YOUNG SMART CITIES

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Cooking with the Sun

Solar-Powered Clean Cooking at Nelson Mandela School

Version A: Parallel Challenge Rounds with a Student Decision Panel Approach

A Young Smart Cities Learning Situation and Lesson Plan · Rwanda

Prepared following the YSC methodology, combining the open Driving-Question format structure focused on both the technical and social/behavioural dimensions of clean cooking adoption.



Part 1 — Learning Situation

Cooking with the Sun: Solar-Powered Clean Cooking at Nelson Mandela School

Context

Across many schools and communities in sub-Saharan Africa, cooking still relies heavily on wood and charcoal — fuels that are costly, time-consuming to gather, harmful to health through smoke exposure, and a driver of local deforestation. At the same time, the growth of solar PV systems in schools and institutions has created a new opportunity: energy that is already being generated but not being used.

Nelson Mandela School is a concrete case of this gap. Its 45 kWp solar system generates far more energy than the school currently consumes, and one of its three inverters — the Fronius Symo 20 kW — sits idle because it cannot yet operate without a balanced three-phase load. Meanwhile, the school's kitchen still depends on wood. Clean cooking solutions exist and are technically well understood, but simply installing new appliances is not enough: adoption depends on cost, reliability, training, trust, and whether the new way of cooking fits real kitchen routines and habits.

This Learning Situation invites students to treat the school itself as the client, and to design a solution that works not only on paper but in practice.

Driving Question

How can Nelson Mandela School convert its surplus solar energy — including the idle Fronius Symo inverter — into a clean cooking system that kitchen staff will reliably use instead of wood, within realistic technical, financial and human constraints?

This question is deliberately narrower than a typical open YSC Driving Question: it names the real asset the school already owns (the idle inverter), the real constraint that determines success (adoption by kitchen staff, not just technical feasibility), and the real baseline to improve on (wood, not an abstract status quo).

Scenario

Clean-cooking transitions like this one carry a well-documented risk: proposals that look technically sound on paper often stall once they meet a real kitchen. Evidence from Rwanda's own eCooking sector shows that high upfront costs and maintenance requirements have limited the adoption of institutional eCooking nationally, and that adoption more broadly depends on affordability, supply reliability, grid stability, and sociocultural factors such as user beliefs and preferences (MECS/EnDev, 2022; Das et al., Sustainable Development, 2025).

Firewood is also sometimes tied into parents' in-kind contributions to school costs — a local economic factor worth investigating directly at Nelson Mandela School.

Nelson Mandela School wants a proposal that avoids this common failure pattern: technically sound, but designed from the start around the people who will actually operate it every day.

Task

Students work in groups to investigate the Driving Question from a holistic angle: not "which appliance is best" in isolation, but **how energy availability, appliance choice, kitchen behaviour, cost and trust interact**.

This Learning Situation uses a **Parallel Challenge Rounds format** (see Approach below): the same four questions are tackled one at a time, in the order their real dependency requires, and within each round every group works on the same question independently and competes to produce the most convincing answer. A student Decision Panel then selects the winning proposal, which becomes the shared, accepted foundation the whole class builds on in the next round.

Nelson Mandela School has already commissioned a written technical proposal covering energy balance, appliance sizing, electrical design and a bill of quantities (see Annex, Part 2). Students are not asked to design from a blank page: their task is to critically test this existing proposal against the Driving Question — confirming what already holds up technically, and identifying what it does not yet address, particularly on the human/adoption side that determines whether a system like this actually gets used.

The accompanying Lesson Plan (Part 2) structures this exploration step by step across an 8-hour block spread over two weeks.

