



Siting Transmission Lines & Substations

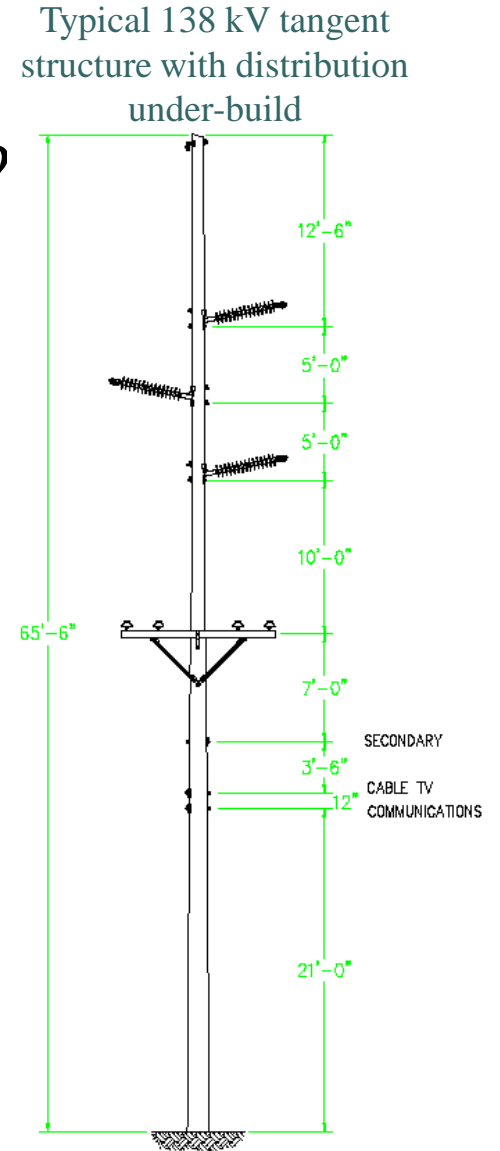
Salt Lake County
Electrical Plan Task Force
December 3rd

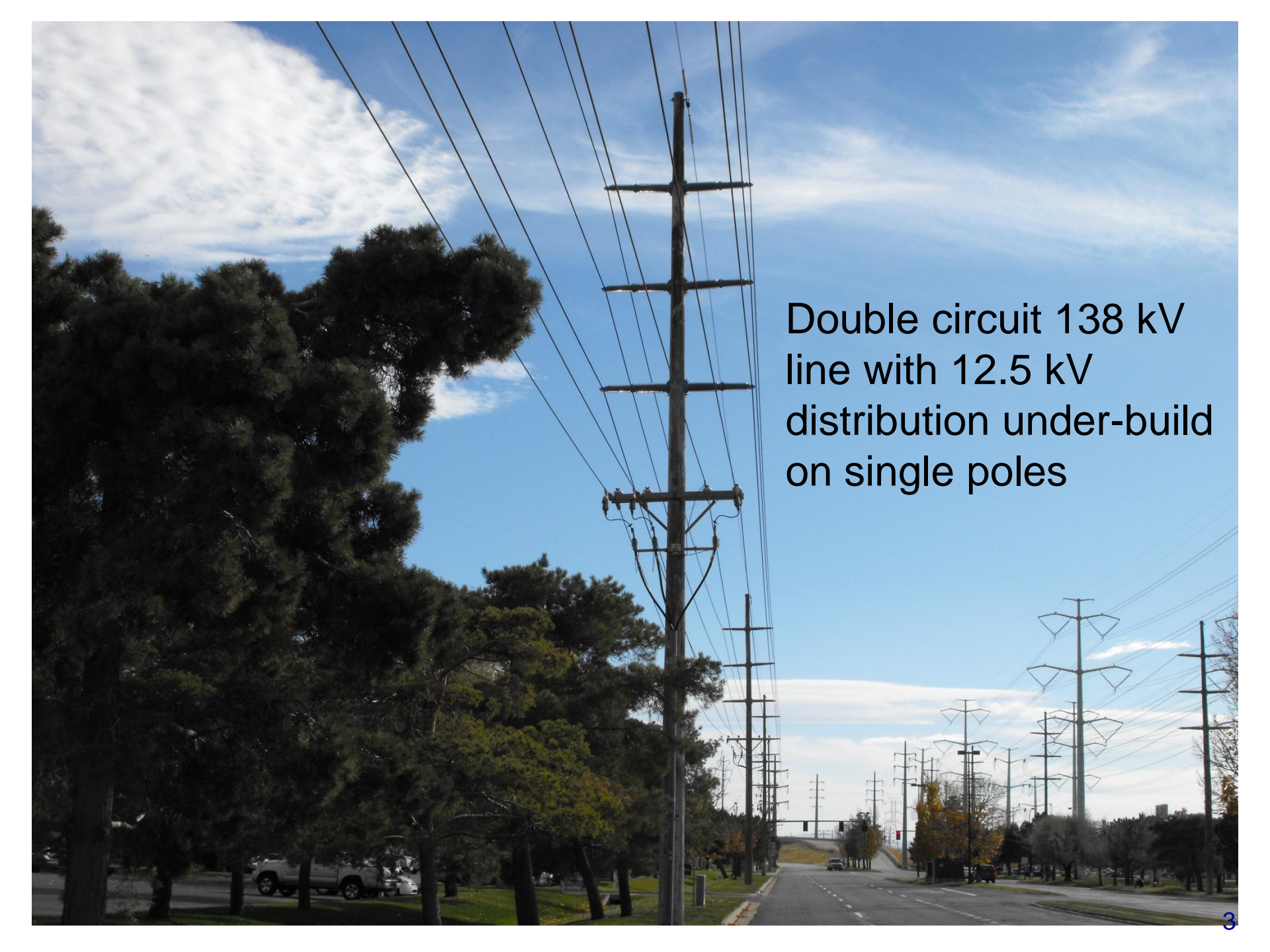
Mickey Beaver
Customer and Community Manager
Rocky Mountain Power



