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TS (Total Solution) Conductor

The Road to Sustainability

August 1st, 2023

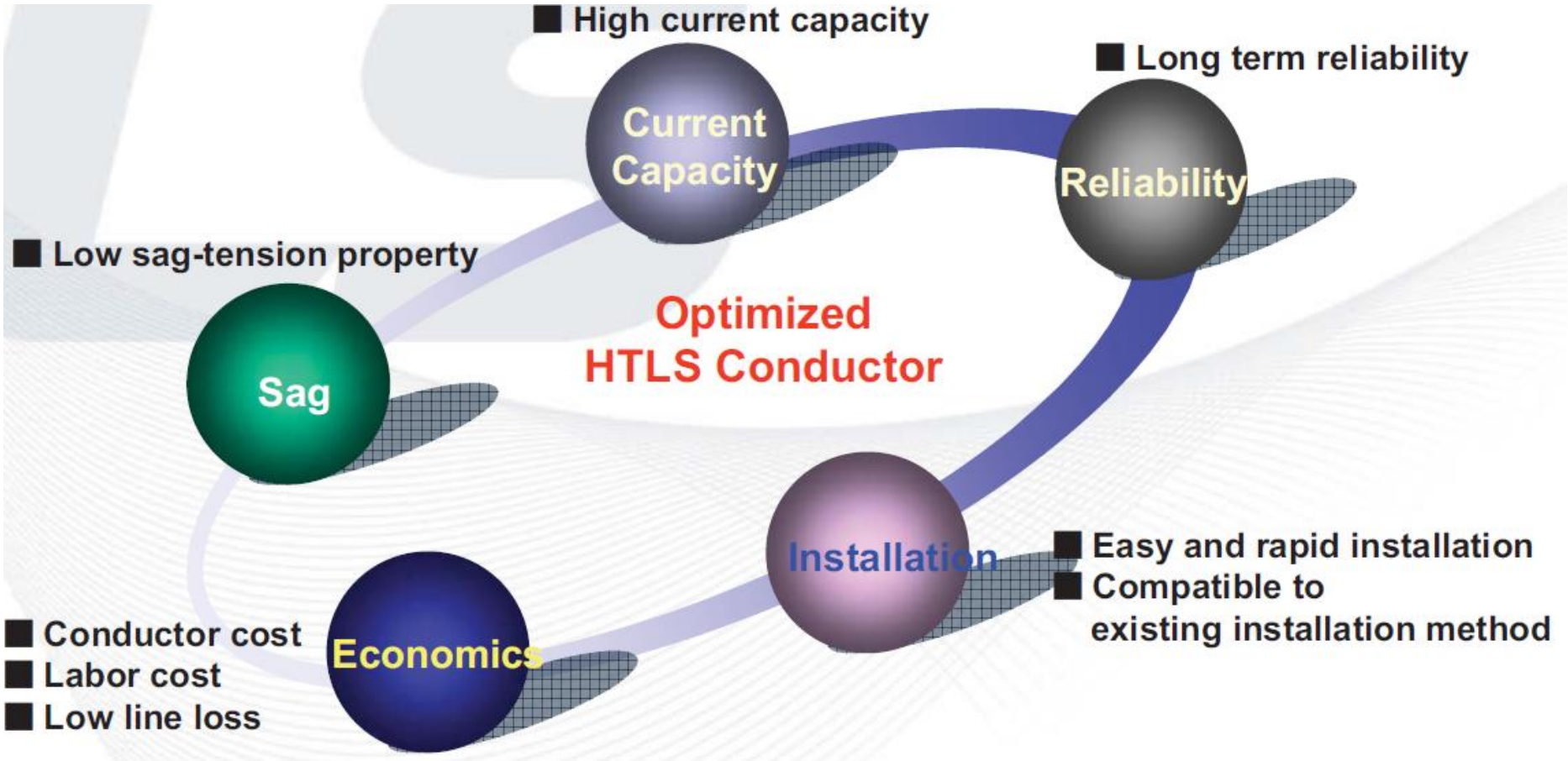
TS Conductor Corporation Background
(US Manufacturing, Safety and Mainstream Application)

Wire the Grid of the World with TS, Specifically,

- ✓ Facilitate Net-Zero and Renewable Integration
- ✓ Enable Grid Self-Monitoring & Improve Resiliency
- ✓ Improve Grid **Efficiency** & Reduce GHG Emission

