A Blockchain-Enabled Solar Energy Management and Communication System

Group Members

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INTRODUCTION

- **Harnessing Solar Power:** Sustainable, abundant resource to tackle global energy deficits

- **Kenya's Equatorial Edge:** Reliable, high solar irradiance throughout the year

- **Revenue Barrier:** KPLC net-metering issues energy-credits only, limiting small-scale earnings

- **Trust Deficit:** Opaque PAYG record-keeping leaves users unsure of system value

- **Our Solution:** Blockchain + REST & MQTT communications for secure, transparent P2P energy trading

PROBLEM STATEMENT

- **Underutilized Solar Assets:** PAYG households lack mechanisms to sell surplus energy back to the grid during loan repayment
- **Insufficient Producer Incentives:** Current compensation models fail to adequately reward small-scale producers
- **Opaque Energy Transactions:** No transparent system for tracking energy contributions or earnings
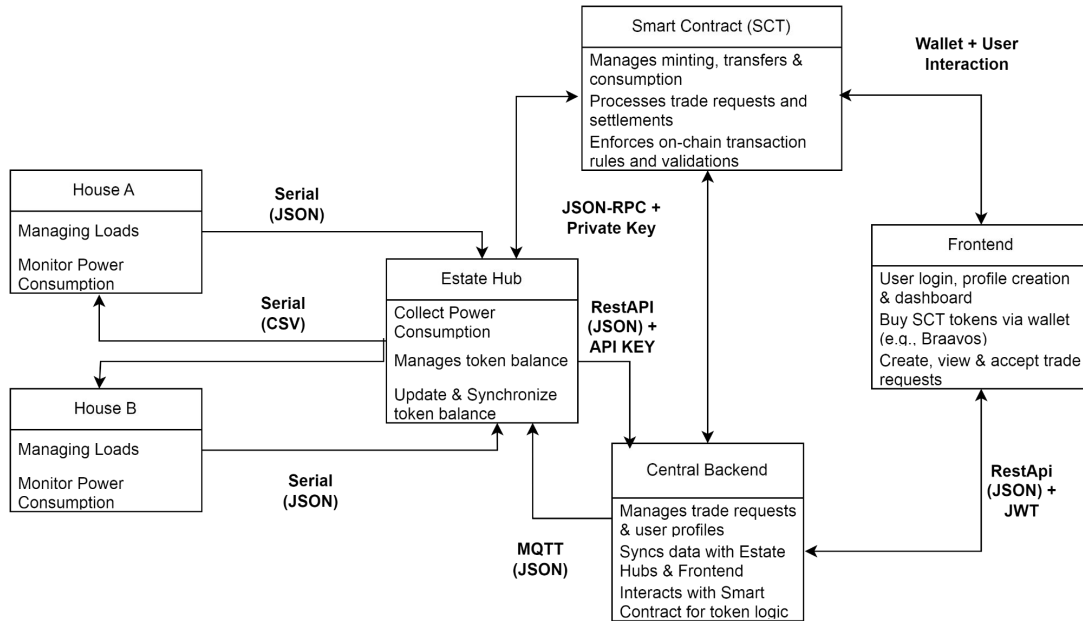- **Lack of Real-Time Monitoring:** Inability to track power consumption accurately