Transmission Lines

- What does a transmission line look like?
 - *Conductors*
 - *Insulators*
 - *Cross arms*
 - *Shield wire/communications*
 - *Ground wire*
 - *Guy wire*
 - *Foundation*
 - *3rd party attachments*





Double circuit 138 kV
line with 12.5 kV
distribution under-build
on single poles



Transmission Design

- What is needed to serve the future load
 - *5 years?*
 - *10 years?*
 - *50 years?*
- Company standards
 - *Avian safe (set by federal regulations)*
 - *Standard materials (restoration and cost)*
- Federal, state, and local regulations
 - *NESC (National Electrical Safety Code)*
 - *WECC (Western Electricity Coordinating Council)*
 - *NERC (North American Electric Reliability Corporation)*
- Right of way
 - *Access for construction, maintenance, and repair*



Transmission Design – What is needed?

- Plan for the future - This is why we are here!
 - *Build once or build and re-build and re-build and re...*
 - *Incorporate community's master plans and vision within the confines of existing regulations*
- *Something to think about...when we plan for the future, do we keep our options open or close the door?*



Transmission Line Capacity

- Many factors determine how much power a given transmission line can carry
 - *Conductor*
 - *Size*
 - *Material*
 - *Conditions*
 - *Ambient temperature*
 - *Wind speed*
 - *Elevation*
 - *Sun angle*
 - *Remember the equation P (power) = V (voltage) \times I (current)*





Transmission Line Capacity

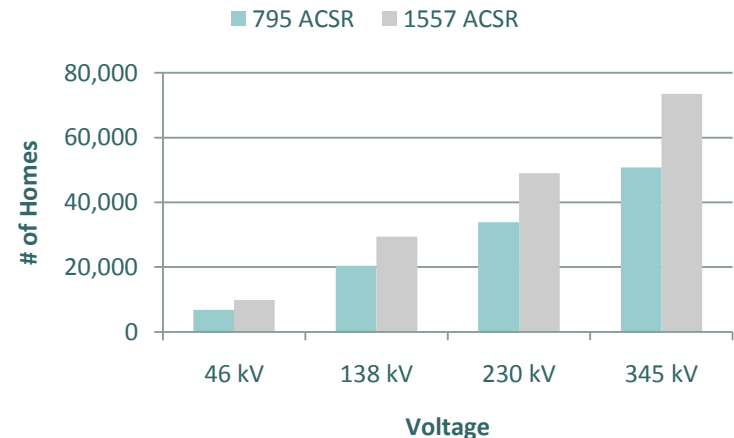
For a transmission line built with 1557 ACSR conductor, typical capacities are:

- 345,000 Volt line can carry ~ 735 MW
- 230,000 Volt line can carry ~ 490 MW
- 138,000 Volt line can carry ~ 294 MW
- 46,000 Volt line can carry ~ 98 MW