- TS Conductor Corp - a Public Benefit Corporation, with focus on sustainability and GHG reduction/decarbonization
  - ❖ Funding from BEV, **National Grid and NextEra**
  - ❖ **Conductor** Manufacturing (Southern California)
- Featuring the Best Materials for Conductor, and Enabling Design with Protection of the Core (**Designed-in Safety, Reliability and Longevity**) and Easy to Use (**Traditional Work Practice**)
  - **3x Ampacity** with Existing Structures
  - **Lowest Capex** (fewer & shorter structures in New Build or rebuild)
  - 50% Better **Efficiency**
  - Smart Conductor (True **Dynamic Line Rating**)
    - Line Sag, Line Fault, Line Damage (e.g., Gun shot & Vegetation) and Extreme Weather Impact
    - Accurate, Real-Time, Life Time

Desired Attributes for Conductors



Conductor Evolution: Material Technology

(TS - Ultimate Combination of the Best from Materials Science)

ACSR Conductor

- Deployed **~1908**, Still Dominant (90%).
- Limited Capacity, Poor Efficiency
- High Thermal Sag
- Vulnerable to Corrosion

Composite Core Conductor

- 1st Gen: **CFCC/ACCR** (~2000)
  - – Successfully Increased Capacity
  - – Exposed Core to Environment
- 1st Gen CFCC Limitations:
  - – Core Sensitive to Bending (fracture)
  - – Incompatible With Conventional Work Methods for Connectors, etc.
  - – Excessive Sag in Ice Loading
- 2nd Gen (TS) – Aluminium Encapsulation of Carbon Core Eliminates Limitations

Options for Aluminum (CONDUCTIVITY)							Options for Core (STRENGTH)				
Name	IACS %	Strength MPa	Thermal Limit, Cont.	Thermal Limit, < 10 hrs	Description	Conductor Types	Description	MoE GPa	Strength MPa	CTE $10^{-6}/^{o}C$	Density g/cc
1350-H19	**61.2**	162-172	**90**	120	Hard Drawn	**ACSR**	HS Steel	200	**1379-1448**	**11.5**	**7.778**
5005-H19	53.3	248	90	120	MS Alloy		EHS Steel	200	1517	11.5	7.778
6201b-T81	52.5	317-331	90	120	HS Alloy	**ACSS**	EXHS Steel	200	1965	11.5	7.778
TAL	60	165-186	150	180	Thermal Resistant		Mischmetal or Al Clad (HS Steel)	200	1379-1448	11.5	7.778
KTAL	55	186-252	150	180	HS Thermal Resistant		Invar Alloy	162	1034-1069	1.5-3	6.588
ZTAL & UTAL	57-60	165-186	200	240	Ultra Thermal Resistant	**ACCR**	Al2O3 in Al Matrix	210	1380	6.3	3.337
XTAL	58	165-186	230	310	Extra Thermal Resistant	**CFCC**	Glass/Carbon Hybrid	**112**	2100	1.61	1.88
1350-O	**63 Most Conductive**	55-96	**250 Highest Temp**	310	**Fully Annealed**	**TS**	**Carbon Composite**	165	**3500 Highest Strength**	**0.06 Lowest Sag**	**1.6 Lightest Weight**

ACSR (Yellow - Hard Drawn Aluminium & HS Steel, was the best material in the 1900s)

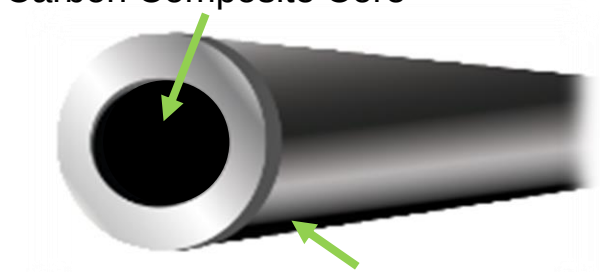
TS (Green – Best Possible Material in 21st Century for the Ultimate Combination) - Ideal for Renewables Integration

Breakthrough Design: For Safety, Reliability and Longevity

Safety, Reliability and Longevity Designed-in; Compatibility with Tradition

Durable Design Technology

- **Shielding**: Gap-free design protects core 100% from environmental degradation and galvanic corrosion for life
- **Toughening**: High tolerance against mishandling, breakage and fracture
- **Cushioning**: Fully compatible with traditional work methods
- **Flexibility**: Tight radius and field handling tolerance



