Rural electrification: the options

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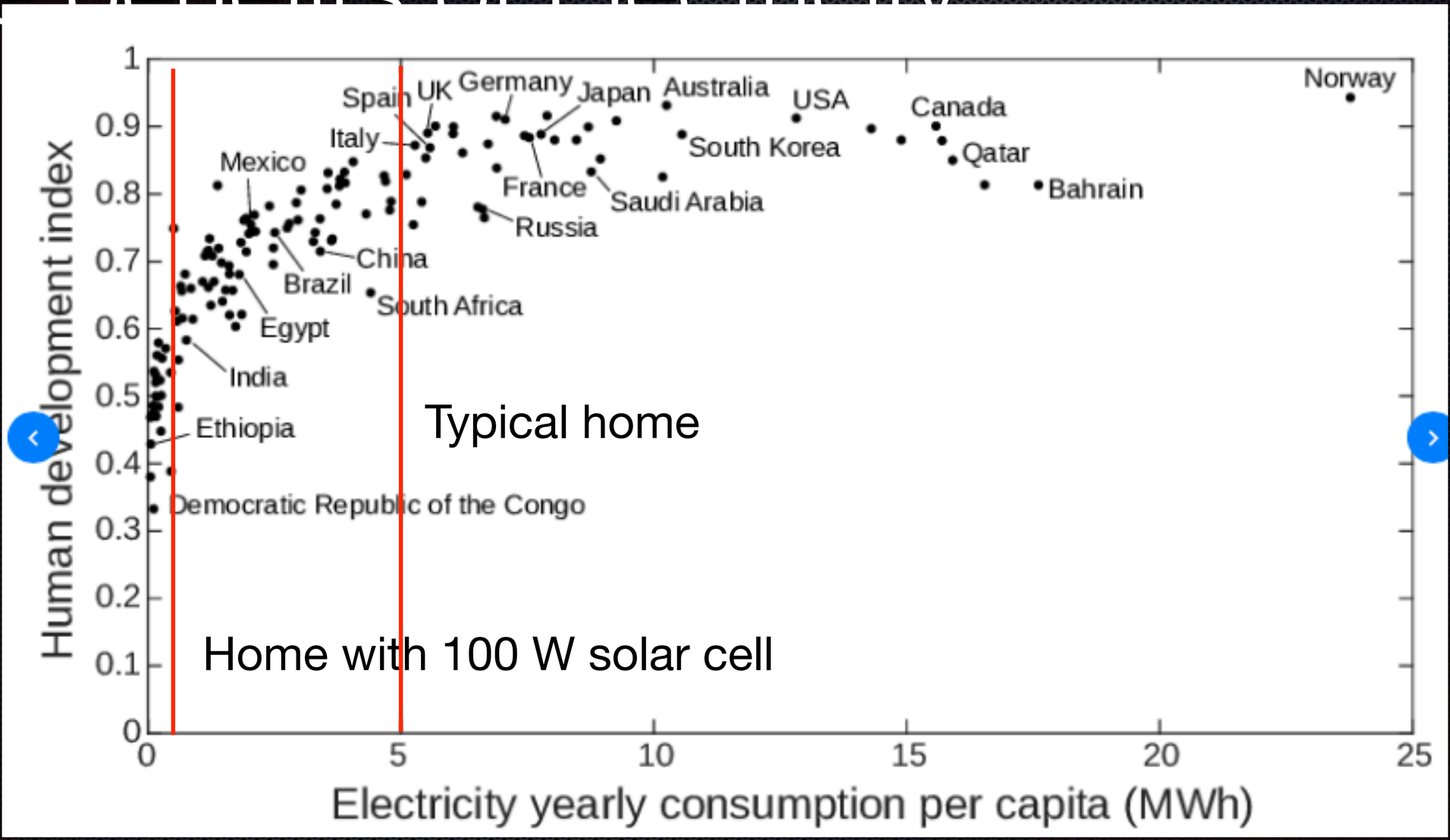
The benefits of Electricity