— In comparison, a transmission line built with 795 ACSR conductor, typical capacities are:

- 345,000 Volt line can carry ~ 508 MW
- 230,000 Volt line can carry ~ 339 MW
- 138,000 Volt line can carry ~ 204 MW
- 46,000 Volt line can carry ~ 68 MW





Transmission Design – Company Standards

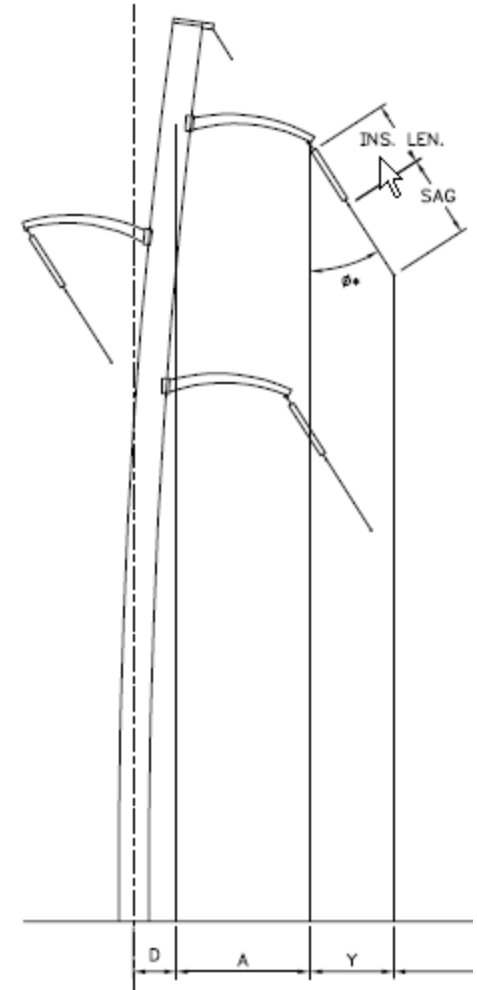
- Avian safety
 - *Lines are designed to mitigate accidental electrocution of protected species*
 - Minimum clearances between energized conductors and grounded components are mandated by federal law
- Standard materials
 - *Use of standard materials minimizes restoration time when a component fails*



Transmission Design – Government Regulations

– Code Requirements

- *Vertical clearance*
 - Maximum conductor sag (line heating, line tension, ambient temperature, conductor weight)
 - What does the conductor cross (roads, railroads, trails, water, structures, etc.)
 - Construction error
- *Horizontal clearance*
 - Pole deflection
 - Conductor and insulator string blowout
 - Construction error



Jim Bridger to Kinport
345,000 Volt Line





Transmission Design Government Regulations

– Code Requirements (cont.)

- *Clearance requirements dependent on transmission line voltage*
 - As voltages increase, required clearances increase
- *General height comparison (there are always exceptions)*
 - Typical 345 kV single circuit H-frame structure will be 90-120' above ground
 - Typical 345 kV double circuit single pole structure will be 130-170' above ground (200' in some cases)
 - Typical 138 kV single circuit H-frame structure will be 60-90' above ground
 - Typical 138 kV double circuit single pole structure will be 70-95' above ground (115' in some cases)