Increased Performance Over ACSR

- Highest aluminium content. Highest ampacity
- Low Sag (heat or ice). Significantly better than ACSS
- Light weight & high strength facilitates longer span or shorter towers, saving on tower and foundation costs
- Higher ampacity than same size ACSR with much lower loss


Trapezoidal Stranding Maximizes Aluminum Content

TS Patented Gap-Free Design Provides the Optimal Balance of Safety/Reliability, Conductivity, Low Sag, and Easy to Work With

Toughened TS Core with Built-in Safety & Reliability

(Significant Bending Robustness after TS Encapsulation Applied)

Bare Core Sharp Edge Bend Comparison

- TS Conductor's Encapsulated Core Is Stronger and More Robust Against Mishandling.
- TS Pre-tension solved the Brittle nature of CFCC Core (poor compression)
- Encapsulation Protects against Sharp Edge

Bare Core Small Radius Bend Comparison

Reconductoring With Existing Structures & ROW

(Saving 40% Capex, Shorten Schedule by 12 months; Energized 3/19/21)

TS Tern for ACSR Drake Conductor
(11 mile MDU 230 kV Circuit, 1.5" Ice)

- Best Project Cost - No Structural Retrofitting
  - ACSS – 90% Tower Retrofit/Replacement
  - TS Solution – Saving 40% Project CAPEX
  - TS Solution – Saving 1 Yr from Project Schedule
- Higher Ampacity – Meet & Exceed Capacity Target
- Greater Resiliency & Reliability
  - TS only 35% Loaded (vs ACSS 62% loaded) in 1.5" ice
- Better Clearance (Most Conditions)
  - 10' less sag, less prone to Galloping
  - Lower EMF & Corona at Ground Level

TS Removes Congestion (per MDU)

- Faster and Cheaper than any Alternative
- Within Existing Right of Way
- With Existing Structures

MDU ACSR Drake Reconductoring (NESC 250D - with 1.5" Ice)	Line Length (miles): 11; Voltage (kV): 230			
	ACSR	ACSS	TS Economy	TS
	1900's Tech	1970's Tech (Saggy)	Current Tech – Lowest Cost	
Diameter (in.):	1.11	1.11	1.00	1.06
Aluminum Area (kcmil):	795	795	816.6	933.8
DC Resistance at 20°C (ohms/kft):	0.0214	0.0208	0.0205	0.0179
Ampacity (A) at Maximum Temp (°C):	934 (90 C)	1580 (200 C)	1544 (200 C)	1677 (200 C)
Max Transmission Capacity (MVA):	372	629	615	668
Wind / Ice or Cold Temperature Sag/Tension	Temperature (°C): -10; Windspeed (mph): 0; Radial Ice Thickness (in.): 1.5; Ruling Span (ft): 800/800/800/800			
Maximum Thermal Sag (ft):	20.5 (90 C)	25.54 (200 C)	9.94 (200 C)	10.8 (200 C)
Maximum Ice or Wind Vertical Sag (ft):	25.84	29.86	25.81	25.81
Total Tower Tension (lbf):	18470	15995	17072	17761
% RTS:	59%	62%	35%	35%
Line Losses (11 miles, 934 Peak Amps)	Load Factor: 0.7; Cost of Energy Generation (USD$/MWh): 131.9			
Line Loss Savings of Conductor (USD$/ft/Year):		$0.36	$0.45	$2.43
Reduces 30 year line loss by (USD$):		$1,857,679	$2,340,953	$12,721,499
Reduces 30 year CO_2 generation by (MT):		13,991	17,630	95,809

Toughened TS Core w/ Enhanced Bending Ability

(Proven Robustness in Field Bending, Suitable with Smaller Reel)

