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Transformative power production futures: citizen jury deliberations in Saskatchewan, Canada

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Abstract

Background Transforming power production systems to achieve net zero emissions and address climate change will require deep structural changes, partially dependent on community perceptions of the necessary energy transition. The article presents results from 2-day citizen juries held in four communities of Saskatchewan, Canada: Estevan, Swift Current, Regina, and Saskatoon in 2021/22 whose purpose was to determine if place attachment impacts future power production preferences and whether social learning can be achieved. Mixed research methods included a survey before and after the citizen juries and a qualitative analysis of the discussions and outputs.

Results Research results confirm that while there are common concerns across communities about unbiased information, transparent decision-making, justice/equity concerns, and people's involvement, community-imagined energy futures can be very divergent. Not only place-based attachment, the existent industry and infrastructure surrounding the community impact preferences but also openness to learning and group dynamics contribute. Focused deliberations on the complex problem of climate change advance social learning.

The coal, oil, and gas community of Estevan supported coal, natural gas, and carbon capture and sequestration (CCS) to a substantially larger extent than other communities, even increasing their preference for coal after the citizen jury. Saskatoon chose Small Modular Reactors (SMR) as their top choice, whereas Swift Current switched from preferring natural gas to solar and SMRs.

Conclusions The findings from the jury sessions suggest changing attitudes toward SMRs as a potential source of energy, as well as a shift from cost considerations to environmental. Future research implications could include differing methodologies and potentially partnering beyond academia. Jurors all expressed the desire for greater government leadership, urging the government to demonstrate accountability, hold large enterprises accountable, and be more proactive in bringing parties together.

Keywords Place-based energy systems, Clean energy technology, Renewable energy, Carbon capture sequestration, Small modular nuclear reactors

Background

The Earth is well on its way to a warming of 3 Degrees Celsius and unless Greenhouse Gases (GHGs) are immediately reduced, achieving the global target of approaching 1.5 Degrees Celsius is out of reach. All emission scenarios predict that the global surface temperature will continue to increase until at least mid-century [1]. The Intergovernmental Panel for Climate Change explicitly

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identified the urgent need to reduce emissions between 45% and 50% by 2030 and phase out fossil fuels, including coal by 95%, oil by 60%, and gas by 45% by 2050 [1]. While great progress has been made in expanding on renewable energy, many power production systems are still highly dependent on fossil fuels, including coal and/or natural gas, including the case study province of Saskatchewan, Canada.

Historically Saskatchewan's power production has been predominantly (70%) fueled by lignite coal [2], an especially dirty and high emission fuel source [3]. However, transition is happening. By 2030 only coal with CCS will be allowed to operate in Saskatchewan [4]. Wind, solar, and natural gas have been added, but natural gas will no longer be available in facilities built after 2024.[1] Saskatchewan's future options include expanding CCS on its existing natural gas facilities, importing more hydroelectricity from Manitoba Hydro, massive expansion of wind and solar (along with the necessary transmission and distribution required), and Small Modular Reactors (SMRs). Four Canadian provinces (Alberta, Saskatchewan, Ontario, and New Brunswick) have committed to coordinate the exploration of SMRs for deployment. Ontario and New Brunswick already have nuclear power generation and are leading SMR deployment with projected availability in 2026 [5].

While technologies exist to achieve net zero emissions, the combination appropriate in a particular region is a complex problem dependent on activities in other sectors (industrial, mining, transportation, etc.), but most importantly social values and priorities that are often informed by peoples' attachment to place [6–9]. 'Place attachment,' is the relationship between people and their spatial settings [10]. Studies have determined that clean and renewable energy projects tend to fail when they conflict with people's sense of place, or perception if a project is a 'fit' within their geographic community; it is these sentiments that are determinative of success or failure and not the idea of 'not in my backyard' [11, 12].

Most studies document why a particular project failed [13, 14], and therefore, there is a gap in understanding and building community perception and imagination of the upstream, pre-project, most desirable power production portfolio [11, 12, 15, 16]. This gap contributes to the continued dominance of fossil fuel power production [16, 17]. Achieving the change necessary to end dependence on fossil fuels requires the participation of people in decision-making to inspire significant reflection and transformation in the personal sphere of ideas, values, and paradigms [18, 19]. Employing the method of Citizen Jury, this research advances social learning, through deliberation, dialogue and reflection [20] to achieve a change in understanding or belief [21].

This study engages people in imagining whole power production portfolios to achieve net zero emissions in the future. Results are analyzed based on three different communities in Saskatchewan, Canada. This research answers the questions: (1) how do peoples' sense of, and attachment to place impact their preferences, learning, and facilitated group strategies for power production into the future? (2) Do 2-day deliberative citizen juries with expert presentations advance learning and social learning?

Literature on place attachment, learning, and participation of people is reviewed followed by a detailed account of the research methodology. Results of the research are outlined followed by a discussion that concludes the article.

Place attachment, social learning, and citizen juries

Although people overwhelmingly support renewable energy, for decades researchers have tried to explain why there is a gap in renewable and clean power production implementation. One avenue has been to advance understanding of place-based characteristics, or place attachment, surrounding failed renewable energy projects in a particular location. Place attachment is defined as:

> *..positively experienced bonds, sometimes occurring without awareness, that are developed over time from the behavioral, affective, and cognitive ties between individuals and/or groups and their sociophysical environment. These bonds provide a framework for both individual and communal aspects of identity and have both stabilizing and dynamic features [22].*

Place attachment, a part of the more general notion of the sense of place, is a complex outcome of both individual and social interactions, influencing how people view their environment. Analyzing communities offers a framework for organizing these interactions in a meaningful manner. By exploring place attachment, one can gain valuable understanding not only of people's emotions toward their community but also of their behaviors [23]. While this broad definition is integrally linked with community attachment, key components include the features and attributes of a community that provide a distinctive identity [24] and the symbolic, cultural, historic, or functional meanings of a place [25]. Important criteria also include physical dimensions of place as well as the social environments [26].

[1] Regulations Limiting Carbon Dioxide Emissions from Natural Gas-fired Generation of Electricity (SOR/2018-261).

Evaluation of changes being made to the environment, including construction of a new nuclear plant or wind farm depends on the perceived contribution of the proposed project to the community's sense of place [12, 25]. The explanation of failed projects through a simplistic hypothesis, such as 'not in my backyard,' has been found to be lacking [12]. Although much place attachment literature relates to failed renewable energy projects [12, 27, 28], an emerging literature uses place attachment to understand peoples' perceptions surrounding whole system portfolios [3, 29] and address climate change [15]. Exploring people's power production preferences before decisions are made involves the participation of people in decision making and the advancement of social learning to achieve the transformation change required to address climate change and reduce GHGs [13, 30]. People's preferences expressed in energy discussions can provide an accurate understanding of their place-based attachments, cultures, lifestyles, and decisions in relation to decarbonized energy technologies [6, 31–33]. While there are many options for renewable and clean power production sources, the combination acceptable in any one community depends on people's preferences and values. People's perceptions of risk and benefits are important concerning their choice of new clean energy technologies and energy infrastructure [9, 34].