Transmission Right of Way

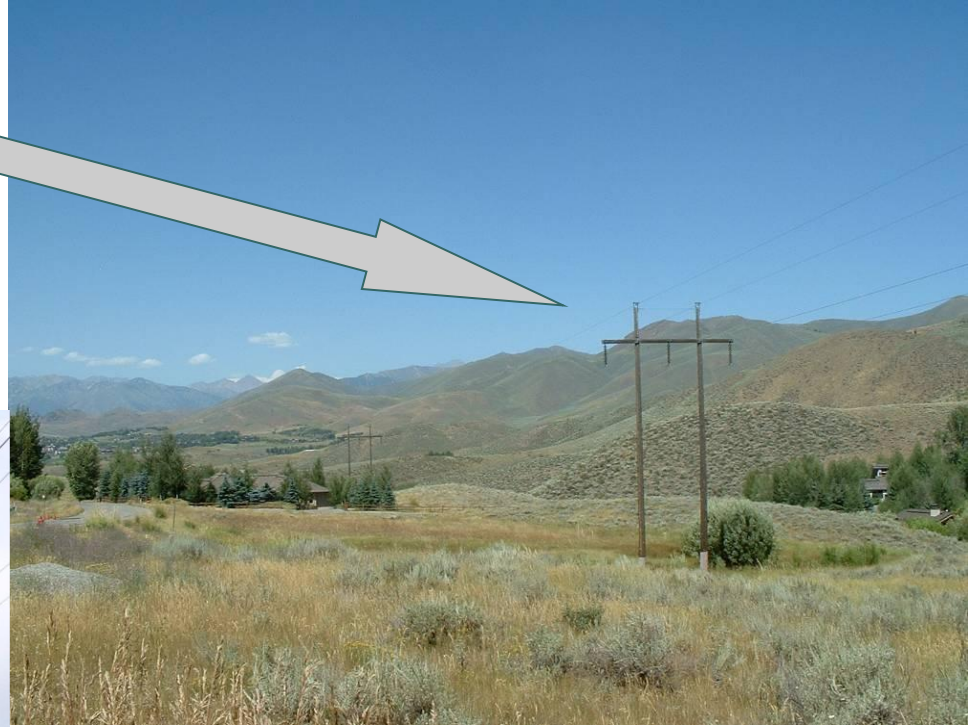
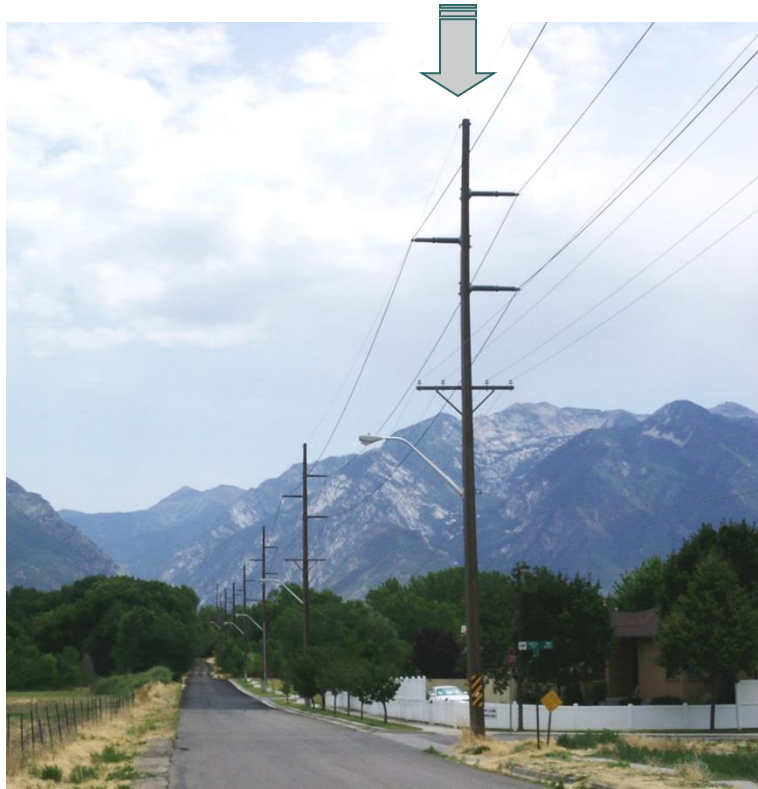
- Minimum width of right-of-way required for a transmission line is set by the National Electrical Safety Code
 - *Takes into account conductor blowout*
 - How far the wire can be expected to swing during a high wind on a hot day
 - Can't come close to structures or trees because of wind
 - *Pole structure, wire size and span length go into the equation*
- Single pole structures require less ROW width than lattice or multiple pole structures