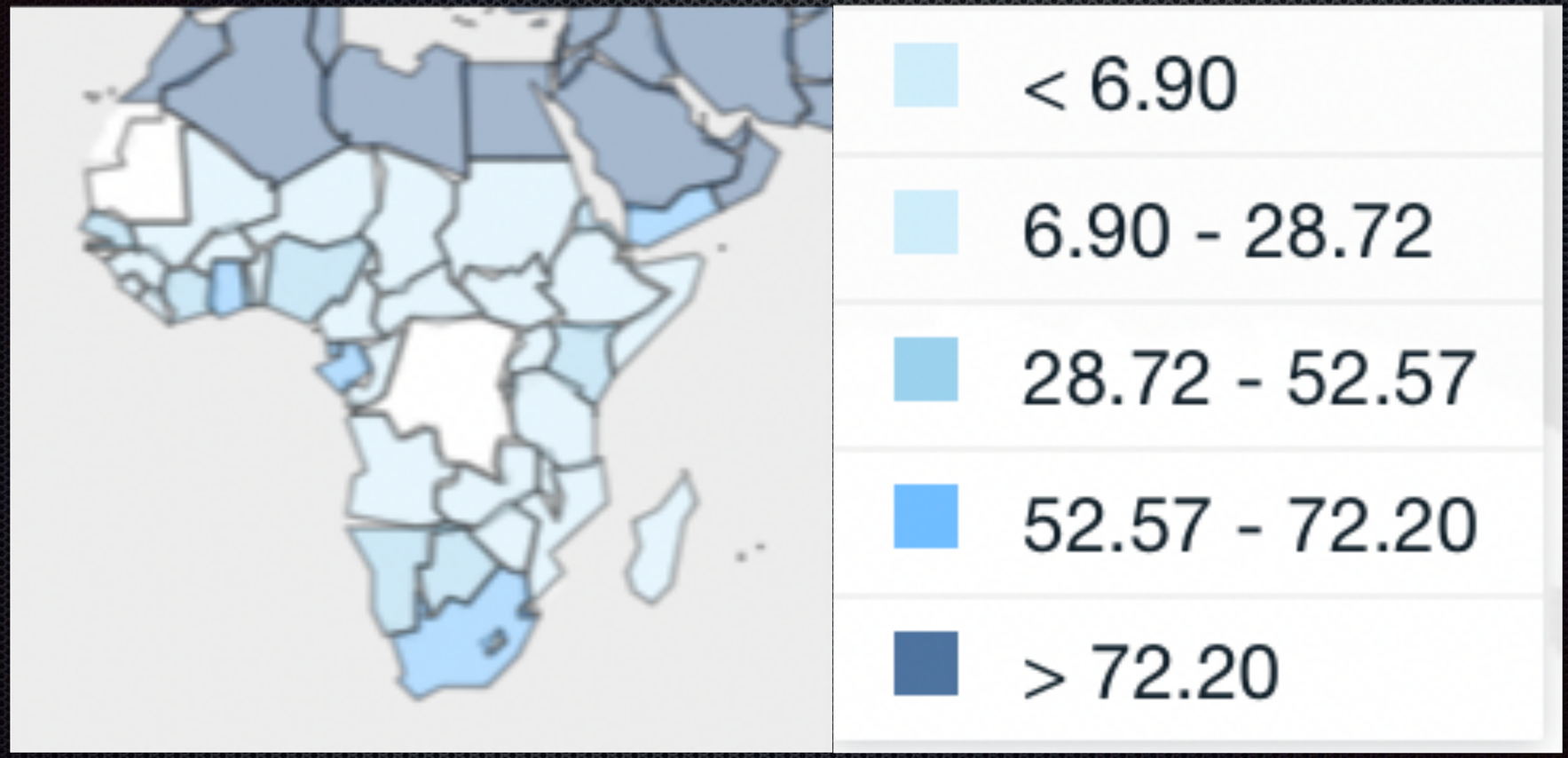


Introduction

Billions of rural people in developing countries lack the benefits of electricity

