really good skills here that they've developed for heavy equipment operators or drilling … that are very easily transferable; they could be retrained into working in renewable energy." GTC leadership echoed this perspective: "There's definitely people who I think have the ability to be able to be trained very quickly … specifically [those] who have worked in the oil and gas field and probably dropped out of school when they were about 15; when oil left, there was no jobs, so there's definitely a lot of people who have past experience in more technical kind of jobs whose skills could just be upgraded." Another community participant noted that the extent of transferrable skills could lead to great positive impacts from energy transitions, as individuals can find new employment opportunities: "They just need the training to transfer over."

Skills Development

Interviewees from all four communities spoke to the importance of, and need for, greater local access to training opportunities for everything from biomass boiler maintenance to solar design and installation, to wind, waterpower, electrical, and other trades. In addition to technical skills, participants identified the need to develop better capacity in financial and business skills to secure and manage energy projects, with an Inuvik participant noting that, "our band has struggled in the past with our business deals" and emphasizing that "we need to invest in ourselves." However, almost all participants raised the challenge of local accessibility of training programs. An interviewee from Inuvik reported that there are solar installers in the region who will sometimes help train local people during installations, or "help find funding for them to go down south to be more well-versed." However, a community member from Tsiigehtchic identified a sharp contrast between the smaller communities and Inuvik:

> There's nobody that comes into the community or even has phoned our office and said, "We're based in Inuvik." Or "We're based in Yellowknife, and we're taking care of your community, and we want you to know that we have so much money in our budget for your community, and is there people that we can be talking to, to access this program?" Nobody does that training.

Interestingly, an interviewee from an intermediary organization indicated that "there are programs that exist," such as through the Arctic Energy Alliance (AEA) and the Indigenous Clean Energy Network, and the GTC has partnered with these organizations. However, in one of the interviews with a GTC member, we heard that a major constraint in this regard was that most formal skills development programs require an educational level that makes the programs largely inaccessible to local community members, such as "incentives for studying at a master's level when we don't have anyone," and that few to no opportunities or incentives seem to be available for people to receive technical training that aligns with local needs. The participant went on to explain that for those people "who are getting to the masters level … then they're not really interested in coming back here," which does little to build local capacity. In Aklavik, Fort McPherson, and Tsiigehtchic, community interviewees emphasized the importance of more informal training and local mentorship, and specifically, of community members being trained by other community members who have received formal training. For example, an interviewee in Fort McPherson referred to an individual trained to operate the woodchipper for biomass energy, and to the opportunity to provide hands-on training to other community members, especially youth, noting that "The training part is not in the youth's mind right now, but once they get going, it'll flow."

Next Generation Leaders

Few interviewees focused specifically on the role youth in their community could play in the community's energy future, but when the topic did emerge, the majority referred to youth as next generation leaders and a current strength in their community. Participants from each of the four communities, from intermediary organizations,

and Gwich'in leadership identified the strength of future leaders. An intermediary participant explained that the renewable energy sector is growing in the North and referred to Aklavik's solar energy installation: "If you are a student and you've never seen a solar system and all of the sudden you get one, and it piques your interest, it might encourage you to follow that as a career." Gwich'in leadership participants also spoke to the value of having an example of a community renewable energy project accessible to youth in terms of sparking their interest to pursue energy-related careers. One participant referred to the high school in Fort MacPherson, which is heated by biomass, noting, "That's an example right where they are, where renewable energy is happening right in their community."

Gwich'in leadership participants also spoke to existing opportunities within communities to engage youth in renewable energy and energy efficiency, and making reference to existing science, technology, engineering, and mathematics (STEM) projects taking place in the schools, from preschool to high school. One participant acknowledged the work of GTC leadership in helping to recruit youth into careers in the energy sector by providing scholarships and bursaries targeted at training in engineering and more technical positions, rather than for office-based positions. Another interviewee commented on a recent initiative with the Northwest Territories Power Corporation to "provide for more apprentice type training positions for those right out of high school."