OBJECTIVES

- **Create Smart Contract (Solaris Conexus Token):** Mint, track, and manage power tokens on Starknet
- **Implement Hybrid Communications:** Use Serial (Houses ↔ Estate Hub), REST API & MQTT for reliable reliable server-to-server data flow
- **Facilitate P2P Energy Trading:** Enable decentralized surplus-energy exchanges via on-chain smart contracts
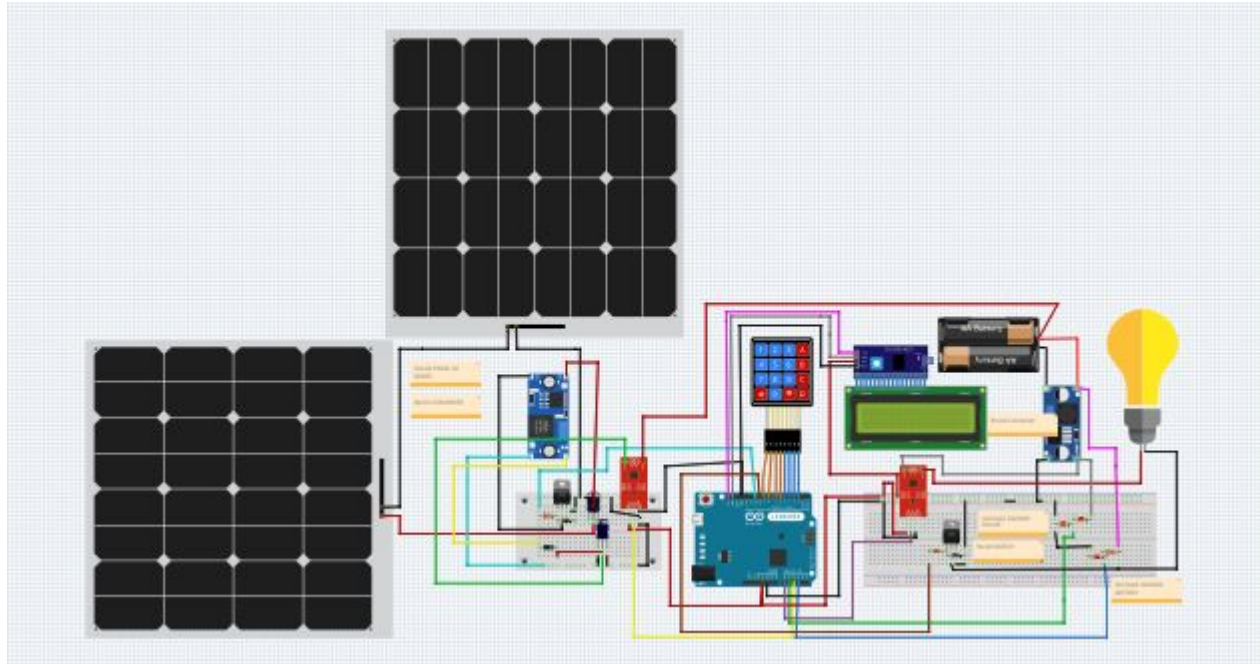- **Provide Real-Time Monitoring & Analytics:** Deliver dashboards for live consumption