Involving the community in decision making is important for achieving social and environmental gains. Place attachment theory highlights people's shared emotional and functional attachment and provides important means for policymakers to identify and engage stakeholders in public participation by purposefully fostering and actively contributing to conversations [35]. In this manner, people learn more about an issue as policymakers learn more about people's values and thoughts surrounding appropriate policy. Acknowledging the three dimensions of people's sense of place (self-others-environment) provides a conceptualization of place values as potential drivers for place-based transformations by framing specific place-shaping initiatives in a way that favours their public acceptance based on a commonly shared sense of what is important and of value [36]. Significant transformational change required to create power production systems that have a net zero emissions balance which requires learning involving people; participation is necessary for inspiring action to achieve this gargantuan change and involves significant reflection in the personal sphere of ideas, values, and paradigms [18, 19, 37]. Involving people in addressing complex problems can advance social learning, solutions, and corresponding policy mixes appropriate for addressing these problems [38].

Social learning can enrich the acceptance of new technologies [39]. Social learning can be defined as a change in understanding of an issue that occurs as a result of interaction among people [21, 40]. While an argument is made for a broad flexible definition to facilitate innovation in sustainability and adaptability [41], others argue for a common definition to advance its evaluation [42]. In this paper, social learning is defined as a change in belief that results from the acquisition of knowledge [43] that could be cognitive (a change of views), behavioural (a change in practices or behaviour), or relational (a change of interconnections with others occurring at the group level) [44, 45].

The methods to advance social learning include facilitating "the ability of a structure, process a set of ideas to reconfigure itself in response to reflection on its performance" [20]. Cognitively, this occurs through deliberation or dialogue amongst people aimed at producing reasonable and well-informed opinions through discussion, exploration of new information, and open consideration of claims made by fellow participants. Participants must be willing to revise their preferences in light of discussion [46]. Citizen juries bring together members of the public (jurors) in a structured discussion through a facilitated and guided process of bottom-up decision making based on lay interests and knowledge (augmented with expert presentation) [47]. Results from citizen juries can be mobilized through social scientist distillation, jurors' advancement of their policy agenda, or a combination of these two approaches that is both qualitative, localized, dynamic, and discursive [48]. In general, citizen juries are structured in advance, but they can be determined by citizen participants rather than interest groups or sectors; sustainability issues can be addressed explicitly as well as an understanding of the construction of citizen value. Citizen values starkly contrast with more traditional consumer values surrounding environmental questions [49]. Citizen juries can be a tool of government, used within policy processes as an evaluation of different options [50], or a research exercise orchestrated by non-government institutions [20]. In this case study, citizen juries are the latter.

Methods

We employed 2-day citizen jury sessions to facilitate deliberative public engagement, aiming to understand, advance, and assess public perceptions and preferences surrounding power production sources. These citizen jury sessions were conducted from 2021 to 2022, encompassing four cities in Saskatchewan, as shown in Table 1.

We chose four comparative case study communities in Saskatchewan: Saskatoon, Regina, Estevan, and Swift Current which are depicted on the map (Fig. 1). Estevan

Table 1 Characteristics of citizen jurors

City	Population	Participant
Saskatoon	266,141	10
Swift current	16,750	11
Estevan	10,851	14
Regina	226,404	13
Total		48

Source:https://www12.statcan.gc.ca/census-recensement/2021/dp-pd/prof/search-recherche/lst/results-resultats.cfm?Lang=E&GEOCODE=47

is a fossil fuel dependent community that has the bulk of Saskatchewan's coal power generating stations, including the world's first post combustion carbon capture and sequestration (CCS) project [51]. Regina is the capital of the province located in the center of the other communities and hosts a steel and pipeline fabrication plant, a canola crushing industry, and a Co-Op Oil and Gas Refinery [52]. Saskatoon borders on the fringe of the boreal forest in Saskatchewan's north and is situated on the South Saskatchewan River [53]. Swift Current is located close to the Alberta border in Saskatchewan's south in its driest semi-arid region which is home to rangeland (Cattle

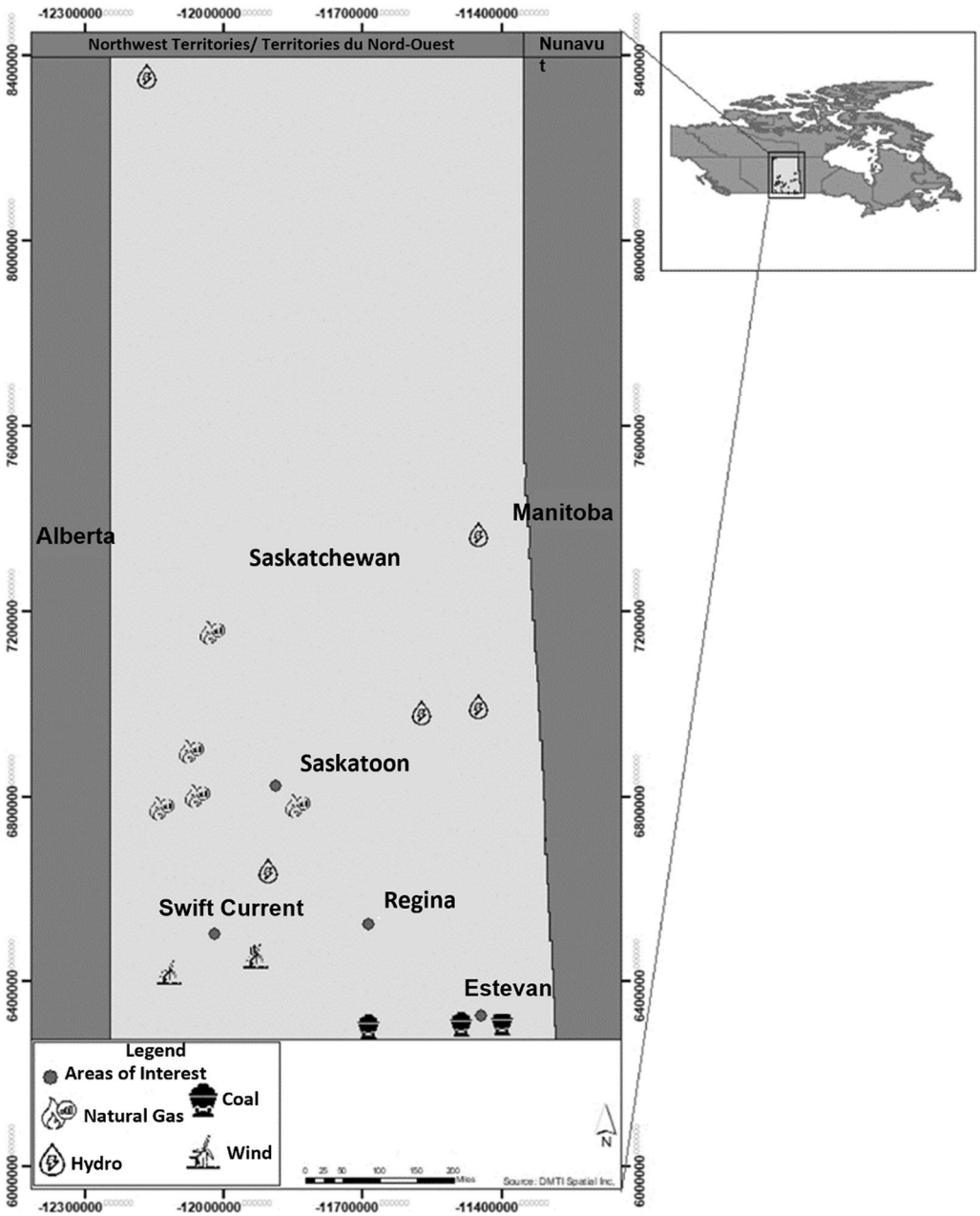

Fig. 1 Map of Saskatchewan showing citizen jury communities and major power production facilities

production), and Saskatchewan's first wind power production farms [54]. Swift Current is also the place, where Saskatchewan's first wind turbines were installed and the majority of wind farms exist. These include the Cypress Wind Power Facility (16 turbines—11 MW) opened in 2002, the Centennial Wind Power Facility (83 turbines—150 MW) opened in 2006, the Morse Wind Facility (10 turbines—2.3 MW) opened in 2015, the Riverhurst Wind Facility (3 turbines—10 MW) opened in 2021, the Blue Hill Wind facility (35 turbines—175 MW) opened in 2022 [55].