Transmission Right of Way

– 138 kV

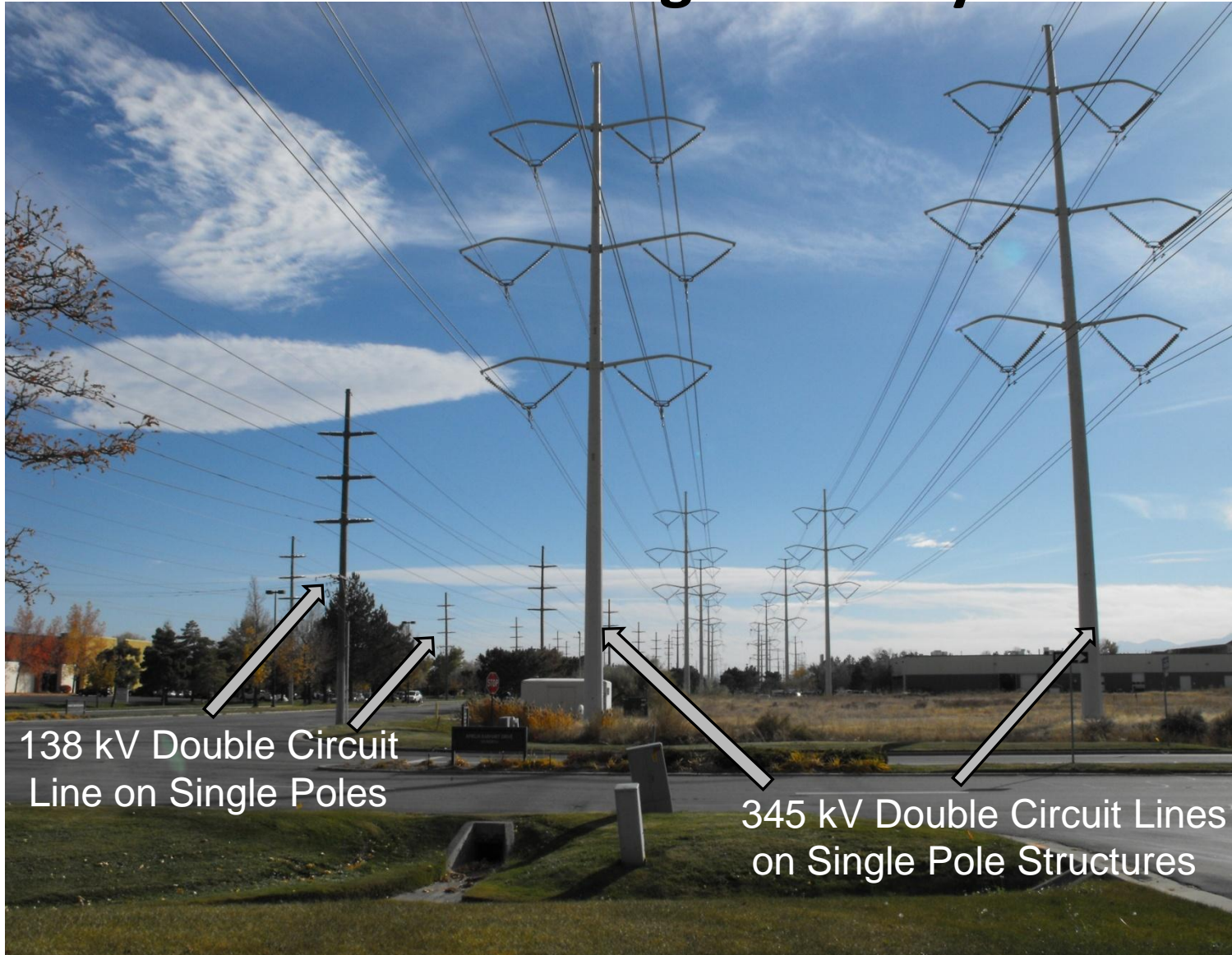
- *H-frame*
 - Typically 100 feet ROW
 - 600 ft average span
- *Single Pole*
 - Typically 60 feet ROW
 - 300 ft average span



If located near road right-of-way,
the private width requirements can
be reduced



Transmission Right of Way



138 kV Double Circuit Line on Single Poles

345 kV Double Circuit Lines on Single Pole Structures

Transmission lines are often in corridors, areas where two or more transmission lines are in close proximity to each other