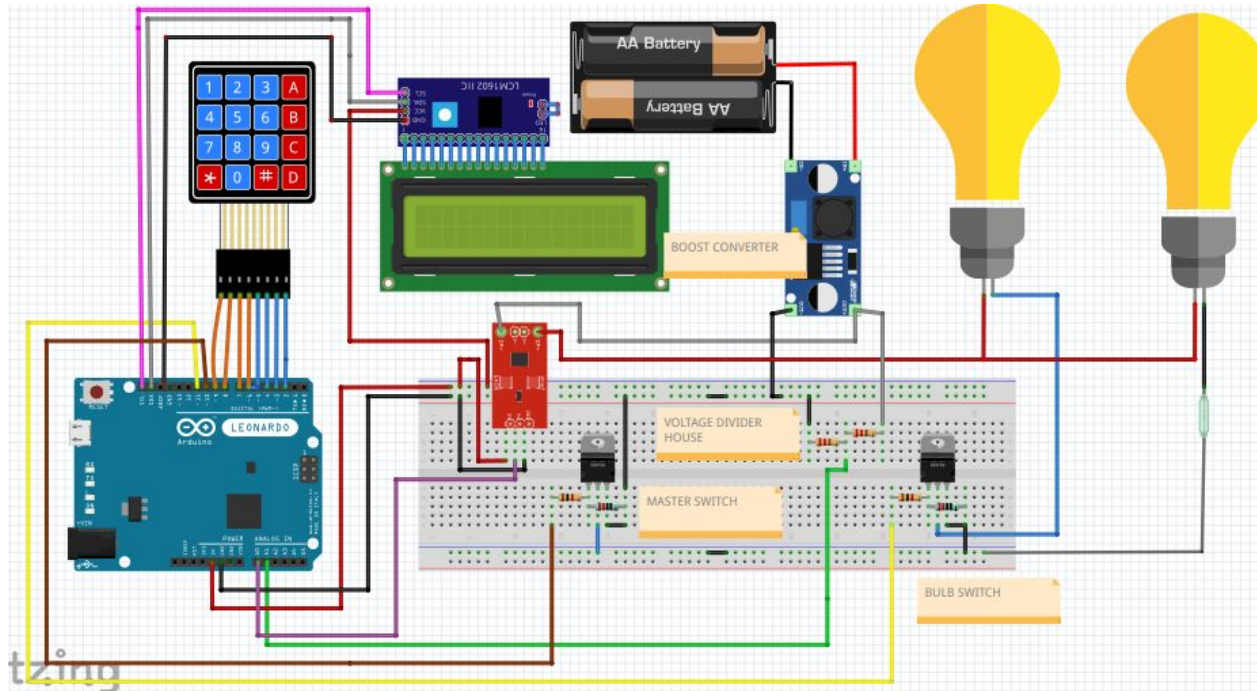# SYSTEM DESIGN AND IMPLEMENTATION

SYSTEM OVERVIEW

HOUSEHOLD A

Overview

Solar Charging System
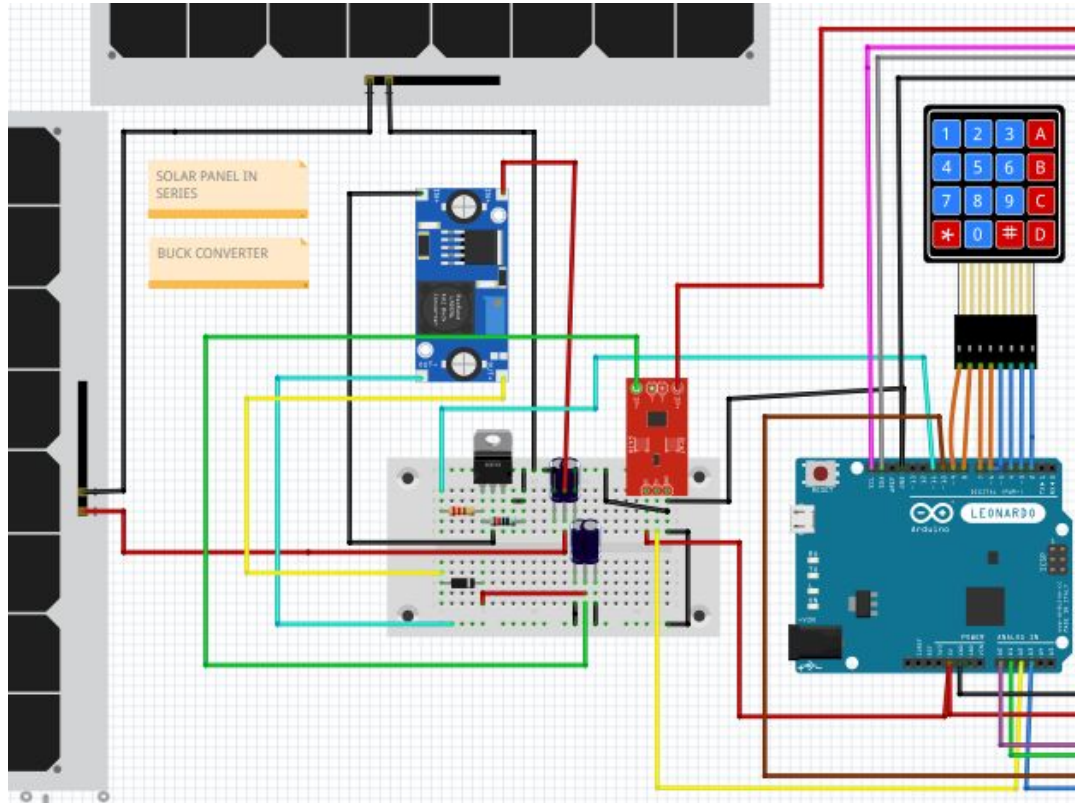
Load Section
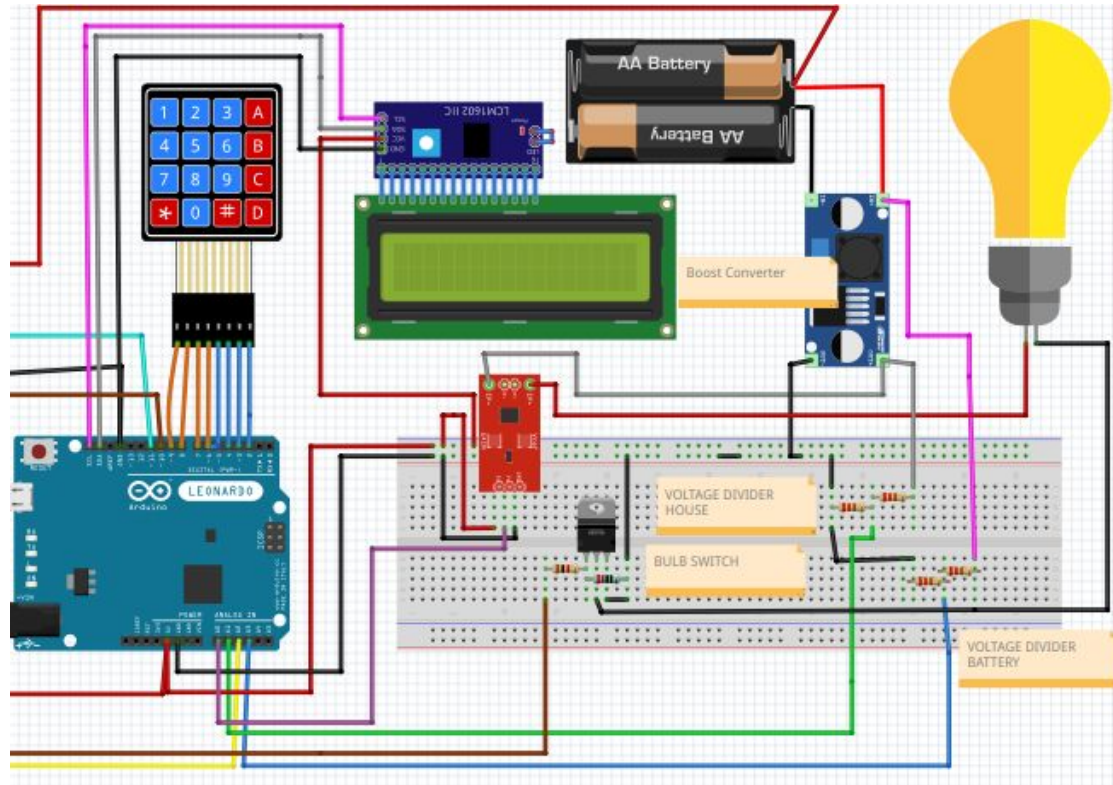
HOUSEHOLD B