The jurors were selected through random phone calls to published phone numbers. While randomly selected based on residence in the community, with only 48 jurors, this study is not a representative sample by gender, age, occupation, or income of Saskatchewan. There is also a self-selection bias to participating (those interested in power production futures) and potential bias toward an older demographic given that only listed phone numbers were used. The number of jurors and population of the communities is presented in Table 1.

An expert facilitator moderated the citizen jury sessions over a virtual meeting space conducting pre-set activities, asking expert presenters questions (advancing discussion on risk, preferences, and perceptions of power production sources), and ultimately developing criteria of decision making and recommendations for government in future power production planning. Sessions were transcribed and analyzed thematically by the researchers surrounding the different sources of power production (coal, Carbon Capture Storage (CCS) and Small Modular Reactor (SMR), natural gas, wind, solar, hydro-electricity).

During the first day, the participants were divided into groups to engage in discussions pertaining to the energy challenges faced by Saskatchewan. An expert from SaskPower (the provincial monopoly power production utility) delivered two comprehensive PowerPoint presentations. The first presentation encompassed SaskPower's mission, sustainability plans, greenhouse gas (GHG) emissions, and considerations for transitioning to decarbonization, including the current supply mix and supply planning. After this session, the participants compiled a list of questions and concerns based on the provided information, which were subsequently addressed by the expert. The second presentation centered on SaskPower's future approach, exploring future supply options, 10-year plans, and emission targets aligning with provincial and federal goals for 2030 and beyond. Similar to the first session, the participants had the opportunity to pose questions to the expert after the presentation. The participants engaged in discussions on essential factors influencing SK's energy policy. The first day concluded with participants expressing their preferences regarding energy alternatives, such as CCS and SMR based on their learnings throughout the day.

On the second day of the session, the participants commenced by reflecting on the discussions from the previous day. An academic researcher delivered a presentation on potential low-carbon futures for SK, exploring various alternatives. As with the prior day, the research presentation was followed by a brief question-and-answer session, providing participants with an opportunity to seek further clarification. The questions posed by the participants during both days are consolidated in Additional file 1: Table S4, which can be found in Appendix SI section. Participants then expressed their preferences for specific energy alternatives, including Northern SK wind, Local wind, SMR, and CCS. These preferences were recorded to capture any changes that may have occurred over the course of the 2-day citizen jury session. The citizen jury session culminated in the participants formulating their recommendations for the SK government's energy policy.

In deliberative public engagement, participants are regarded as citizens, important in decision making and policy processes, and also as scientific citizens, engaging in the driving assumptions and values of science that interact with a range of social concerns and meanings [56]. By opening scientific knowledge, its underlying values, driving assumptions, and uncertainty open to broader public scrutiny and debate, new conditions for knowledge formation and alternative directions for public agendas and policies become available [57]. To advance the reflexivity of participants, we allowed a balanced dialogue of our participants with experts to open up, and not close down conservations surrounding science [20] (involving climate change, power production sources, and planning). Facilitated group discussion on both days advanced the group's social relations (identified as important by Armitage et al. 2017) [58]. After participating in an icebreaker at the beginning of day 1, jurors identified energy challenges and challenges in developing a future power production strategy. Jurors then worked as a group to develop a consensus on the most important factors for a power production policy (days 1 and 2) and make recommendations for the government (end of day 2). Findings are reflected in Tables 2 and 3. Time for reflection (identified by Dryzek and Pickering 2017) [20] both as individuals and groups was provided as well as opportunities to critique and advance group developed plans.

The 2-day duration, while less than the ideal of 4 days [59], allowed for all jurors to complete the process without attrition, and full absorption of climate change and power production issues. Expert presentations were kept to 15 min to maximize information retention of jurors

Table 2 Most important factors for a good power production policy

Theme	Estevan	Regina	Saskatoon	Swift current
Most important factors for a good power production policy—day 1				
Cost/Economics	Inflation and cost of unemployment need to be considered	Consider all costs and rebates for consumers	Equitable distribution of costs to protect small-scale producers	Government needs to cover the cost of retrofitting houses and rising food prices
	Consider the economic impact of the energy options		Avoid disproportionately favouring large-scale producers	Expand GDP
Education	Incorporate more resources on climate change in the curriculum	Deliver informative public education tailored to the specific audience, devoid of sales tactics	Revise school syllabi to incorporate science-centered programs for everyone	Prioritize additional testing of SMRs and CCS, then expand wind and solar projects
	Promote awareness of global climate action activities	Proper public consultation on diverse energy alternatives and decisions	Facilitate the exchange of university and scientific knowledge within the community	
	Create recognition for companies, networking systems, and websites with clean energy/low emissions			
Environment	Integration of multiple factors, including waste management, transportation, and water while avoiding conflicts	Sustainable alternatives considering future generation	Assess environmental impacts for future generations considering the whole life cycle of all technologies	Consider the impact of extreme climate events
		Consider all impacts of climate change		Consider a sustainable energy option that is going to last
Decision-making	Governments should cooperate and everyone needs to do their part	Transparency in everything, including risks, financial implications, public consultation, goals, and vision	Incorporate Indigenous knowledge and promote Indigenous partnership with leadership involvement	
		Access to information		
Most important factors for a good power production policy—day 2				
Social impact/cost	Solutions should be cost-effective for vulnerable people	Cost should not hinder the goal	Energy must be affordable to all	Capacity for GDP growth
	Employment considerations are important	Prioritize provincial well-being over generating profit	Cost considerations from inception to disposal	Ensuring general financial stability
		Comprehensive end-of-life cycle planning for power production		
Education	Provide education through clear communication	Unbiased education	More consultation and education	Need better and more understanding of nuclear energy
	Organize public forums for engagement	Easier access to information		Gradual implementation and testing of CCS
Environment	Government should adopt a proactive role and lead in addressing climate change	Local interests should be a priority	A comprehensive plan to reduce GHGs	Need full story, long-term consideration of risks, benefits, human cost, and transparency
Decision-making	All inclusive of people and options	Transparency of information and decisions with disciplinary action for failure	Create an ongoing community committee consultation model	
	Engagement forums with the community			