Interviewees identified the regional Gwich'in youth council, which includes a youth representative from each community, as an example of next generation leadership capacity. A Gwich'in leader explained that the youth council members attend academic conferences each year, and they have a high success rate of youth council members attending post-secondary education. The initiative targets youth who have recently graduated high school but haven't attended post-secondary. After the first four years of the program, 83% of participating youth have begun a post-secondary program, an internship, or some sort of education or training. As explained by an interviewee from GTC leadership, investment in next generation leaders is "helping young people be aware of their responsibility especially as Indigenous people and specifically Gwich'in … . we were all taught a very deep responsibility to be a part of our communities and to give back, and if you have the ability to do so, then it's your responsibility to do so."

DISCUSSION

This research identified socio-technical capacity strengths and challenges across Gwich'in communities. Results indicate several attributes for which a strong baseline capacity for energy transition exists. These include community energy values, a strong community vision, embedded skill sets, and opportunities for strengthening community energy knowledge and next generation leaders. But there are also areas where capacity building is needed for community energy transition, such as in supports for local energy champion(s) and to enable inter-local energy networks. Reflecting on the relative opportunities, strengths, and actor perspectives across the Gwich'in region, we offer several key observations regarding the capacity for long-term socio-technical energy transitions in northern and remote communities that are applicable across contexts and foundational for ensuring community appropriate, sustainable energy transitions.

Interconnectedness of Socio-technical Capacity Attributes

Based on results from our study region, the foundational attributes of socio-technical capacity for energy transition in northern communities are interconnected, and strengths or challenges in one area often reflect strengths or challenges in another. For example, successful energy transitions often hinge on communities identifying value from energy planning or from specific energy projects, which may, in turn, hinge on available and sufficiently resourced local energy champions (Krupa, 2012; Hoicka et al., 2021)— a noted capacity deficit in the study region. However, if communities have not articulated the potential value of community energy beyond energy conservation measures, it may be difficult to identify passionate leaders from within the community to drive transitions (van der Horst, 2008; Walker and Devine-Wright, 2008; Middlemiss and Parrish, 2010).

Similarly, noted deficiencies in energy literacy (e.g., education, programming) and skills development opportunities (e.g., technical skills training) appear to be tightly coupled. Arguably, deficits in either one reflect or cause deficits in the other: without opportunities for training and capacity development, it is challenging to nurture strong energy literacy programs in communities (Rosenbloom et al., 2016; Arctic Council and Sustainable Development Working Group, 2019), and without energy literacy programs, lessons from both the circumpolar North (Lovekin et al., 2016; Holdmann et al., 2019) and the Global South (Yazdanpanah et al., 2015; Miller et al., 2018) indicate that it is challenging to advance technical skills to support transitions. Unfortunately, deficits in energy literacy programming and skills development opportunities may translate into deficiencies in the future embedded skill sets of a community (Bhattarai and Thompson, 2016; Pasqualetti et al., 2016; Mortensen et al., 2017) and in next generation leaders who can maintain community energy projects and energy transitions in the longer term (Yazdanpanah et al., 2015; Nelson, 2019; McCarthy and Morrison, 2020). Further, lack of community knowledge about energy and widespread misinformation could obstruct and diminish the value of transitions (Mercer et al., 2017).

Alignment Between Capacity Building and Community Values and Aspirations

There are often diverging perspectives between community members and other interests, including intermediaries, about community energy capacity, priorities, and challenges. In this research, the views of community members differed from those of other participants regarding local access to energy literacy and training programs, and the skills development and training needed to pursue community energy. In the literature, we find the example of Alaskan communities that have undergone successful energy transitions, where community members expressed agreement, along with intermediaries, on how energy literacy programs were essential in helping people understand energy systems and how they can reduce costs (Holdmann et al., 2019). Conversely, in our research, community members' concerns about local opportunities for energy literacy programming and for hands-on training (i.e., apprentice mentorship) in energy systems installations and maintenance often contrasted with the perspectives of other participants, who spoke of the variety of programs and their availability across the Gwich'in communities. This divergence may reflect misalignment between the types of energy literacy and training programs available versus what communities consider appropriate for their energy future. For example, though intermediaries, the energy sector, and leadership often spoke of energy efficiency and energy use education, community members emphasized the need for knowledge and training about energy production and distribution and how to secure external funding for new energy initiatives, as opposed to programs focused on using less energy.