FEATURE CODES

Device ID:
H001

Balance:
4.89 SCT

Connection:
0 (OFF)

LED Status:
OFF

Avg Current:
0.78 A

FRONTEND

User Registration

Profile Creation

Profile Settings

First Name

Gituru

Last Name

Trevor

Date of Birth

08 / 25 / 2000

Gender

Male

Phone Number

0701342609

Account Address

0x4b1cea62c4bf725c69b8f1e12ed5c7525bbf4bada1a3712cc73fb4c9e4adb5a

Connected: 0x4b1c...db5a Copy

Disconnect

Email Confirmed ✓

Save Changes

RE: Confirmation Email Inbox ×

Solaris Connexus <solaris.connexus@gmail.com>   7:05 AM (0 minutes ago)

to me ▾

Email Confirmation

Hi giturutrevor,

Thank you for signing up with Solaris Connexus!

Please confirm your email address by copying and entering the following code:

948333

If you did not request this email, you can safely ignore it.

Best regards,
The Solaris Connexus Team

This is an automated message. Please do not reply directly to this email.

Add Token

solaris.razaoul.tech is requesting to add the following token to your wallet

Name
SolarisConexusToken

Address
0×696e1ba36b1b46ccfda4a6ae963b12c

Symbol
SCT

Decimal
0

Decline

Approve

Gituru Trevor
Male

Date of Birth
2000-08-25

Phone Number
0701342609

Wallet Address
0x4b1cea62c4bf725c69b8f1e12ed5c7525bbf4bada1a3712cc73fb4c9e4adb5a

Purchase Tokens

View your SCT token purchase history and buy more tokens.