By adopting international best practice, the cost of rural electrification can be more than halved

Africa: % electrified



Electricity

A reliable, adequate and economic supply of electricity provides:

- low cost lighting, cooking and modern appliances
- low cost motive power for irrigation and village industries
- information and communications from smartphones

All these are needed for substantial rural economic growth

Solar lighting is not enough

The solution is low cost rural electrification

Cost

- Power from small petrol generators costs more than 50c per kWh
- Kerosene lighting and cooking costs more than $1/kWh
- 10 kW of solar power and batteries for a village industry will cost more than $1/kWh
- Grid electricity typically costs 10 - 20c/kWh
- Small hydro costs 20 — 50c/kWh

The critical decision

Should we..

- extend urban distribution systems into rural areas
- OR
- adopt - or adapt - the low cost technologies already proven in New Zealand, Australia, the USA and many other countries?

The difference between the two can be measured in many millions of dollars of savings in total cost and huge economic advantages

Where it started

From the 1920s to the 1970s, rural electrification expanded very rapidly in Australia and New Zealand.

Rural cooperatives were established to reticulate power to isolated villages and farms

There was never enough money, so the engineers had to do everything at minimum cost

They used local poles, fencing wire for HV conductors and the farmers provided labour and horses.

Many of these lines are still in service

By the 1940s, New Zealand was ahead of the USA

Single Wire Earth Return

In 1925, Lloyd Mandeno, an enterprising New Zealand engineer invented the SWER system that uses a single HV conductor and earth return

The advantages

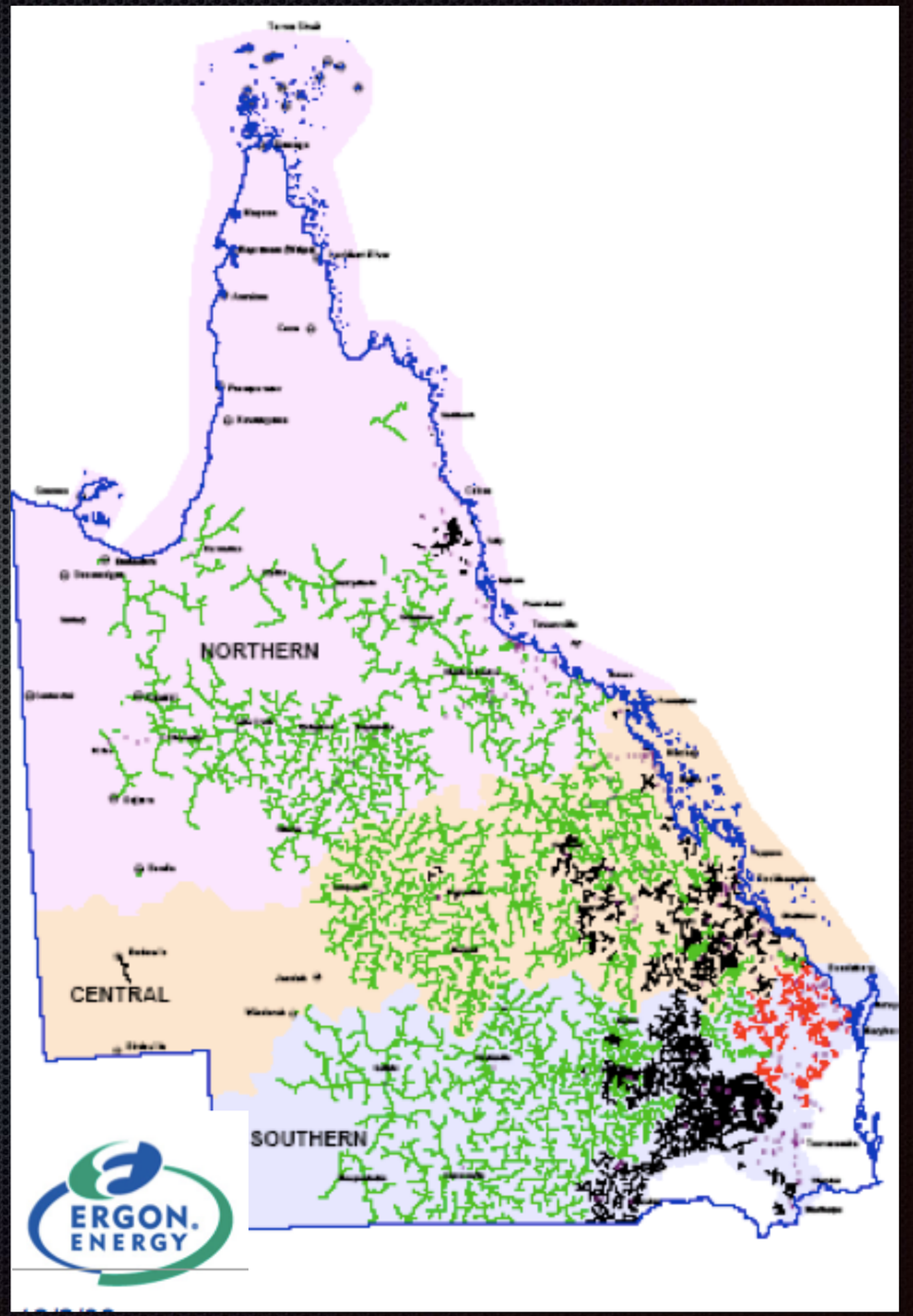
- Much lower cost per consumer
  - Savings 50-70% over conventional systems
- Needs a single small conductor
- Longer spans can be used
- More reliable
  - no risk of conductor clashing