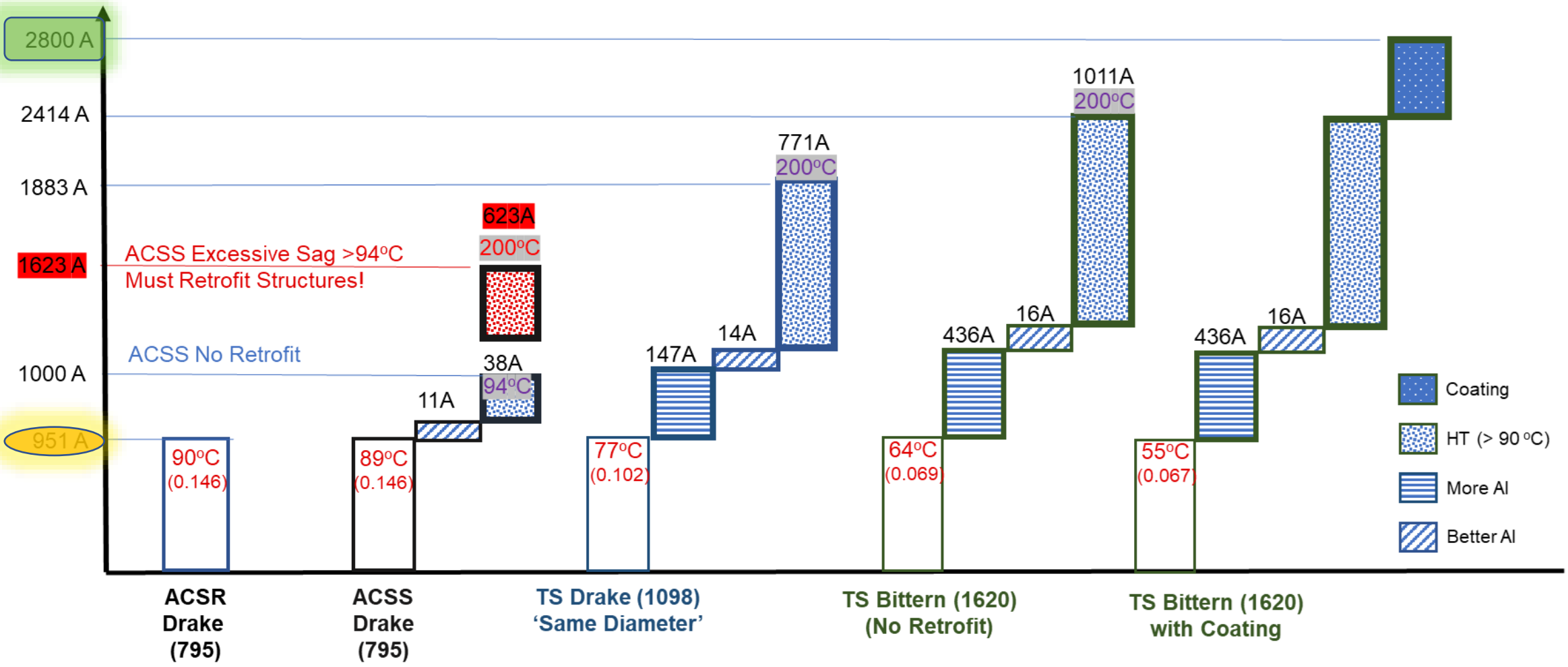
Before Encapsulation:
1.4m Reel

After Encapsulation:
0.83m Reel

Bill Parsons (MDU Crew) Commentary on Toughness & Bendability of TS Conductor
(Hands-on Experience In the Field)

300% Capacity Enabled, with Existing Structures & ROW

(While Also Improving Grid Efficiency by 50%)



TS Enables Ampacity Increase to 300% with No Structure Retrofitting (AND > 50% Better Efficiency).

400' Span, NESC Heavy; 35 C, 2 ft/s wind, 90, 0 elevation, NS, 33 Latitude, June 10 (12 pm), Clear, 0.5/0.5 for Ampacity unless noted; 69 kV Subtransmission

Reconductoring or New Build With TS Options
(Lower Capex, More Ampacity, Lower Line Loss)

TS for ACSR Dove Conductor
(North East Power 69 kV Circuit, NESC Heavy)

- Best Project Cost - No Structural Retrofitting in Reconductoring
  - TS Condor – 230% Capacity of ACSR Dove
  - Most Economical and Fastest Way for Capacity Upgrade
  - Efficient ($2/ft Saving Annually)
- Best Project Cost – New Build or Rebuild
  - TS Pelican, Saving ~1 Structure per Mile
  - Better Clearance (Most Conditions)
    - 10' less sag, less prone to Galloping
    - Lower EMF & Corona at Ground Level