SCT Token Purchase

2

[Pay STRK] [Pay M-PESA]

Date	Tx Hash	Amount (SCT)	Amoun Used	Payment Method	Payment Tx
6/4/2025	0x4841...7ef8	1 SCT	Ksh 10	MPESA	ws_CO_...2609
6/3/2025	0x6014...88ae	1 SCT	0.001 STRK	STRK	0x351e...ca60

Trading Power

My Trades

Create a trade and view your trade history.

Create New Trade

| 2 | 1 | Create Trade |

Trade History

Date	SCT Offered	STRK Price	Status	Action
6/3/2025	1.00000000 STC	1.00000000 STRK	Pending	View
6/3/2025	1.00000000 STC	1.00000000 STRK	Cancelled	View

HouseHold Registration

Edit Device

Arduino Uno ⌄

H001

Producer ⌄

Juja

Pin Loads

| 1 | Bulb |

Close   Save Changes

My Devices

H001

Device Type: Arduino Uno

Power Role: Producer

Estate: Juja

Status: active

Pin Loads:
- 1: Bulb

Registered: 6/3/2025, 3:00:00 AM

Toggle Device   Monitor   Edit Device

CENTRAL BACKEND

```
INFO:      41.139.178.89:0 - "GET /residents/trade/user HTTP/1.0" 200 OK
INFO:      41.139.178.89:0 - "OPTIONS /residents/trade/available HTTP/1.0" 200 OK
2025-06-09 07:47:11,412 - INFO - Available TradeRequests for current user requested by username: trevorx10x
INFO:      41.139.178.89:0 - "GET /residents/trade/available HTTP/1.0" 200 OK
2025-06-09 07:49:53,889 - INFO - Login request received for email: trevorx10x@gmail.com
2025-06-09 07:49:54,201 - INFO - User logged in successfully: trevorx10x
INFO:      41.139.178.89:0 - "POST /auth/login HTTP/1.0" 200 OK
2025-06-09 07:49:58,528 - INFO - Profile fetch requested by username: trevorx10x
2025-06-09 07:49:58,529 - INFO - Profile data returned for username: trevorx10x
INFO:      41.139.178.89:0 - "GET /residents/user_profile/get HTTP/1.0" 200 OK
INFO:      41.139.178.89:0 - "OPTIONS /residents/device/get HTTP/1.0" 200 OK
2025-06-09 07:50:00,130 - INFO - Device fetch requested by username: trevorx10x
2025-06-09 07:50:00,134 - INFO - Device data returned for username: trevorx10x
INFO:      41.139.178.89:0 - "GET /residents/device/get HTTP/1.0" 200 OK
INFO:      41.139.178.89:0 - "OPTIONS /residents/device/toggle HTTP/1.0" 200 OK
2025-06-09 07:53:13,447 - INFO - Toggle device request received for username: trevorx10x
[MQTT] Published to juja/commands: {"device": 2, "instruction": 2}
INFO:      41.139.178.89:0 - "GET /residents/device/toggle HTTP/1.0" 200 OK
INFO:      ('41.139.178.89', 0) - "WebSocket /residents/device/stream?token=eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJzdWIiOiJ0cmV2
b3J4MTB4IiwiZXhwIjoxNzQ5NDU3MTk0fQ.LlcoNHdFr-cGTPUCeQh0uALo7JyQDrGJuIwrIA0NctU" [accepted]
[MQTT] Listener registered for juja/power/2
[MQTT] Published to juja/commands: {"device": 2, "command": "stream"}
INFO:      connection open
INFO:      connection closed
[WebSocket] Timeout waiting for data from device 2
[WebSocket] Stopping stream for device 2
[MQTT] Published to juja/commands: {"device": 2, "command": "stop"}
```

ESTATE HUB

HouseHold Connection

```
(venv2) razaoul@trevor-HP-650-Notebook-PC:~/Documents/software_dev/solaris_conexus/estate-backend$ python3 src/main.py
[Info] Trying to connect to /dev/pts/4...
[Main] Started monitoring 1 devices.
[MQTT] Connected with result code 0
[MQTT] Subscribed to juja/commands
[Success] Connected to /dev/pts/4
[Raw] {"device_id": "H001"}
[Info] Received device ID: H001
[Sent] 10,1
[Raw] {"current": 0.44, "voltage": 4.13, "req": "false"}
[Info] Received 'current' reading; exiting connect()
[Raw] {"current": 0.38, "voltage": 3.76, "req": "false"}
[Info] Received 'current' reading; exiting connect()
[Sent] 10,1
[Raw] {"current": 0.42, "voltage": 3.82, "req": "false"}
[Decoded] Current: 0.42 A, Voltage: 3.82 V, Request: false
[Info] Power consumption recorded successfully: {6112}
[Redis] Accumulated: 15.661200000000077 W for H001
```