Approach: Parallel Challenge Rounds with a Student Decision Panel

The class works through the same four lenses as four sequential rounds, in the order the real-world dependency requires. Within each round, every working group tackles the same sub-question in parallel and independently and competes to produce the most convincing proposal. A small student Decision Panel, role-playing the school's decision-makers, then evaluates the competing proposals and selects (or synthesises) the winning one, which becomes the accepted foundation for the next round:

Round	Guiding Question	Nature
1. Energy & Systems	How much surplus solar energy is really available, and what does it take to bring the idle Fronius Symo inverter online for cooking loads?	Technical
2. Appliances & Fit	Given the accepted energy budget, which cooking appliances actually match local meals, quantities and the school's morning routine — including cooking before sunrise?	Technical / Practical
3. People & Adoption	Given the accepted appliance mix, why do institutional cooking transitions often fail to stick even after the technology works, and what would make Nelson Mandela's kitchen staff trust, learn and keep using this system?	Social / Behavioural
4. Cost, Health & Environment	Given the accepted energy, appliance and adoption plan, what does the full package actually save or cost — in money, health, and deforestation — and is it worth funding?	Sustainability / Economic

This keeps the competitive, comparative energy of a challenge format (several groups tackling the identical problem at the same time, with nobody idle waiting on someone else) while also keeping a strong cooperative and argumentative component: each group must build a convincing case and pitch it to the Decision Panel, and the Panel itself must weigh trade-offs and justify its choice to the class. Unlike four independent lenses combined only at the very end, each round's accepted answer becomes real input data for the next round, so the sequence — not the group structure — carries the dependency.

The **Decision Panel** is a small group of students (3–4) who role-play the school's decision-makers — for example the headteacher, the facilities manager, and a PTA representative — and can co-opt a kitchen-staff representative for Round 3 specifically. The Panel can either stay fixed across all four rounds (so its members see the whole project cohere) or rotate its membership each round so more students get to practise the decision-making role; either works, and the choice can be made locally.

Role of the Teacher: Facilitation & Reflection

This format depends on teachers who can moderate group work and presentations, and synthesise what a group has done — not just judge it. After each round's pitches (while the Decision Panel deliberates its verdict, see Lesson Plan, Part 2), the teacher runs a short facilitated reflection with each individual group to help it move forward into the next round, using guiding questions such as:

- What did we present, and why?

- What did we forget, or not consider?
- What did we let ourselves be too strongly guided by?

This per-group reflection is a core facilitation skill for running the Parallel Challenge Rounds format, not an optional extra: it is what turns the Panel's verdict from a simple win/lose result into learning that each group actually carries into the next round.

Expected Output

Beyond the in-class proposal that emerges from the four rounds, the class produces one further, shared deliverable: a **single written article, a video, or both, for the Young Smart Cities blog** (youngsmartcities.com) — one public-facing account of the class's Driving Question, process and findings, written for an outside reader rather than for the teacher, and assembled from the four round-winning proposals rather than duplicated group by group. This turns the classroom exercise into one real piece of publishable communication and gives students a genuine, shared audience beyond the school.

Part 2 — Lesson Plan

Case: Solar-Powered Clean Cooking — Nelson Mandela School

Case Description

Nelson Mandela School generates far more solar energy than it consumes, yet still cooks with wood. A 20 kW inverter sits idle. Evidence from Rwanda's own eCooking sector shows that institutional cooking transitions often succeed technically but fail to stick — held back by high upfront costs, maintenance demands, and sociocultural factors around trust and habit (MECS/EnDev, 2022; Das et al., Sustainable Development, 2025). Students must design a proposal for Nelson Mandela School that anticipates this kind of failure rather than repeating it.

Driving Question

How can Nelson Mandela School convert its surplus solar energy — including the idle Fronius Symo inverter — into a clean cooking system that kitchen staff will reliably use instead of wood, within realistic technical, financial and human constraints?

Structure

Four sequential Challenge Rounds — Round 1: Energy & Systems, Round 2: Appliances & Fit, Round 3: People & Adoption, Round 4: Cost, Health & Environment — spread over 2 weeks. In each round, every working group tackles the same sub-question in parallel and pitches its proposal to a student Decision Panel, whose verdict becomes the accepted foundation for the next round. Fieldwork (staff interviews, conducted jointly by one representative per working group) is carried out between weeks, feeding shared evidence into Round 3. Total in-class time: 8 hours.