TS Multiple Options

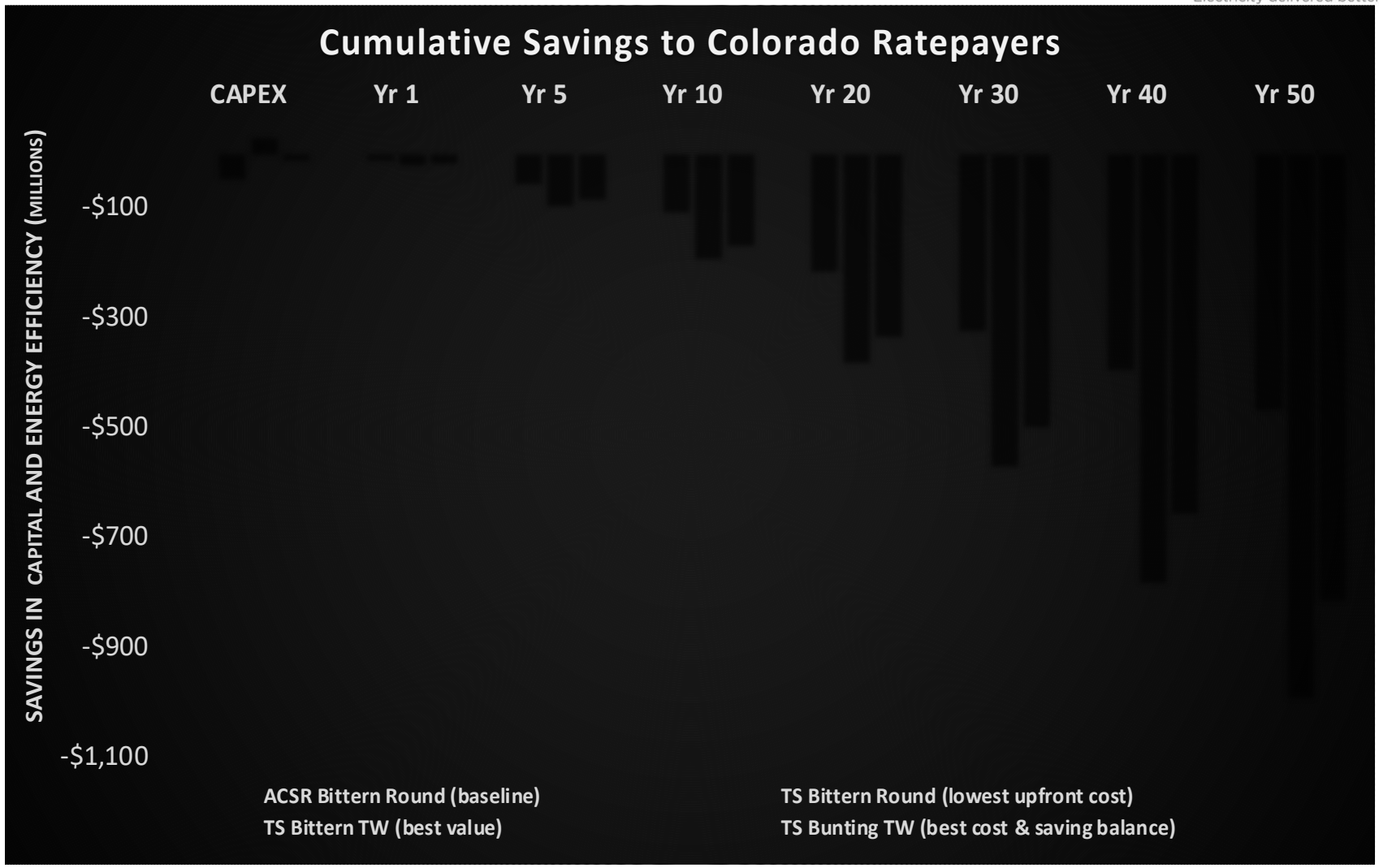
- TS Condor (Highest Ampacity, Best Efficiency)
- TS Pelican (Best CAPEX in New Build or Rebuild)
- TS Dove (Balance in Capacity/Efficiency/CAPEX)