Power Consumption

```
[Info] Power consumption recorded successfully: {6135}
[Redis] Accumulated: 50.99170000000008 W for H001
[Action] Threshold reached! Minting tokens on-chain...
[Sent] 10,1
[Raw] {"current": 0.21, "voltage": 3.8, "req": "false"}
[Decoded] Current: 0.21 A, Voltage: 3.8 V, Request: false
[Info] Power consumption recorded successfully: {6136}
[Redis] Accumulated: 1.7897000000000796 W for H001
[Sent] 10,1
[Raw] {"current": 0.49, "voltage": 3.7, "req": "false"}
[Decoded] Current: 0.49 A, Voltage: 3.7 V, Request: false
[Info] Power consumption recorded successfully: {6137}
[Redis] Accumulated: 3.6027000000000795 W for H001
[Sent] 10,1
[Raw] {"current": 0.26, "voltage": 3.51, "req": "false"}
[Decoded] Current: 0.26 A, Voltage: 3.51 V, Request: false
[Info] Power consumption recorded successfully: {6138}
[Redis] Accumulated: 4.51530000000008 W for H001
0xfe9116b5b4da45a61c17a1c53fac9efd0bad22e0080e0c4b1b48a716c8473c
[Sent] 10,1
[Info] Updated device 5 token_balance to 9
```

MQTT Communication

```
[MQTT] Message received on juja/commands: {"device": 1, "command": "stream"}
[Stream] Started streaming for device 1
```

```
[MQTT] Message received on juja/commands: {"device": 1, "command": "stop"}
[Stream] Stopped streaming for device 1
```

```
[MQTT] Message received on juja/commands: {"device": 5, "instruction": "2"}
[MQTT] Updated instruction for device 5 to 2
[Raw] {"current": 0.44, "voltage": 4.13, "req": "false"}
[Decoded] Current: 0.44 A, Voltage: 4.13 V, Request: false
[Info] Power consumption recorded successfully: {6199}
[Redis] Accumulated: 6.062900000000077 W for H001
[Sent] 8,2
[Raw] {"current": 0.4, "voltage": 3.96, "req": "true"}
```

SMART CONTRACT

Overview

Contract Data

Portfolio

Tokens   NFTs

List of all ERC20 tokens owned by this contract

VERIFIED 1 ✓   ALL

🪙 Tokens Value: **$0.03**

ASSET	SYMBOL	CONTRACT ADDRESS	BALANCE	VALUE
🪐 StarkNet Token ✓	STRK	0x0471...938d ⧉	0.247	$0.032706
➕ SolarisConexusToken	SCT	0x0696...6827 ⧉	9,867	-

Contract data

Transactions   Token Transfers   Bridge Txns   Events   Messages   **Account Calls**   Token Holders   Code   Class History   Read Contract   Write Contract   Read Storage

ID	TXN HASH	CALL	FROM	BLOCK	AGE
841808_2_2	0x2db5...30a8 ⧉	createTrade	0x074d...f42e ⧉	841808 ⧉	24 minutes ago
827599_5_2	0x4841...7ef8 ⧉	buy	0x040d...d90b ⧉	827599 ⧉	5 days ago
826323_13_2	0x6014...88ae ⧉	buy	0x040d...d90b ⧉	826323 ⧉	6 days ago

CONCLUSION

- Successfully developed a low-cost, user-friendly solar energy management prototype

- Combined blockchain, IoT communication, and renewable energy for a transparent and decentralized system

- Enabled real-time monitoring, load control, and secure energy transaction recording

- Addressed key gaps in existing systems by focusing on affordability, simplicity, and individual-level usability

- Demonstrated potential for energy democratization and user empowerment through tokenized energy trade