Overview

Lesson	Week	Focus	Duration
Lesson 1	Week 1	Framing + forming working groups & Decision Panel + Round 1: Energy & Systems	2h
Lesson 2	Week 1	Round 1 verdict + Round 2: Appliances & Fit + designing the joint staff interview	2h
— Fieldwork —	Between W1/W2	Homework: one representative per working group jointly interviews kitchen/facilities staff; findings shared with the whole class	—
Lesson 3	Week 2	Round 2 verdict + shared interview findings + Round 3: People & Adoption	2h
Lesson 4	Week 2	Round 3 verdict + Round 4: Cost, Health & Environment + final synthesis	2h
— Blog Contribution —	After Lesson 4	Homework: the whole class collaboratively drafts one shared Young Smart Cities blog piece	—

Lesson 1 — Framing & Round 1: Energy & Systems (Week 1, 2h)

Content	Methods	Links to School Subjects
Initial question: Is the surplus really ~180 kWh/day, and would eliminating wood actually be realistic?	Whole-class discussion using the school's own PV/consumption figures; assumptions and doubts collected on a flipchart.	
Introduce the Parallel Challenge Rounds format and why it's used: the four questions depend on each other, so they are tackled one at a time, with every group competing on the same question in each round.	Teacher explanation + short class Q&A.	
Formation of working groups (e.g. 4–5 small groups) and a Decision Panel (3–4 students role-playing the school's decision-makers); Round 1 briefed using Annex A data.	Group assignment; Decision Panel briefed separately on evaluation criteria (technical soundness, feasibility, clarity of reasoning).	
Round 1 challenge (all working groups, in parallel): How much surplus energy is truly usable, and what would it take to bring the idle Fronius Symo inverter online? Does the school's own proposal for phase-balancing hold up?	Group work: verify the school's energy balance calculation (Annex A); assess the proposed Fronius reactivation method; propose improvements or alternatives.	
End of lesson: each group pitches its Round 1 proposal (2–3 minutes) to the Decision Panel, which takes the proposals away to deliberate.	Short pitches + Q&A from the Panel; Panel deliberation (verdict announced at the start of Lesson 2). While the Panel deliberates, the teacher runs a short facilitated reflection with each group (see Part 1 — Role of the Teacher).	

Lesson 2 — Round 1 Verdict & Round 2: Appliances & Fit (Week 1, 2h)

Content	Methods	Links to School Subjects
Decision Panel announces and justifies its Round 1 verdict. The winning energy/inverter solution becomes the class's shared, accepted foundation for the rest of the project.	Panel presentation to the class; brief discussion of the reasoning behind the choice.	
Round 2 challenge (all working groups, in parallel): given the accepted energy budget, which appliances (Annex B) actually match local meals, quantities and the before-sunrise breakfast gap?	Group work: design and justify a cooking-appliance mix and load plan that fits within the accepted energy budget; stress-test the before-sunrise assumption.	
The class agrees on one common set of staff-interview questions, so that Round 3 starts from the same evidence for every group.	Class discussion; questions drafted collaboratively, drawing on what each group has learned so far.	
End of lesson: pitches to the Decision Panel; Panel deliberates (verdict announced at the start of Lesson 3).	Short pitches + Q&A; Panel deliberation, alongside the teacher-facilitated group reflection (see Part 1 — Role of the Teacher).	
Homework briefing: one representative from each working group forms a joint interview team and	Homework instructions.	

Content	Methods	Links to School Subjects
conducts the staff interviews together before Lesson 3, so every group starts Round 3 with the same shared evidence.		

→ Fieldwork period (between Week 1 and Week 2): the joint interview team (one representative per working group) interviews kitchen/facilities staff and writes up shared findings for the whole class.