Table 3 Recommendation for the government

Theme	Feature
Public engagement and awareness	Engagement platforms (e.g., summits, dialogues) for the leaders, researchers, industry experts, and public to engage on climate change, potential future alternatives, project status, and effective practices Educating citizens on energy alternatives and sustainable energy practices Reduction targets and target years should be clearly laid out
Affordability	Energy alternatives should be economical and affordable for all
Cost implication	There should not be any hidden cost Cradle-to-grave cost should be laid out in plain language for citizens to make informed choices
Clear communication/Transparency	Citizens should be given the full narrative, including all benefits and drawbacks, as well as risk factors to make informed judgments
Leadership/proactive governance	Proactive holistic government approaches for a tangible and visible outcome A leadership to promote climate resilience strategy and sustainable energy policy
Evidence-based research	All the energy options need to be investigated thoroughly before committing to one Have a mix of multiple energy grids Learning the best practices
Sustainability	Overall sustainability in regard to energy options, financial aspects, research, capacity building of manpower, long-term environment impact, population-based customized alternatives

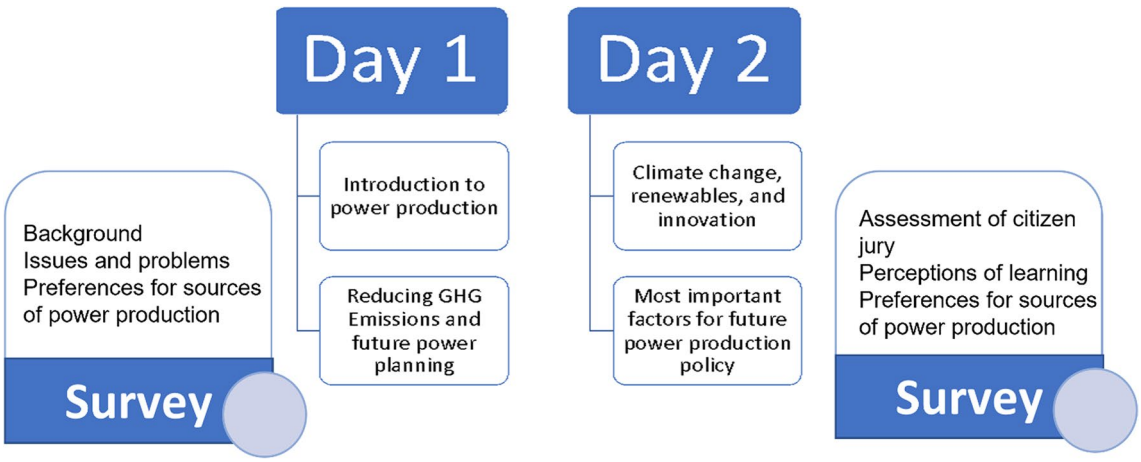

Fig. 2 Summary of research steps

and time for constructive dialogue. The same expert facilitator moderated all citizen juries.

Our comparative case studies not only provide evidence of social processes, learning, and context in relation to power production systems and their transitions [16] but also an exploration of place attachment. The steps employed in our research summarized in Fig. 2 allowed us to quantify changes in perceptions of power production sources pre- and post-citizen jury (important in monitoring opinion change [60], and together with qualitative analysis of focus group discussions, triangulate our research findings [61].

The citizen juries from four communities are not statistically significant, nor a representative sample. As well, there is a potential self-selection bias and older demographic due to the use of published phone numbers. Furthermore, we have used the mean of our results and not the median.. However, the Additional file 2: Appendix SII provides median calculations for each of the four cities individually and collectively, with corresponding visual representations in Figs. 3 and 4, offering supplementary insights for better understanding.

Results

Place-based perceptions of power production preferences

Two-day focused discussion on power production considerations had an impact on participants' perceptions of power production technology. Additional file 2: Figure S8 illustrates the change of perceptions from pre-citizen jury to post-citizen jury for all participants. While the sources of coal and natural gas declined in support, the sources of SMRs and solar increased. Support for hydro-electricity and wind remained constant (and high). However, the

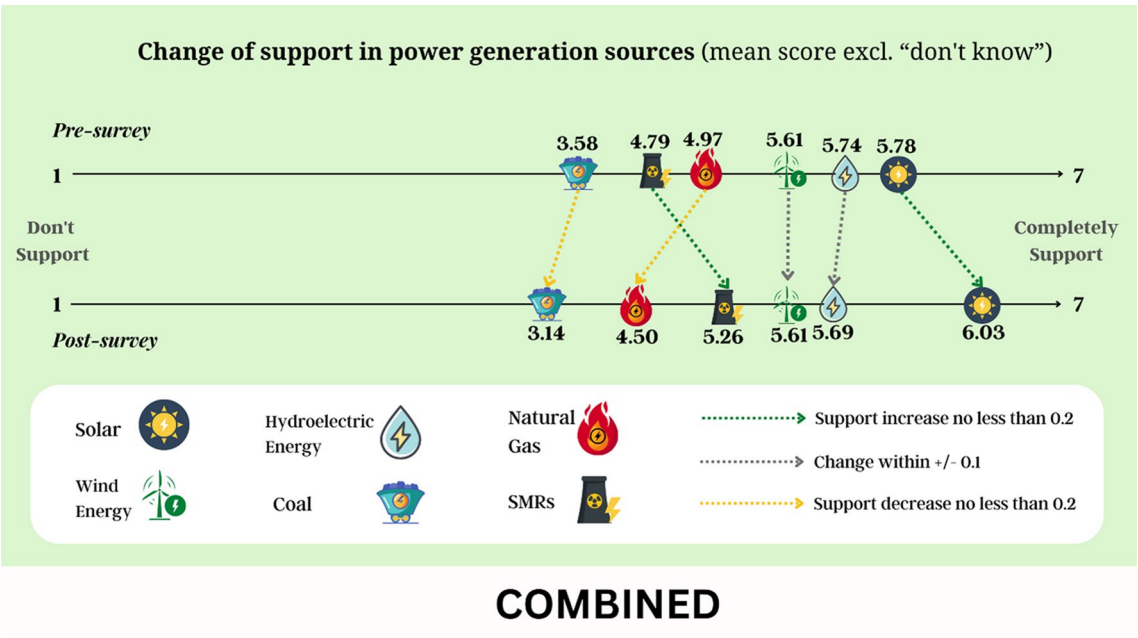

Fig. 3 Change in support for power production sources (All citizen juries combined)