TS Option for ACSR Dove (NESC Heavy)	Line Length (miles): 10.5; Voltage (kV): 69			
	ACSR	TS Efficient	TS	TS Economical
	282 - DOVE	532 - TS Condor M3 7	369 - TS Dove M3 7.5	281 - TS Pelican M3 7
Diameter (in.):	0.93	1.09	0.93	0.81
Aluminum Area (kcmil):	556.5	1050.2	728.9	555.4
Rated Strength (lbf):	22600	30810	32310	27640
Weight (lb/kft):	766	1029	733	564
DC Resistance at 20°C (ohms/kft):	0.0305	0.016	0.023	**0.0301**
Ampacity (A) at Temperature (°C):	Total Peak Operating Amps: 826; Load Factor: 0.5			
Ampacity (A) at Maximum Temp (°C):	826 (90 C)	1879 (200 C)	1490 (200 C)	1250 (200 C)
Wind / Ice or Cold Temperature Sag/Tension	Temperature (°C): -20; Windspeed (mph): 40; Radial Ice Thickness (in.): 0.5; Ruling Span (ft): 800/800/873/925			
Maximum Thermal Sag (ft):	21.25 (90 C)	21.11 (200 C)	16.55 (200 C)	12.75 (200 C)
Total Sag (ft):	18.08	21.25	21.24	21.18
Total Tower Tension (lbf):	9182	9180	9168	9136
% RTS:	41%	30%	28%	33%
Line Losses (10.5 miles, 826 Peak Amps)	Load Factor: 0.5; Cost of Energy Generation (USD$/MWh): 60			
First Year Line Losses (MWh):	11232	5422	8098	11261
.ine Loss Savings of Conductor (USD$/ft/Year):		$2.10	$1.13	-$0.01
Reduces 30 year line loss by (USD$):		$10,458,667.17	$5,640,443.24	-$51,588.74
Reduces 30 year CO_2 generation by (MT):		173,157	93,385	-854

No Green Premium (Go Green…Get Green!)

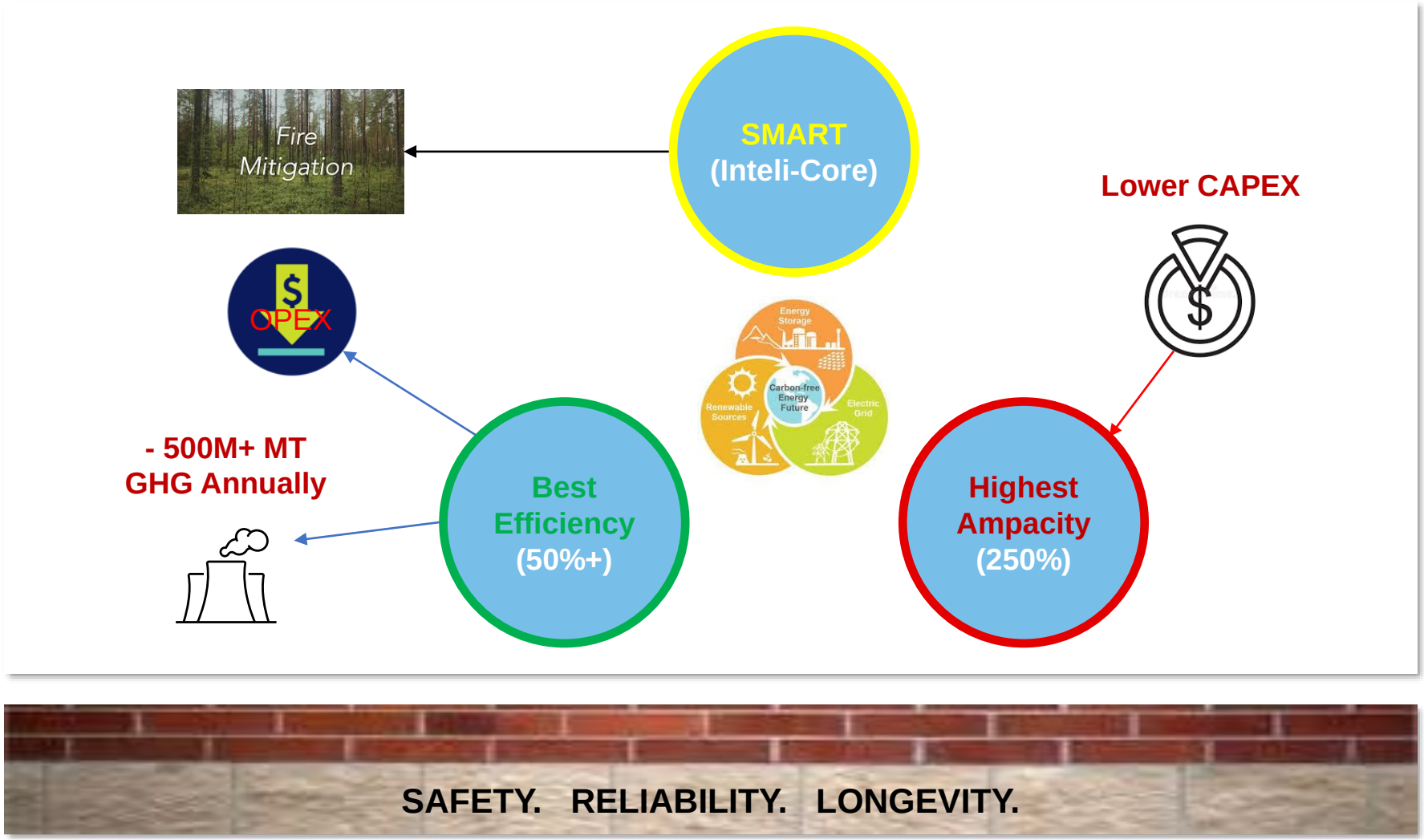
TS Options vs. ACSR Bittern
(345 kV, Twin Bundle, Double Circuit, 560 Miles, 60% Load)