Lesson 3 — Round 2 Verdict & Round 3: People & Adoption (Week 2, 2h)

Content	Methods	Links to School Subjects
Decision Panel announces its Round 2 verdict. The winning appliance mix and load plan becomes the accepted foundation.	Panel presentation to the class.	
The joint interview team reports back: staff habits, past experience with equipment changes, fears and expectations — shared as common evidence for everyone.	Group presentation of raw findings to the class; class discussion on what surprised them.	,
Round 3 challenge (all working groups, in parallel): given the accepted appliances and the shared interview evidence, design a training / trust-building / adoption plan for kitchen staff (Annex C).	Group work; AI-assisted research on behaviour-change and technology-adoption factors.	
End of lesson: pitches to the Decision Panel, extended for this round with a co-opted kitchen-staff-representative role, who weighs in specifically on which plan actually seems trustworthy and workable.	Short pitches + Q&A; Panel deliberation (verdict announced at the start of Lesson 4), alongside the teacher-facilitated group reflection (see Part 1 — Role of the Teacher).	

Lesson 4 — Round 3 Verdict, Round 4: Cost, Health & Environment & Final Synthesis (Week 2, 2h)

Content	Methods	Links to School Subjects
Decision Panel announces its Round 3 verdict. The winning training/adoption plan becomes the accepted foundation.	Panel presentation to the class.	
Round 4 challenge (all working groups, in parallel): given the accepted energy, appliance and adoption package, build and argue the cost–benefit case and check the Bill of Quantities (Annex D) — is the full package worth funding?	Group work: cost–benefit analysis; check for missing or optimistic assumptions.	
Final pitches to the Decision Panel; the Panel selects the Round 4 winner, then combines the four winning round-proposals into the single integrated class proposal for Nelson Mandela School.	Short pitches + Q&A; Panel synthesis, presented to and discussed with the whole class. The teacher closes with a facilitated group reflection on the whole project (see Part 1 — Role of the Teacher).	
Briefing for the take-home task: the four round-winning working groups each draft the write-up of	Teacher hands out the blog-writing guidelines; a small editorial team (drawn from the	

Content	Methods	Links to School Subjects
their winning round for one shared Young Smart Cities blog contribution (see Final Output, below).	Decision Panel, who already have full oversight of the project) is appointed to merge the sections into a single, consistent post.	

Expected Results

By the end of Lesson 4, the class is expected to have one integrated proposal — not just a technical design, but one that also addresses how kitchen staff would be trained, trusted, and supported so the system doesn't stall the way many similar projects elsewhere have. Because each round was won by a different working group's proposal, the final result is genuinely built from the class's strongest thinking at each stage, not from a single group's blind spots.

During the final discussion, the following should be addressed:

- Which factor turned out to be the real bottleneck — energy/technical, or human/behavioural?
- What did the staff interviews reveal that groups hadn't anticipated?
- What would concretely prevent kitchen staff from reverting to wood once the novelty wears off?
- Which parts of the proposal are solvable now, and which need a pilot phase or more data?
- What would the school need to monitor after implementation?
- Where does the school's own existing technical proposal (Annex) hold up well, and where might it still fail in practice, based on the wider evidence about eCooking adoption?
- Did competing independently within each round produce stronger proposals than one group working alone would have? What made the Decision Panel choose the winning proposal each time?
- Did organising the work as sequential rounds actually solve the dependency problem? Where, if anywhere, did groups still have to guess ahead at a later round while working on an earlier one?

Suggested Time Allocation

- Lesson 1 (2h): Framing + Round 1 (Energy & Systems)
- Lesson 2 (2h): Round 1 verdict + Round 2 (Appliances & Fit) + interview design
- Fieldwork (homework, between weeks): joint staff interviews
- Lesson 3 (2h): Round 2 verdict + Round 3 (People & Adoption)
- Lesson 4 (2h): Round 3 verdict + Round 4 (Cost, Health & Environment) + final synthesis

Total in-class time: 8 hours across 2 weeks.