Recent scholarship indicates that limited access to energy literacy education in the North, coupled with limited locally available technical training programs, poses a significant barrier to community energy transitions (Cherniak et al., 2015; Mercer et al., 2017). Our results indicate that equally important to program access is that such programs align with community needs, values, and aspirations. Drawing on community energy experiences in rural sub-Saharan Africa, for example, Ikejemba et al. (2017) and Tenenbaum et al. (2014) show that, in the absence of local capacity reflecting local values, energy projects can be implemented, and attempts can be made by interested parties to reshape values, but the resulting energy future and priorities may not succeed in the long term or serve to maximize economic or social value to the community. In this research, interviewees from the smaller communities of Aklavik, Fort McPherson, and Tsiigehtchic, but not necessarily from the larger centre of Inuvik, often spoke of energy intermediaries or the federal government as "outsiders." This is not surprising, as Canada's history reflects systemic differences of values and priorities, and often, a divide between what Indigenous communities want versus what external interests believe is best for Indigenous communities. Focusing on community appropriate capacity building that aligns with the values and interests of the communities is essential for a successful, long-term, sustainable socio-technical energy transition.

Sister Communities as Energy Support Networks

There are numerous examples of the opportunities that can emerge from inter-local community energy networks. In Wales and Scotland, for example, energy co-operative programs have been most successful in networks of close-knit rural communities (Strand, 2018), while in Alaska, several regional grids have emerged, and utilities have developed systems for supporting regional energy planning and project maintenance across otherwise remote locations (Holdmann et al., 2019). Similarly, in the Global South, research has shown the value in community-to-community mentorship for developing renewable energy projects in rural areas and providing a network for knowledge transfer (Ulsrud et al., 2018). Such community-to-community relationships provide support and enable communities to share success stories of, and lessons learned in, energy transition efforts (Cherniak et al., 2015). Strengthening sister-community relationships within and external to the Gwich'in region may be a solution to many local capacity challenges. A strong inter-local energy network among communities can allow for capacity deficits in one community to be levelled out by the collective capacity strengths of networked communities (Onyx and Leonard, 2011; Shaw, 2017; Berka et al., 2020). For example, if Aklavik does not have a locally resourced community energy champion, they may leverage the strengths of the other partner Gwich'in communities; or, as the larger of the four communities, if Inuvik has certain embedded energy technology skills, there is an opportunity for knowledge transfer and training to build similar skill sets in other communities.

We found cohesive regional interest in our study area in developing partnerships and knowledge-sharing platforms and a shared interest in future inter-local energy networks. However, some of the reason for the current limited energy networking and knowledge transfer among the four communities may be due to the fact that they are each at relatively similar stages of energy transition, thus emphasizing the importance of sister-community relationships that extend beyond the Gwich'in territory. Ulsrud et al. (2018) explains that such relationships between communities in India and Kenya allowed inter-local learning about specific socio-technical experiences in different geographical contexts sharing contextual similarities to occur. In this way, the lessons and experiences with energy projects or innovations, including new skill sets, were transferred to other settings. Many participants in our research indicated the importance of learning from other communities in the Northwest Territories that have embarked on local energy initiatives, and especially the opportunity to learn from neighbouring Alaskan communities that are recognized

as leaders in community energy transition solutions. Such networks can build local capacity through community-to-community learning, even in the absence of more formal training programs locally, and support more collaborative energy planning, technology transfer, resource sharing, and transition opportunities.