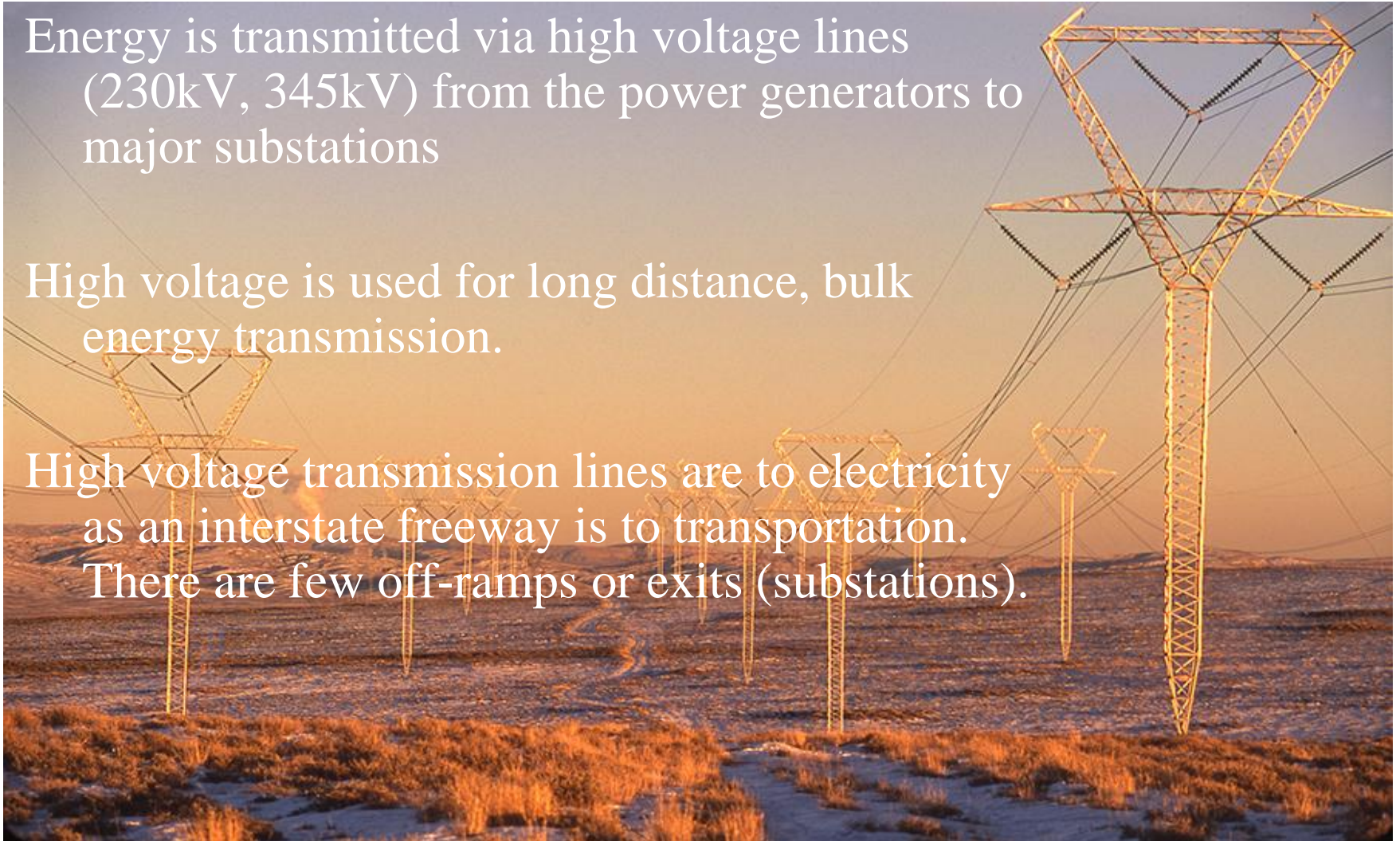


Transmission Design

Energy is transmitted via high voltage lines (230kV, 345kV) from the power generators to major substations

High voltage is used for long distance, bulk energy transmission.

High voltage transmission lines are to electricity as an interstate freeway is to transportation. There are few off-ramps or exits (substations).





Transmission Design

Sub-transmission Lines (Local Transmission)



- Sub-transmission voltages – 46 kV and 138 kV.
- Used to transmit energy from major substations to regional and local substations.
- Sub-transmission = state highway or arterial road



Transmission Reliability

- When do you want your power?
- Rocky Mountain Power must provide reliable service under all normal operating conditions and prefers to serve the majority of customers under expected abnormal operating conditions
- An abnormal operation condition is the loss of one or more electrical components. These include:
 - Generators (power plants)
 - Transmission lines
 - Substation transformers



Transmission Reliability

- Rocky Mountain Power complies with Western Electricity Coordinating Council (WECC) reliability standards
- Reliability standards are federally mandated and include penalties for poor reliability performance (≥ 100 kV)
- Rocky Mountain Power must periodically submit reports to the reliability councils
- Public Service Commission has some oversight authority