Final Output — Young Smart Cities Blog Contribution

Rather than every working group producing its own write-up — which tends to yield several near-identical posts — the class produces one single, shared contribution — a written article, a video, or both — for the Young Smart Cities blog (youngsmartcities.com): one real, public piece with one clear voice, rather than several similar drafts nobody quite owns.

As homework following Lesson 4, each of the four round-winning working groups drafts the section of the shared post covering its winning round. A small editorial team (drawn from the Decision Panel, who already have full oversight of how the four rounds fit together) then merges the section drafts into one coherent piece, resolves overlaps, and agrees on a single title and closing reflection with the class.

Suggested structure for the written article (roughly 500–800 words total), with sections mapped to the round winners:

- Title & Hook — one or two sentences on the real problem (surplus solar energy sitting unused while the kitchen still burns wood). Drafted by the editorial team, using material from all four rounds.
- The Challenge — a short retelling of the Driving Question and why it's harder than it looks (grounded in evidence about why similar transitions elsewhere have struggled), plus a brief explanation of the Parallel Challenge Rounds format itself. Drafted by the editorial team.
- Round 1 & 2 Findings (Energy and Appliances) — what the winning proposals in these rounds actually decided, and why the Decision Panel chose them. Drafted by the Round 1 and Round 2 winning groups.

- Round 3 Findings (People & Adoption) — what the joint staff interviews revealed and how the winning training/adoption plan responds to it. Drafted by the Round 3 winning group.
- Round 4 Findings & Our Proposal (Cost, Health & Environment) — the winning cost–benefit case, the integrated final proposal, and one honest sentence on what would still need to be tested before this could actually be built. Drafted by the Round 4 winning group, finalised by the editorial team.

The post should include at least one image, diagram or photo (e.g. a sketch of the energy balance, a photo from the site visit, or a simple appliance comparison graphic) and should be written in an accessible, engaging tone suitable for a general public audience rather than a technical report register.

Video option: if the class produces a video instead of, or alongside, the written article, the same five-part structure (Hook, Challenge, Rounds 1 & 2, Round 3, Round 4 & Proposal) carries over as a scene/segment outline. Aim for roughly 4–6 minutes total, with each round-winning group filming or narrating its own segment (e.g. a short walkthrough at the school, a diagram explained on camera, or a re-enacted excerpt from a staff interview) and the editorial team responsible for editing the segments into one coherent video with a single intro and closing reflection, in the same accessible, public-facing tone as the written version.

Annex — Data Packets for Challenge Rounds

These handouts are excerpted from Nelson Mandela School's own existing technical proposal for solar-powered clean cooking. They are provided as common input data for all working groups in the relevant round, so that every group starts from the same evidence — real data to verify, question and build on, not a finished answer.

Annex A — Energy & Systems (input for Round 1)

Solar availability (from the school's proposal):

- PV generation: ~225 kWh/day
- School load: ~45 kWh/day
- Surplus: ~180 kWh/day
- Cooking demand estimate: ~60–70 kWh/day (beans scenario, 20 L appliances)

Proposed Fronius Symo reactivation method:

- Install a phase-balancing transformer or load-sharing controller
- Use dedicated cooking circuits evenly distributed across the three phases
- Synchronise with the Deye inverter for hybrid operation

Proposed circuit design:

- Distance from energy house to kitchen: 20 m
- Voltage: 230 V single-phase / 400 V three-phase
- Cable: 10 mm² copper, 3-core (voltage drop < 2% at 20 m for a 40 A load)
- Main breaker: 63 A, 3-phase; sub-breakers: 16 A per appliance circuit
- Distribution board: 12-way with RCD protection

Round 1 task (all working groups): verify these figures against the school's real consumption data if available, assess whether the proposed reactivation method is sufficient, and identify any technical risks or open questions the proposal does not address.