Queensland SWER

- Only SWER lines shown
- South East of state has bulk of population
- Three voltage levels shown

  Green 19.1kV, Red 11kV, Black 12.7kV

- Bulk of line built in 70s 80s as part of States Rural Electrification Subsidy program



Guiding principles

“The lower the cost, the larger the area that can be reticulated with the amount of money available.”

The simpler the system the more reliable it is!

3 phase or single phase?

- In the USA, rural distribution is predominantly single phase
- 10-50 kW electronic converters from single phase to three phase are now available
  - MUCH cheaper than replacing a long single phase line to pick up one or two three phase loads!

A single phase supply is no longer a problem!

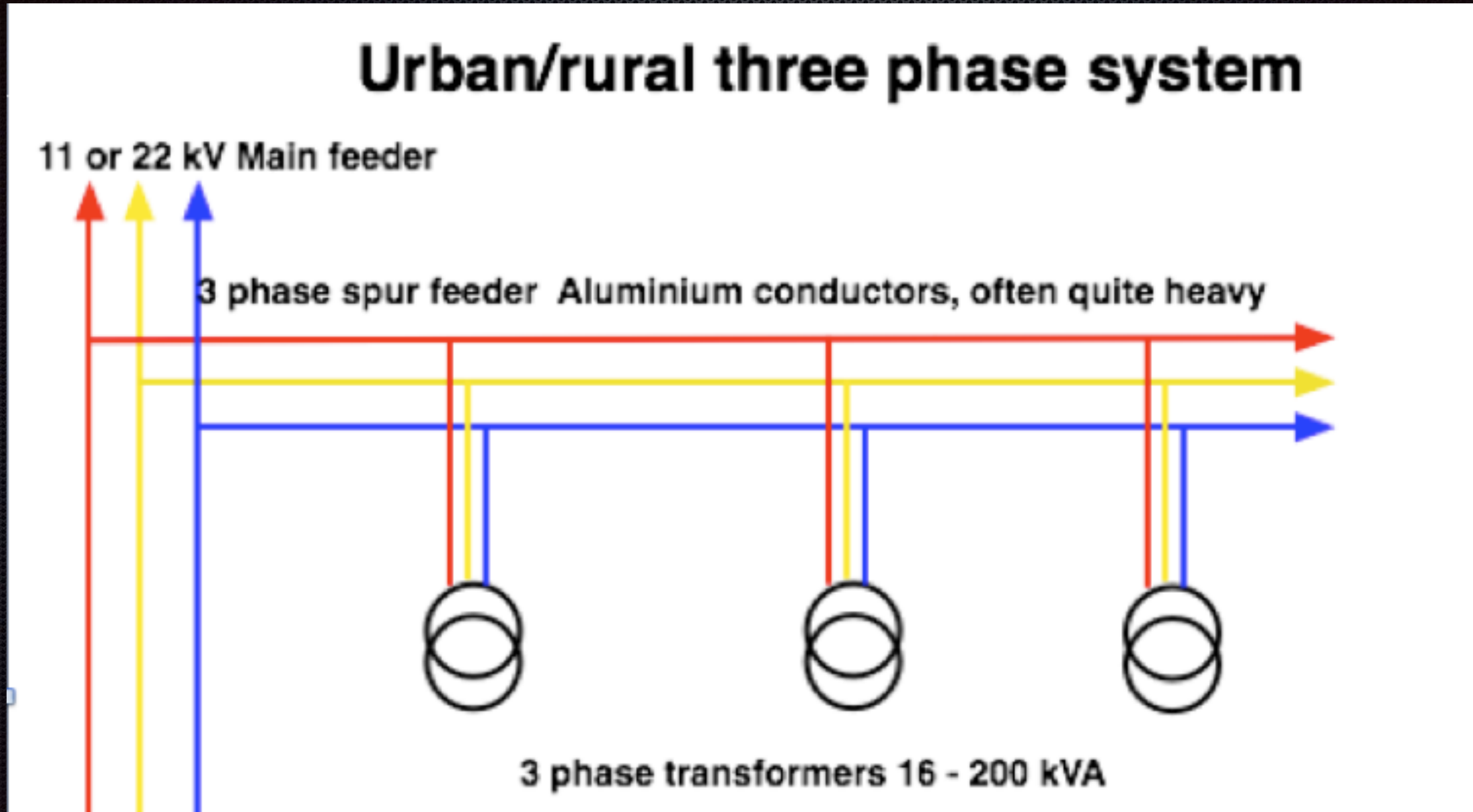
Planning for Rural Electrification

Key decisions

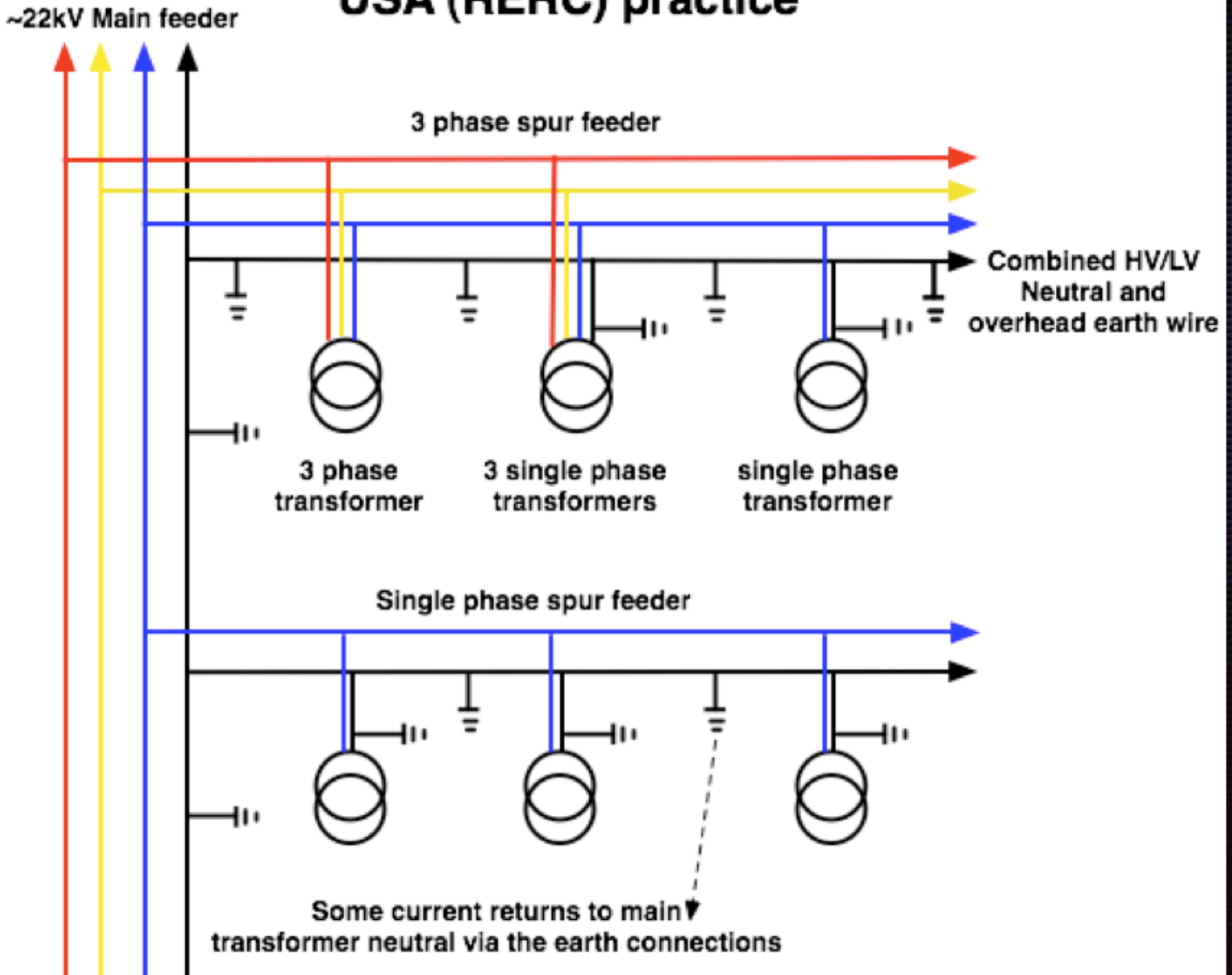
- What voltage?
  - 11kV, 20-22 kV or 33 kV?
    - 20-22 kV has big advantages
- What system?
  - SWER (lowest cost) US RE system or 2 or 3 phase (2 and 3 times more expensive)?

These are multi million dollar decisions!