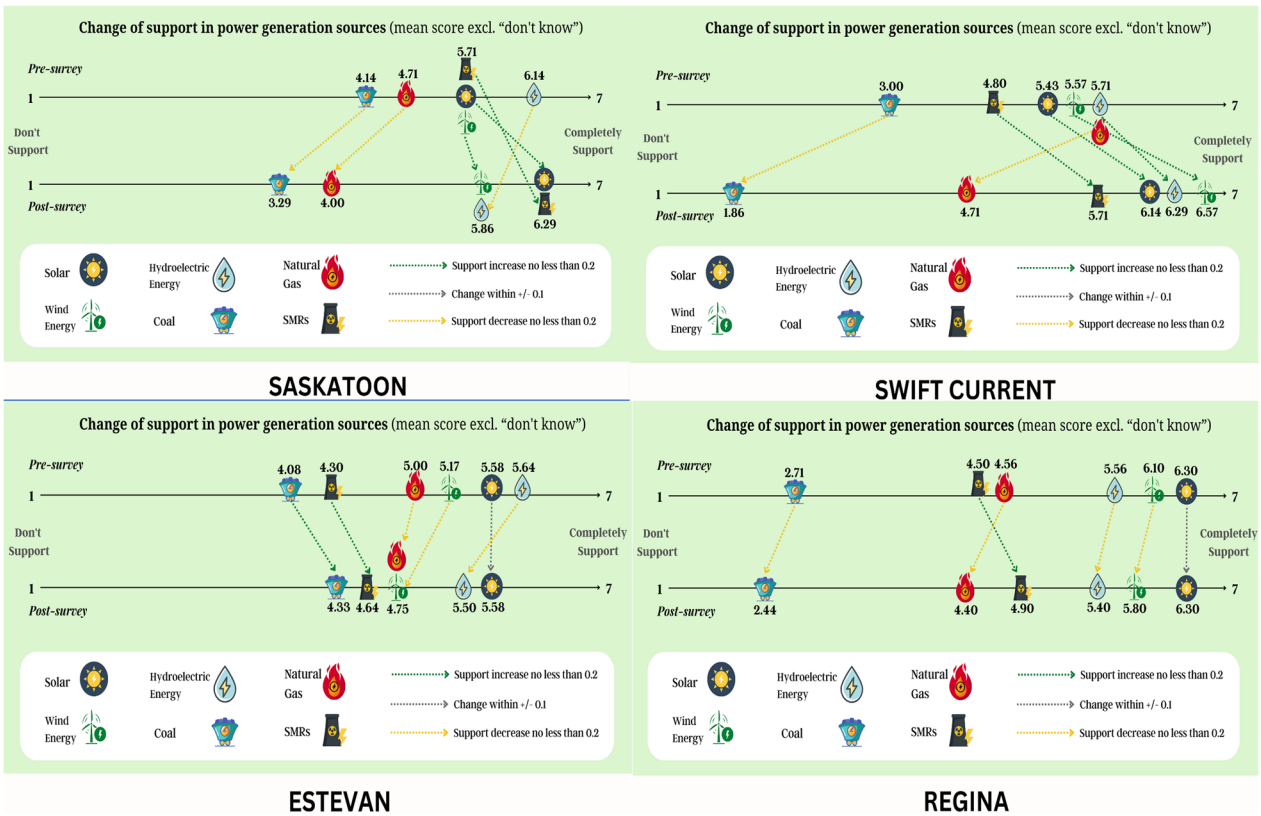

Fig. 4 Change in support for power production sources (citizen juries by community)

diversity of place can be seen by comparing each community's results in Additional file 2: Fig. S9.

Socio-technical systems of place matter

Significant divergence exists between the communities' responses that correspond to place-based socio-technical community systems. This is illustrated in three respects. First, Swift Current exhibited interesting place-based characteristics, corresponding to its unique place-based infrastructure. Swift Current is the most recent city in Saskatchewan to have a new 353 MW natural gas power production facility opened in 2019 at a cost of $605 million with 25 permanent workers [62]. It is close to one of two proposed sites for an SMR in SaskPower's fleet and is surrounded by wind power generation sites. On a 1–7 scale, pre-citizen jury surveys reflected very high support for natural gas power production ($\bar{x}=5.71$); natural gas tied with hydroelectric power production ($\bar{x}=5.71$) as the most favourable source followed by wind ($\bar{x}=5.57$), and then solar ($\bar{x}=5.43$).

Interestingly, the Swift Current focus group commenced its first day with several cautionary comments about wind power. One juror observed that acres of turbines in California are not working. After this, a discussion surrounding end-of-life and lack of recycling of wind turbine materials ensued. SC-2 (Swift current participant 2) reflected that wind turbines resulted in "*not seeing nature in the same way but seeing windmills and the impact on health of those living near them.*" SC-3 (Swift current participant 3) stated:

> *"There are some (windfarms) that have been implemented in Saskatchewan but they're dependent on the weather. So you have to kind of like have other alternative energy sources well in case it's not windy that day or that week or that month."*

Swift Current is also the citizen jury community closest to the Gardner Dam and Coteau Creek Hydroelectric Station. This area, and specifically the town of Elbow (124 km from Swift Current) was identified by SaskPower (after the citizen jury) as a potential site for an SMR (the other being in Estevan) [63]. Reasons cited included proximity to a water source, labour force, and exiting power transmission infrastructure (ibid.). Swift Current ranked second of the citizen jury communities (only after Saskatoon) in support of SMRs in the survey at the end of the citizen jury.

The second notable place-based socio-technological finding occurred in Estevan. Unsurprisingly, the community closest to historic coal mining and coal power production expressed the most support for coal ($\bar{x}=4.08$) and natural gas ($\bar{x}=5.00$) power production in both pre and post-survey, including combinations with CCS. This was consistent across the two separate citizen juries in Estevan. In fact, after consideration of new technologies and climate change drivers, Estevan supported coal more, especially coal with CCS. E-2 (Estevan participant 2) during the day 1 session noted:

> *"We discussed the community destruction that was going to result when energy towns, such as Coronach and Estevan lost their principal industries, which are the coal and oil extraction and power production from those sources; some of those communities are going to be really badly affected. Coronach is probably going to be a ghost town."*

The participants' support toward coal and coal with CCS can be observed with the questions jurors put together for expert 1, including, "*Clean coal: is carbon capture as terrible as depicted or is there some effectiveness that we could keep looking at this lowest and most cost effective (coal) technology?*" (comment from E-3 (Estevan participant 3) from 2021). In the question–answer session, there were questions about the possibility of utilizing CCS to prolong the usage of coal as it is the cheapest energy source. Jurors asked if carbon capture technology used for coal could be applied to reduce natural gas power production emissions. On day 1, Estevan's citizen jury chose stranded assets (current lignite coal mines) as one of Saskatchewan's top energy challenges and E-2 (Estevan participant 2) commented:

> *"Stranded assets, we have a lot of money invested in our existing coal fire generating stations, now we just walk away from those mines…we leave those units with good provincial taxpayers' money invested in those. What are we going to do about the infrastructure?*

In addition, the oil and gas sector was heavily emphasized during their discussion, as seen by remarks of E-3 (Estevan participant 3) in the day 1 session, "*We lose our coal industry around here and next gas industry is taking a hit. We want to make sure that oil and gas is out there added into the mix.*"

Additional file 2: Figure S9 depicts how this conversation resulted in Estevan jurors being even more favourable to coal in the post-jury survey (deviation about the median is 2.50 in the pre-test and 3.00 in the post-test), in contrast to all other communities, where coal was retained or reduced in favourability (Saskatoon and Regina had both 2.00 in the pre-test and 1.00 in the post-test).

The most northerly community close to the boreal forest tree belt, Saskatoon, was the most pro-environmental community, based on a few survey results. Saskatoon had the highest number of people agreeing that

climate change is a significant problem and disagreeing that enough is being done for the environment (both pre- and post-survey). In the group's final recommendation to the government, one key message was there, "No more space for climate change deniers" and a call for consistent messaging from the government and clear leadership. Saskatoon was also the only community that, in addition to focusing on comprehensive public consultations, separately identified the importance of incorporating Indigenous knowledge alongside scientific knowledge, the promotion of Indigenous partnership with leadership involvement, and that "*Indigenous community leaders and company (SaskPower (sic)) authorities should come together to decide on the way forward*", comment from S-5 (Saskatoon participant 5).