Annex B — Appliances & Fit (input for Round 2)

Cooking technologies proposed in the school's plan:

Technology	Power (W)	Capacity	Suitability
Induction stove	3,500	20 L pot	Porridge & rice — fast, ~85% efficient
Electric pressure cooker	3,000	20 L	Beans — cuts cooking time ~70%
Rice cooker	2,500	20 L	Lunch/supper — automatic shutoff
Solar-electric hybrid cooker	2,000	20 L	Daytime cooking, flexible PV/battery use
LPG gas stove (backup)	—	—	Backup for cloudy days

Proposed daily cooking-load estimate:

Meal	Appliance / Units	Duration	Energy
Breakfast (porridge)	Induction stove × 4 (3,500 W each)	1 h	14 kWh

Meal	Appliance / Units	Duration	Energy
Lunch (beans + maize/rice)	Pressure cooker × 6 (3,000 W each)	2 h	36 kWh
Supper (beans + maize/rice)	Pressure cooker × 6 (3,000 W each)	2 h	36 kWh
Total daily cooking energy	—	—	≈ 86 kWh/day

Note: the proposal recommends soaking beans overnight to reduce cooking energy and improve digestion.

Round 2 task (all working groups): check this appliance mix and load estimate against real school meal sizes and timing, and test the before-sunrise breakfast assumption against the energy budget accepted at the end of Round 1 (Annex A).

Annex C — People & Adoption (input for Round 3)

The school's technical proposal addresses staff training only briefly, as one phase of a four-phase implementation roadmap:

- Phase 1 – Electrical Integration: activate the Fronius inverter, install dedicated kitchen circuits
- Phase 2 – Appliance Procurement: purchase induction stoves, pressure cookers, rice cookers; install battery storage
- Phase 3 – Training & Commissioning: train kitchen staff on safe electric cooking; monitor energy use and adjust load scheduling
- Phase 4 – Evaluation: track energy savings and health improvements; document CO_2 reduction and community impact

Round 3 task (all working groups): this is the thinnest part of the existing proposal — one line covering what, in similar transitions elsewhere, has often taken a full redesign cycle and dedicated staff training and monitoring tools to get right. Investigate what "training" should actually include, and use the shared staff-interview findings to test whether Phases 3 and 4 are realistic as written.

Annex D — Cost, Health & Environment (input for Round 4)

Proposed Bill of Quantities (indicative):

Item	Specification	Qty	Total (USD)
Induction stove	3.5 kW, 20 L pot	2	360
Pressure cooker	3 kW, 20 L	6	1,200
Rice cooker	2.5 kW, 20 L	2	300
Battery storage	5 kWh $LiFePO_4$	2	4,000
Cable	10 mm^2 Cu, 3-core, 20 m	1	200
Circuit breakers	63 A main, 16 A sub	10	250
Distribution board	12-way with RCD	1	300

Item	Specification	Qty	Total (USD)
Earthing kit	Rod + clamp + cable	1	150
Surge protector	4-way, heavy duty	2	80
Installation & labour	Wiring, mounting, testing	—	250
Total estimated cost	—	—	6,040

Proposed cost–benefit comparison (wood vs. solar-electric cooking):

Parameter	Wood Stove	Solar-Electric Cooking
Daily fuel cost	$10–12 (wood purchase)	$0 (solar surplus)
Annual cost	~$3,500	~$0
Health impact	High smoke exposure	Clean air
Efficiency	~15%	~80–90%
CO_2 emissions (combustion)	~10 tons/year	Near-zero
Total climate impact (incl. deforestation)	~23–30 tons CO_2/year	Near-zero
Payback period	—	≈ 3 years

Round 4 task (all working groups): check this comparison for missing or optimistic assumptions (e.g. battery replacement cost, maintenance, training cost, monitoring cost) and assess whether the ≈3-year payback period is realistic once the full cost of a successful — not just installed — system, including the Round 3 training/adoption plan, is included.

Sources

- MECS / EnDev, "Rwanda eCooking Market Assessment", February 2022 — mecs.org.uk
- Das, I. et al., "The Costs and Benefits of Clean Cooking Policies in Low- and Middle-Income Countries Under Real-World Conditions", Sustainable Development, 2025 — scholars.duke.edu

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