Local Area Transmission Reliability

- In areas that have multiple transmission lines, the additional lines have capacity available in case something happens to one of the other lines, e.g. normal operation with one line down (N-1)
 - *Example: The proposed Railroad to Silver Creek 138 kV line is needed to maintain service to Summit and Wasatch Counties during peak demand upon the loss of either existing 138 kV source to the area*



Transmission Reliability

- Not all local transmission has backup
 - *Many times a single, lower voltage line will be the only transmission serving an area. If the line goes out of service, customers served by that line lose power*
 - Typical of smaller demand areas such as in mountains or rural areas
 - *Example: For the transmission line serving Oakley and Kamas, there is no backup to the single 46 kilovolt lines*



Transmission Reliability

- Not everyone sees the same level of reliability
 - *It would be prohibitively expensive to ensure all customers have the same reliability*
 - *Customers located in urban areas generally have the ability to receive power from more than one distribution or transmission line*
 - *Remote customers may only have one distribution or transmission line serving their area*
 - *In mountainous areas, snow and wind may cause more outages*

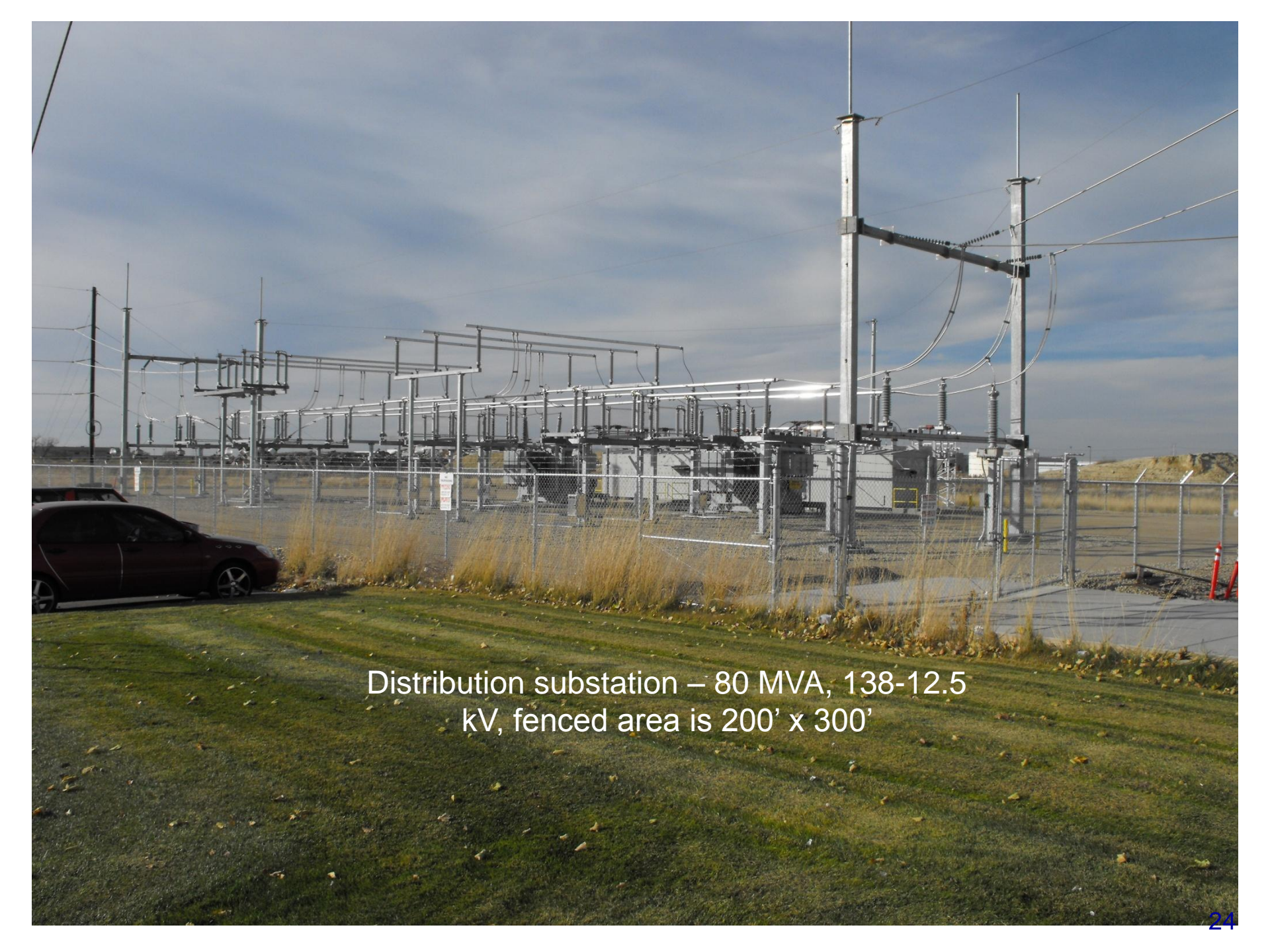


Transmission Design - Increasing Capacity of Existing Lines

- Capacity of existing transmission lines can sometimes be increased
 - *Increase wire size*
 - *Increase voltage*
 - If electrical clearances are great enough
 - If ROW is available

●●● Substations

- A substation transforms or changes voltage levels and contains equipment to protect and control power lines.
- Substations can contain the following:
 - Transformers
 - Switches
 - Circuit breakers
 - Large metallic pipe called bus work
 - Support structures to terminate transmission lines
 - Communications equipment
- **Substations do not generate power.**

A photograph of a distribution substation. The substation is enclosed in a chain-link fence. Inside the fence, there are several tall metal structures (poles) with cross-arms and insulators, connected by overhead power lines. A dark-colored car is parked on the left side of the fence. The foreground is a grassy area with some dry grass and fallen leaves. The sky is overcast with grey clouds. The overall scene is an industrial or utility site.

Distribution substation – 80 MVA, 138-12.5
kV, fenced area is 200' x 300'

●●● Substations

- Major substations (main grid): Convert power from high voltage transmission lines (230 kV, 345 kV) to sub-transmission voltages (46 kV, 138 kV)
- Regional substations (sub-transmission): Convert power from sub-transmission lines (46 kV, 138 kV) to other sub-transmission voltages and distribution voltages (12.5 kV, 25 kV)