Contrast Between Community Energy Scholarship and Northern Context

Energy transitions are accompanied by social shifts. This makes it important to understand local capacity to recognize, pursue, incorporate, and govern such complex and dynamic social transitions (Miller and Richter, 2014; Miller et al., 2015; Feurtey et al., 2016; Newell et al., 2017). However, this research demonstrated that recent scholarship regarding local capacity for community energy does not always tightly align with or reflect the nuances of energy transitions in northern and Indigenous communities. This was evident in three areas.

First, the importance of local leadership in community energy is well established in the literature, with the lack of local energy champions identified as among the most significant challenges to energy transition in the North (Cherniak et al., 2015; Menghwani et al., 2022). We agree that such community-level leadership with formal professional and technical skills is important to secure the financial and technical resources for energy projects and to establish and maintain important energy support networks with external actors (Martiskainen, 2017; Ghorbani et al., 2020). That said, while the lack of formally designated community energy leaders may be constraining, we should not assume that the communities lack local leadership to advance community energy. As emphasized by participants in this research, there are energy champions in each community who may not carry an official title, but who are energy champions through their traditional way of life—promoting community well-being and environmental and cultural awareness, and thus mobilizing the social capital necessary to support energy transitions. In addition to the more formalized understandings of community energy leadership, we should consider this understanding of energy champions as community social and cultural leaders when approaching when approaching communities in the North.

Second, recognizing the social value of energy is critical to transition efforts (Jenkins et al., 2018). The dominant focus of much of the community energy literature, however, including on energy policy, is often on energy efficiency and emissions reductions (Government of Canada, 2016; Hossain et al., 2016), with much less consideration for how such initiatives generate social and cultural value for communities. This approach was also echoed by intermediary participants in our study. In this regard, energy transitions are often criticized for reflecting external or top-down values (Stefanelli et al., 2019), thus omitting the importance of cultural and social values in shaping energy transition in northern Indigenous communities (Krupa, 2012). An overarching emphasis in the conversations we had with community members was on the importance of energy for the entire community, which highlights the importance of energy transitions that create new social value and economic opportunity, generating new energy to support community growth, and creating new resources to invest in local programs and services.

Third, literature often focuses on the capacity deficits of northern and Indigenous communities (Stevenson and Perreault, 2008), emphasizing the skill sets that are missing rather than also focusing on the resilience of existing skills and the value and diversity of community experience. The community energy literature consistently refers to the importance of professional skills and training programs and the lack of skills or skill deficiencies in many communities as barriers to energy transition (Cherniak et al., 2015; Advanced Energy Centre, 2016; Mortensen et al., 2017). But in this research, participants discussed the value of hands-on learning-by-doing that communities can draw from existing and retired people who pass their knowledge on to others in the communities, which represent embedded skill sets, and an overarching strength. No one should assume that northern and Indigenous communities lack the knowledge and skills to embark on energy transitions. The resilience of skill sets in a community, which can be adapted and transferred to new types of energy systems and transition efforts, is important in understanding local capacity.

CONCLUSION

This research aimed to understand the socio-technical baseline capacity for renewable energy transition in Gwich'in communities in Northwest Territories, Canada. In doing so, this research serves to advance knowledge and create opportunities for other northern and Indigenous communities to inform the exploration and assessment of their own baselines, energy futures, and opportunities for energy transitions. Building on the scholarly literature and drawing on lessons from on-the-ground assessment, our study provided insight into the socio-technical baseline capacity challenges and strengths of remote, northern Indigenous communities for embarking on energy transitions. The results paint a complex regional picture of multiple strengths and challenges and forms of socio-technical capacity across communities. Our results also reveal often diverging perspectives on socio-technical capacity strengths and challenges between community members and other participants, but also differences between the smaller, more isolated communities and the larger community of Inuvik. Strengthening sister-community relationships within the region to share skills and resources, and building new relationships with communities outside the region to learn from community energy innovators are foundational to establishing local socio-technical capacity for local energy transitions. However, a cross-cutting lesson emerging from our

research is that capacity building opportunities, from local energy leadership and education to skills development and youth engagement, must be shaped by local community values, needs, and desired energy futures.

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