Given this strong environmentalism, it is noteworthy that SMRs were tied with solar in the post-citizen jury survey as the most supported power production source in Saskatoon. On a scale of 1–7, both SMRs and solar received a rating of 6.2. There are several place-based explanations. Saskatoon is situated close to uranium and nuclear facilities; it is the most northerly of the citizen jury cities, and closest to the uranium mining in northern Saskatchewan. It is also where the uranium mining giant Cameco's head office is located (49% owner of Westinghouse Electric Company, a leader in new nuclear power technology and SMRs). Cameco has recently signed a 12-year uranium supply contract to fuel Ukraine's massive nuclear power sector [64]. Finally, Saskatoon previously was home to a Slow Poke reactor and currently hosts a 24 MeV cyclotron nuclear facility [65].

Values matter but are changing

The landscape of nuclear power generation in the Saskatchewan landscape is changing. Values changed pre and post-citizen jury. Support for renewable and clean power production sources (solar and SMRs) increased and fewer people supported fossil fuel power production (Additional file 2: Fig. S8). While Saskatoon and Regina increased support for wind, Estevan and Swift Current decreased.

Previously, in 2008 large nuclear power plants had been considered and rejected in Saskatchewan. This was mainly due to the large geographical span of the Saskatchewan power production system, few clients and power needs, and the absence of any power production facilities greater than 350 MW on the grid [66]. However, climate change and policies requiring net zero emissions by 2050 are changing the policy and power production landscape. As illustrated in Additional file 2: Fig. S8, SMRs increased in popularity as a result of the citizen jury.

The most significant change in relation to SMRs occurred in the post-Citizen Jury survey in Saskatoon, where support increased to 10%. Out of a 1–7 scale, the citizen jury survey results preference of hydro ($\overline{x}=6.14$), wind ($\overline{x}=5.71$), and solar ($\overline{x}=5.71$) (in that order) which post-citizen jury resulted in SMRs ($\overline{x}=6.29$) in the lead with solar ($\overline{x}=6.29$) followed by hydroelectricity ($\overline{x}=5.86$) in a tied position with wind ($\overline{x}=5.86$). SMRs were also ranked ahead of natural gas and coal in Regina, and Swift Current; but wind, solar, and hydroelectricity were ranked ahead of SMRs in these cities. 20 of 36 respondents thought SMRs were a 'very good' or a 'fairly good' idea. Other changes in values were outlined in 3.1.1, where Swift Current's pre-citizen jury strongly supported natural gas power production, but the post-citizen jury did not, and where Estevan's support for coal and coal with CCS increased post-Citizen Jury.

This data from the citizen juries supports the information deficit model. This model provides that communication about issues in science and technology communication can increase public support by overcoming their knowledge deficit [31, 67]. The increased support for SMRs, Swift Current's reduction of support for natural gas within the context of climate change, and achieving net zero emissions evidence this.

However, for a few people, more information did not change their views (as recognized by Boykoff 2009) [68]. Although most were very favourable to SMRs, some indicated concern surrounding SMRs. Two people in Regina and one in Estevan still responded in the final survey that they felt nuclear was a bad idea. In an open-ended survey question asking people to explain why they thought it was a good or bad idea, the two that were negative about SMRs identified the fact the technology does not exist yet and the long lead time required to develop it. Thirteen respondents identified positive aspects of SMRs and eleven stated they needed more information. One of these respondents, E-5 (Estevan participant 5) from day 1 session of 2022, stated:

> *"I think it would be more expensive, dangerous, economy crashing, and I feel like I'm being given the 'pretty sales pitch' version of details and not the whole picture."*

These statements, although few in number, support opponents of the deficit model who argue that people's sense of risk extends beyond rational, scientific considerations and includes culture, trust in the communicator, religion, and sociodemographic factors, such as education or age [68]. Arguably Estevan's continued support for coal and coal with CCS post-citizen jury also reflects context and culture, and as pointed out in 3.1.1, place-based attachment impacting deliberations.

Embracing environment and rethinking economics and justice

All citizen juries rethought their primary consideration when making decisions relating to future power production sources in Saskatchewan. In Estevan, Regina, and Saskatoon, at the outset of the citizen jury, one of the top considerations in setting a power production strategy was identified as 'cost' (impact on consumer bills). Only Swift Current identified power production source's effects on the environment as its primary consideration at the citizen jury's start. However, by the end of the citizen jury participants in all three communities ranked cost as the third, or last, consideration. All four communities identified energy independence (not relying on foreign power production sources) as the primary consideration for decision making at the end of the citizen jury. This shift from cost considerations to environmental is also reflected in the outputs of the citizen juries between those factors identified as most important for future power production and energy strategies on day 1, versus day 2, outlined in Table 2.

In the discussion of cost on the first day, much of the discussion centered on principles of wealth generation and expanding GDP. Regina participants even concluded that 'cost should not hinder the goal' of addressing climate change. Both Regina and Saskatoon determined that all costs of power production options from cradle to grave or full life cycle, needed to be considered. However, by day 2, only Swift Current still mentioned the importance of expanding GDP and financial stability. The remaining three communities' discussions turned to the impact of increasing energy costs on the poor and vulnerable. It is interesting that issues of justice and morality informed citizen jury deliberations. This confirms that building climate mitigation and resilience futures inherently underpins justice issues [69, 70]. Citizen jurors were only asked about factors and characteristics of power production strategies; there were no prompts or questions surrounding justice or equity considerations so these intrinsically arose in the jurors' discussions.

Place-based social learning

As outlined in our methods above, the 2-day citizen juries' purpose was to facilitate social learning concerning climate change and mitigation of GHGs in relation to power production. After the citizen juries, participants ranked their knowledge higher about how energy is produced, delivered, and used. In addition, more people agreed that 'climate change is an immediate and urgent problem' after their participation in the citizen jury. All participants increased the level of belief that ordinary citizens should be involved in complicated technical decisions.

While measurable changes in opinions are evidenced in Additional file 2: Fig. S8, there were significant differences in these results depending on the community. While Sect. 3.1 establishes that 'place' makes a contribution to these differences context and group dynamics do as well. Quantitative and qualitative data illustrated how the groups' learning readiness within group expertise also impacted results.

Learning readiness

Pre-survey questions inquired on the level of interest in issues, including new medical discoveries, local education issues, new inventions and technologies, environmental pollution, economic issues and business conditions, and new scientific discoveries. Most participants were very to moderately interested in all of these topics. However, what is notable is that in Saskatoon no one chose 'not at all interested' in regard to any of these. Each of Swift Current, Regina, and Estevan had someone identify disinterest in one or more of these topics. Saskatoon also had the highest proportion of participants identify as 'not at all interested' in sports.

In Saskatoon, the initial questions for the expert were "tell us more" in relation to both CCS and SMRs. Later questions concerned what the benefits of SMRs were, how to address perceptions of SMRs, why Saskatchewan was not being aggressive on hydrogen, how to measure the whole life cycle of emissions, and where CCS technology and development was headed. Other citizen jury questions in other locations were very targeted and less open-ended. Regina's questions included questions surrounding electric vehicles, the cost of SMRs, the safety of the 90-year-old Saskatchewan grid, transportation, disposal of nuclear fuel, and who pays the cost of education and insurance. Estevan's questions concerned what was happening surrounding flaring and oil and gas production, carbon offset strategy, recycling of wind turbines, recycling of all materials in general, solar panel waste, peak uranium, and why small scale solar was not being supported. Swift Current questions included why SMRs were taking so long, Saskatchewan's change in solar policy, what peak power was and its implications, and the future of hydrogen.