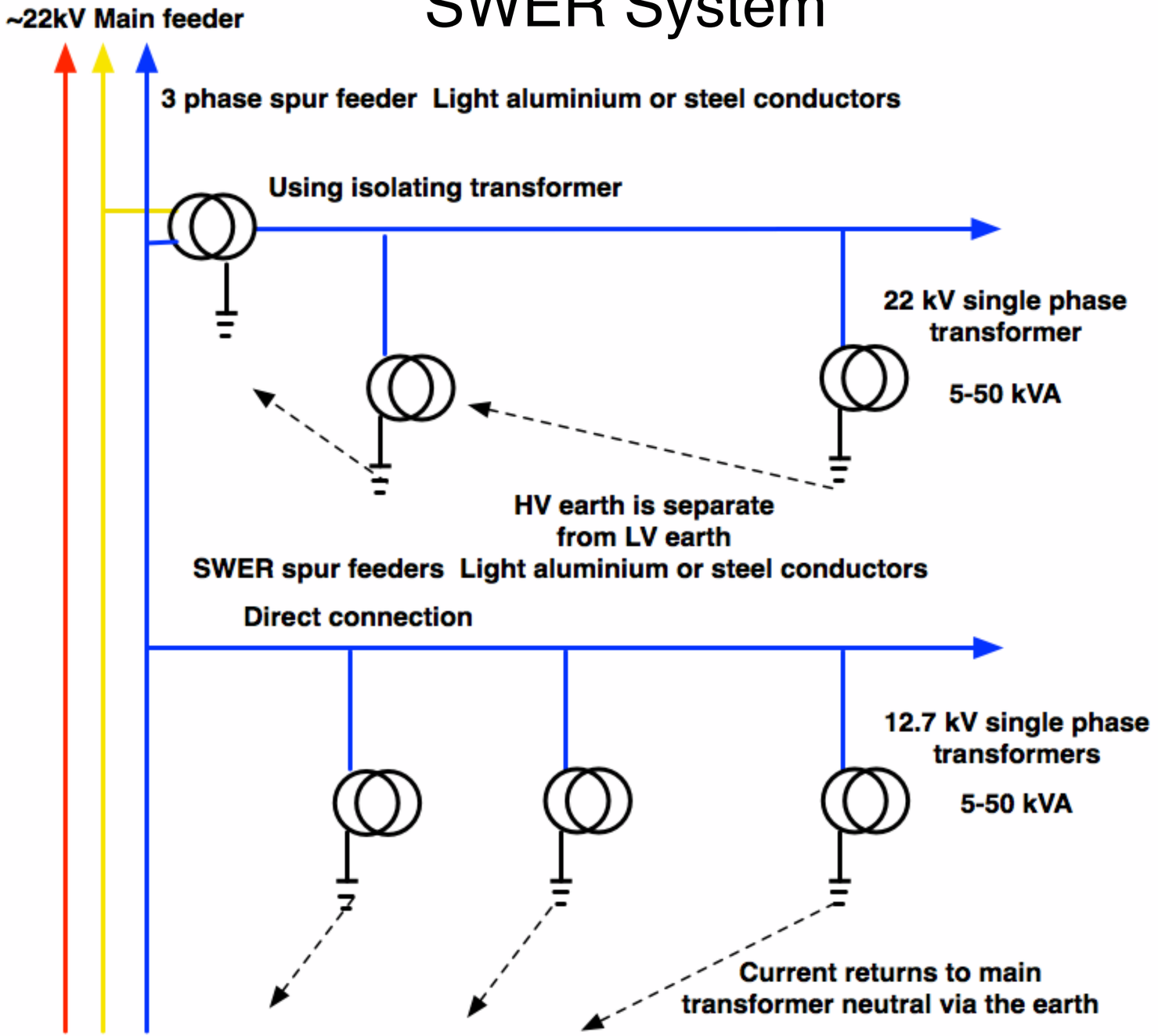
Conventional system

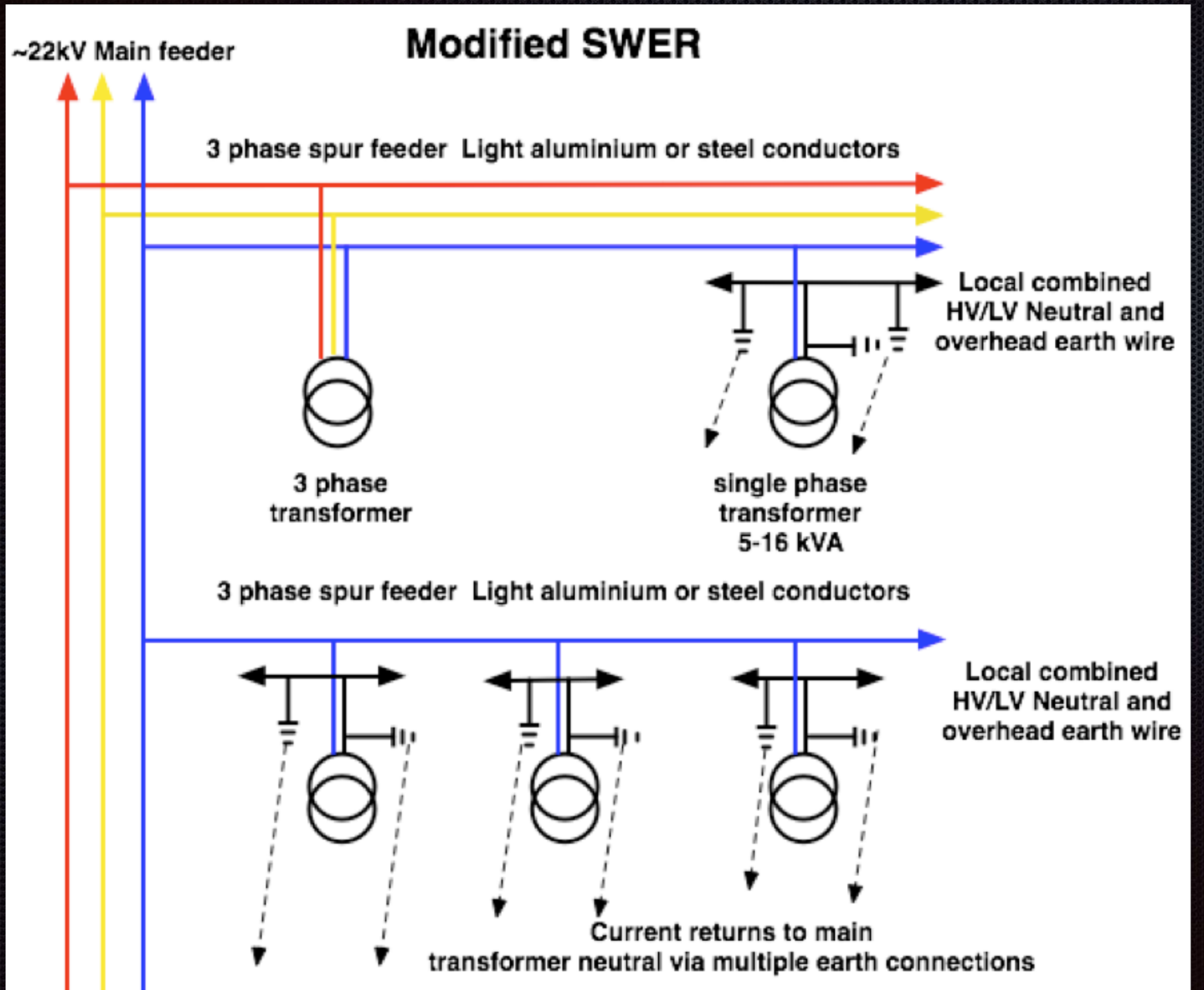


USA (RERC) practice



SWER System


~22kV Main feeder
3 phase spur feeder Light aluminium or steel conductors
Using isolating transformer
22 kV single phase transformer
5-50 kVA
HV earth is separate from LV earth
SWER spur feeders Light aluminium or steel conductors
Direct connection
12.7 kV single phase transformers
5-50 kVA
Current returns to main transformer neutral via the earth


Modified SWER
~22kV Main feeder
3 phase spur feeder Light aluminium or steel conductors
Local combined HV/LV Neutral and overhead earth wire
3 phase transformer
single phase transformer 5-16 kVA
3 phase spur feeder Light aluminium or steel conductors
Local combined HV/LV Neutral and overhead earth wire
Current returns to main transformer neutral via multiple earth connections

Why doesn’t everyone do it?

The major reasons

- no pressure to extend electrification at minimum cost
- the management and engineers are conservative
- aid projects/banks don’t insist on low cost systems
  - **The consumer loses!**

High cost or low cost?

Transformer in E Timor

Transformer in Bhutan

NZ SWER transformer

Minigrids

Many mini grids run at 230/400 V

This seriously limits transmission distance

If the distances are only a few km

- 3 Phase 1000 V is a viable alternative
- uses standard 400 V cables and gear
- reduces percentage voltage drop by a factor of 6

Can then use one mini hydro plant to feed several villages

What needs to be done?

New design standards are needed

- for guidance
- for safety
- to make sure that the philosophy is applied uniformly over the whole organisation
- they must concentrate on economy and safety rather than perpetuate existing inappropriate standards

Employ an experienced engineer from Australia or another country with a successful, low cost, rural electrification system?

Conclusion

By adopting international best practice an adequate and reliable supply can be given to more people at a much lower cost

This is NOT the way to do it