 - *Silver Creek substation located in Summit County*
- Local substations (distribution): Convert power from sub-transmission lines (46 kV, 138 kV) to distribution voltages (12.5 kV, 25 kV)
 - *Examples of these in Summit/Wasatch:*
Silver Creek sub; Summit Park sub; Snyderville sub; Park City sub; Judge sub; Jordanelle sub; Kamas sub; Oakley sub; Coalville sub; Henefer sub

●●● Substations – Highway Analogy

- Think of a major (main grid) substation as an on-ramp or off-ramp from an interstate
- Think of a regional (sub-transmission) substation as an intersection connecting a state highway to a main city street.
- Think of a local (distribution) substation as an intersection connecting a main city street to a residential or commercial subdivision.
- The different types of substations can be co-located.

●●● Substations - Highway Analogy

- Using the highway analogy, electricity travels through lines and substations in the same way a commuter might go home from work.
 - First the commuter leaves the interstate by way of an off-ramp or high voltage substation.
 - Then high voltage moves down a smaller state highway, leaving the highway at a major intersection or local sub-transmission substation onto a city street.
 - Next it turns off the city street via a minor intersection or distribution substation into a subdivision.
 - Finally the commuter turns into the driveway via a pole or pad mount transformer.

●●● Local Distribution Substation Design

- Balance Reliability and Cost
- Location considerations
 - *Central to the area to be served for local distribution substations*
 - Most flexibility to recover from outages
 - Consistent reliability opportunity for all customers
 - Creates strongest support for least cost
 - Maximizes coverage area
 - *Sufficient land area*
 - Typical local distribution substation requires 1 acre inside fence
 - Clearances for electrical safety (NESC minimum)
 - Access for large equipment
 - Room for expansion to ultimate build-out

Local Distribution Substation Design

- *Sufficient land area (continued)*
 - Ultimately serves up to 80 MW of load
 - 1-3 square miles for industrial load
 - 2-5 square miles for commercial load
 - 6-8 square miles for typical urban residential load (8000 homes)
- *Environmental considerations*
 - Year-round access
 - Soil and site conditions
- *Proximity to existing electrical infrastructure*
 - Transmission corridors
 - Existing distribution facilities



Cottonwood substation 138-46 kV, 138-12.5 kV, & 46-12.5 kV



90th South substation
345-138 kV, 138-46 kV, & 138-12.5 kV

West Jordan substation
138-12.5 kV



Hoggard substation 138-12.5 kV



South Jordan substation
138-12.5 kV



Sunrise substation
138-12.5 kV