Participants were asked "There is a lot of talk these days about climate change; that is a long-term change in the planet's weather patterns and average temperatures. People have different views about climate change. Which of these statements best reflects your own views?" People were given choices from "don't know", "I'm still not convinced that climate change is happening" to "climate change is an immediate and urgent problem." Estevan had one person both in pre- and post-citizen jury choose that they were not convinced climate change is happening

and had the least amount of perception change toward identifying climate change as a problem. Swift Current, Saskatoon, and Regina all experienced a significant swing in post-citizen jury survey toward identifying climate change as an immediate and urgent problem. One participant in Estevan in post-citizen jury stated they had "never heard of SMRs before;" even though the second energy expert presented several slides covering SMRs. However, at the end of the citizen jury, the overwhelming majority of participants stated they 'know a bit about SMRs.'

The presence of expertise in a group

There was a nuclear expert participant in both the Regina and Saskatoon citizen juries and two CCS experts in the Estevan citizen jury. These respondents identified as 'knowing a lot about SMRs/CCs", respectively. While Saskatchewan does not yet have nuclear power generation, we conclude that this expertise may have impacted social learning in both these citizen juries. In Estevan it is unclear how to separate the influence of these experts from the place-based values of coal, oil, gas, and CCS, given Estevan is the home of the world's first postcombustion power production CCS plant.

Place-based energy policy considerations

Between expert presentations and the facilitated development of questions for the experts, the citizen jurors worked in groups developing and agreeing on the most important characteristics of an energy strategy (days 1 and 2) for the province and making recommendations to the government (end of day 2). The results of the discussions are summarized in Table 2.

Education, environment, and decision making

Dominant themes that were discussed on both days included education, environment, and decision making. Costs are discussed above in 3.1.3. While citizen juries were asked on the last day to develop their most important recommendations, ideas were developed in considerable detail on day 1 that warrant mention. Over the course of 2 days, the development and refinement of ideas can be observed within the three themes.

Education was a predominant theme most discussed in all citizen juries. The depth and breadth of the discussions could not be summarized fully in Table 2. Education recommendations related to the topics of climate change, clean energy, and technologies of CCS and SMRs. Discussions reflected a desire for unbiased information and 'not receiving a sales pitch.' The target of education included the school curriculum and young people to all ages of people, and businesses. Citizen jurors wanted more information, especially surrounding the newer technologies of CCS and SMRs. Swift Current wanted local domestic input into the design, manufacturing, service, and testing of new technologies (including SMRs and CCS) in Saskatchewan (not waiting for results from other provinces). Transparency in this testing and a greater understanding of the public was a dominant theme on both days in Swift Current.

While Swift Current strongly worded the education obligations toward government, Saskatoon endorsed a wider ambit of responsibility from schools, to public science-based programs for citizens to tour different energy alternatives (tech companies, oil and gas, etc.) and university research groups to share their insight. Ultimately Saskatoon tasked the government with developing a comprehensive consultation and education plan, requested the government to provide clear leadership and expunge any government members who were climate change deniers. Estevan stressed the importance of education and full disclosure for transparency and trust building of 'everybody at every direction at every level.' Retaining a mix of multiple power production sources and including the full narrative of all options without a 'back door policy' was identified as important. Regina also expressed concern about receiving a 'sales' pitch and identified increased funding of public education, albeit appropriate for the target audience.'

Even before the third expert presentation on day 2 concerning climate change, socio-economic impacts, and whole system solutions, citizen jurors discussed the environment in a holistic manner. Swift Current's day 1 recommendation surrounding the environment identified the consideration of the impacts of extreme climate events on their community (closely replicated in Regina and Swift Current) and Estevan identified the full integration of considerations of the environment, including water, waste management, and transportation to avoid conflict. These considerations continued into day 2 and were expressed as: long-term considerations of sustainability in Swift Current; long-term futuristic energy alternatives for stewardship by Saskatoon; sustainability, affordability, economic and environmental impacts, and dependability for generations to come in Estevan; and sustainable alternatives considering future generation in Regina.

Only Swift Current did not discuss the process of decision making. As a result, there is no description in its row in Table 3. Swift Current used the language of 'we' need to do things, and ultimately when asked for government recommendations (below) identified several. Swift Current worked as a group and even when making their recommendations to the government "affirmed their collective priorities as a group."

Saskatoon also stood out in relation to decision making as it was the only community that identified the requirement of Indigenous partnership and leadership involvement. On day 2, Saskatoon recommended a committee consultation model with the public for decision making with adequate representation of community members, complete with education and consultation, in their community. Estevan made a similar request for a community consultation summit, even stating the Saskatchewan urban and rural municipal organizations should cooperate on hosting it.

Finally, Regina, the government city, focused on transparency, clear messaging, and disclosure of information and consultation.

Recommendations to government

In the citizen jurors' final exercise, recommendations to the government were compiled. The southern oil and gas communities of Swift Current and Estevan specifically identified considerations of job security and the need to retain jobs with technological advancement.

All citizen juries emphasized the requirement for continued clear communication with and involvement of citizens in future decisions surrounding power production. Saskatoon emphasized a comprehensive emission reduction strategy with diversified energy alternatives, environmental considerations, and a cradle-to-grave costing of all options.

Finally, all citizen juries placed an emphasis on the need for leadership from the government. While Estevan desired a proactive integrated government approach for tangible and visible outcomes, Saskatoon called for leadership and government to make difficult decisions, demonstrate accountability, and hold large enterprises accountable. Swift Current requested the provincial government establish a much greater understanding of nuclear technology and other viable technologies and clearly laid out policies to the public being upfront with dates (2030). Even Estevan, the coal, oil, and gas community asked that the government be more proactive in addressing the climate change challenge, be a leader of climate change and the environment, and take a strong role to facilitate and bring parties together collectively.

When asked during post-citizen jury, if participants feel more or less likely to take action on an issue (such as attending a demonstration, signing a petition, or attending a public meeting), Estevan participants were significantly more likely to do so than the other communities. Choices about who gets to imagine climate change futurities may set the stage for which social relations are legitimized over others [71] and whose relations, local assets, or values are important and whose lived experiences are worthy of protection [72]. Our research results confirm Estevan, the coal, oil, and gas community is very interested in sustaining participation in decision making surrounding power production.

Discussion

Citizen juries held in 2020 and 2021 in four communities in Saskatchewan, Canada provide both quantitative and qualitative data to understand power production preferences. This research found that peoples' sense of, and attachment to place impact their preferences for power production sources into the future. Thus, context matters [12, 32, 68]. However, we also found considerable support for the proposition that providing information and filling jurors' deficit of knowledge impacts perceptions challenging the conclusion that providing information is unable to address pre-conceived bias [7, 67]. Two-day deliberative citizen juries with expert presentations advanced learning and social learning; identifiable and measurable learning was common across three comparative communities in Saskatchewan, Canada, but influenced by the groups' readiness to learn and the presence of power production experts within focus groups.

Although not a representative sample, the 48 citizen jurors expressed common ideas and learning. Being confronted with the dual problems of climate change and imagining future power production sources that achieve net zero GHG emissions, resulted in jurors supporting renewable and clean power production sources to a greater extent. Quantitative data confirms that citizen jurors perceived they were more knowledgeable after participating in citizen juries and identified climate change as a more urgent problem. Cost and economic considerations also decreased in importance.

Common concerns in the four communities include access to unbiased information, extensive education concerning climate change and new power production sources, transparent information and decision-making, and the involvement of people. However, place-based considerations inform community power production future imaginaries and priorities and can be very divergent [73]. Estevan, the coal, oil, and gas mining center endorsed coal, natural gas, and CCS to a significantly greater degree than the other three communities even increasing their preference for coal in post-citizen jury (driving factors for these decisions reflected in the citizen jury discussions were in relation to the loss of jobs in the community). Swift Current, Estevan, and Regina all identified job loss as an important consideration of a future power production strategy (confirming Healy and Barry's findings (2017) [74]. Citizen juries identified visions to achieve measurable change [18, 19].

Swift Current moved from prioritizing natural gas as their first choice to solar and SMRs; Saskatoon

prioritized SMRs as their first choice. While place-based characteristics help explain these preferences, group context does as well concern learning readiness and the presence of expertise within the group. Therefore, while place attachment is clearly a driver of preferences [12, 27, 28], social learning within groups also contributes.

Resource rich communities (which include Swift Current and Estevan) do have unique concerns which include employment and job security [9, 34]. These concerns will need to be addressed in these communities when transitioning to net zero emissions. While the 'not in my back yard' concept has been resoundingly rejected in explaining public opposition to new developments near homes and communities in relation to energy technologies [11] fossil fuel rich communities (Estevan) have unique perceptions because of what is in their back yard (including pre-existing CCS). Because of this, this community supported coal with CCS more than other communities due in part to considerations of economy and job loss. These citizen juries demonstrate that energy justice and morality inherently underpin citizen jury deliberations [69, 70]. Without prompting, issues of poverty, vulnerability, and Indigenous rights, involvement, and leadership were earmarked as important.

Saskatoon and Regina demonstrate divergent priorities and confirm that bottom-up deliberative methods vary by community and recognizing this acknowledges the 'messiness' of energy transitions [75] and the existence of multiple controversial perspectives [76]. Effecting community energy futures in this manner confirms that it is neither simply an 'information deficit', nor selfish, ignorant, or irrational objection to certain options that prevent imagination [7]. The best approaches employ plural lenses embracing a plurality of views, employing reflexivity, and demonstrating an understanding of the politics of energy futures [76], and simply filing an information deficit is insufficient; citizen jurors strongly recommended more information and education. While fossil fuel-based communities need concerns about economics and jobs addressed, they were more amenable to clean technology, such as CCS. Other communities require concerns of vulnerable, poor people, and Indigenous rights to be addressed. Given that our participants are potentially an older demographic and not representative (given the small number of jurors), determining concerns at the outset of a citizen jury would be good practice. Furthermore, it is probable that younger participants would have different concerns and perspectives.

Citizen jury research sheds light on how groups of citizens address complex problems of climate change and achieve net zero emissions in the future. Insights were provided by jurors expressing their preferences in relation to power production technology, their understanding, values, and concerns for new technology (including SMRs, CCS, and renewable energy wind). Citizens are very interested in participating in decision making to achieving net zero emissions and oil and gas communities show particular interest in job security. However, all communities want the federal government to take leadership, be more proactive in addressing climate change, play a strong role in bringing parties together, make the difficult decisions, demonstrate accountability and hold large enterprises accountable.

Conclusions

This comparative case study research employing citizen juries in four Saskatchewan, Canada communities offers insights into place-based dimensions of imagined energy futures. At the same time, the research confirms social learning and group context determine outcomes. Although not statistically significant nor representative, important policy recommendations for government are triangulated amongst the communities, and include broad communication, education, and people's involvement in decision making.

While place-based attachment informs community imagined power production futures in the context of climate change, social learning is still possible and even oil, gas, and coal communities can imagine a new future. This future might include technologies, such as CCS, that are less acceptable to non-oil, gas, and coal communities, but still endorsed by the international energy community and IPCC as part of the solution [77, 78]. Furthermore, in a Saskatchewan context where fossil fuel power production is no longer permitted and hydroelectric resources are scarce, opportunities for new technology (including SMRs) may be present.

This research contributes to a growing body of literature that addresses a gap in upstream system power production portfolios [15] going beyond merely analyzing a failed renewable energy project [14]. Research results demonstrate that significant transformational change through learning involving people [18, 19] can happen with 2-day citizen juries, addressing a gap in the literature [13]. Two-way information flows through facilitated exchanges with experts and group exercises advancing reflexivity, can engender transformational change in perceptions of power production sources.

While these citizen juries in four Saskatchewan communities' evidence social learning for sustainability, to achieve transformational change, more is needed. Increasing the number of citizen juries while retaining the quality through representative sampling, maintaining the 2-day duration as well as the quality of expert–participant interaction will be important. It would be possible to experiment with both methods of selecting

jurors (potentially excluding those with expert backgrounds in the subject matter) and structural flexibility within the citizen juries to account for place-based attachment. These juries were orchestrated by social scientists. While partnering with government or civil society organizations in this work might provide the necessary leverage to increase the number and geography, the downside might be reduced structural consistency and perceived neutrality of the researcher.

The limitations of these citizen juries included a potential overrepresentation of older participants. This, in combination with the small number of participants (48), reduces the representativeness of the participants [47]. Although the citizen juries were conducted with the same structure, expert presentations, and questions, there is a possibility of differing conclusions given the participants, and their relative interests, power dynamics, and emotions.

Future research questions remain including how to deploy power production preferences that are diverse between communities and how to accommodate diverse community preferences. Randomly selecting jurors provided a relatively representative sample. However, screening to ensure gender and other demographic characteristics might improve the research results. Furthermore, screening out experts in power production would also allow groups not to potentially be swayed by these participant experts (However, social groups are inherently populated with participants with differing education and background). Further citizen juries that are representative of a regional or provincial jurisdiction could also be compared to the results of local, place-based juries testing for the impact of local place versus region.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13705-023-00424-1.

Additional file 1. Participant questions from the jury sessions are shown in Table S4.

Additional file 2. Median calculations.

Author contributions

MH primarily wrote the paper, providing the overall structure, framework, and content. She conducted the initial research, formulated the main arguments, and ensured the coherence and flow of the manuscript. TD conducted the qualitative analysis, contributing to the interpretation of the data and providing insights into the findings. She assisted in editing the paper, ensuring the accuracy and completeness of the cited sources, and in presenting the data visually. CV conducted the quantitative analysis, employing statistical methods and tools to analyze the data. She contributed to the numerical interpretation of the findings and provided statistical support for the conclusions drawn in the paper.

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Availability of data and materials

Available upon request.

Declarations

Ethics approval and consent to participate

Our study received ethical approval from University of Regina's Research Ethics Board and consent forms were collected from participants for both participation and publication.

Competing interests

The authors have no competing interests that might be perceived to influence the results or discussion reported in this paper.

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