- Everyone Wins
  - Rate Payers Save even More from **Efficiency Enabled by TS**
- 'Future Proof' Capacity for Optimal Renewable Integration
  - > 5000 MW (vs ACSR ~3000 MW)
  - Lowest $/MW/Mile.
- Greater Reliability & Resilience
- Better Clearance (5'-7', w/o Ice)
- **Fewer Or Shorter Towers with TS Options**
  - Less Land Encroachment or Land Destruction/Disruption



- Up to $1 Billion Savings from Line Loss Reduction in 50 yrs (@$30/MWhr) with TS Bittern TW

More to Come (Smart Functionality)

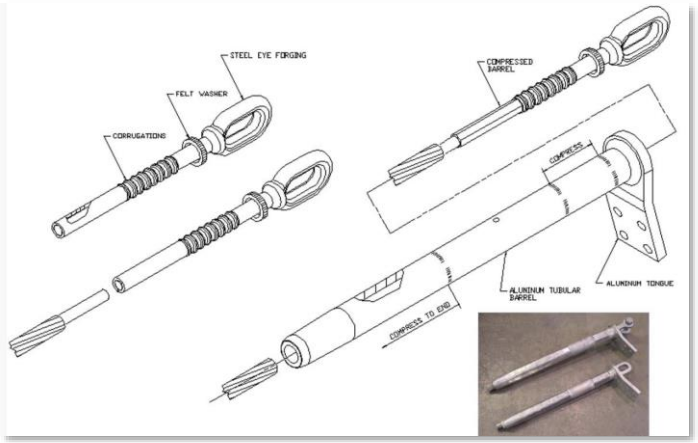


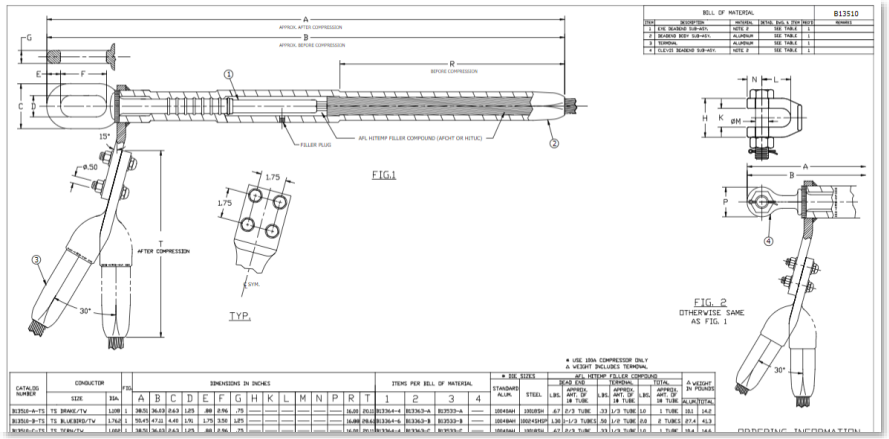
Electricity Delivered Better

Better is…

- **More:** Triple the Line Capacity (without structural retrofit & minimal outage time)
- **Easier:** Familiar Tools and Techniques for Linemen (installation & maintenance)
- **Resilient:** Durable & Corrosion-proof design; Strong & Higher Margin of Safety; Excellent Self Damping (annealed TW aluminum for aeolian vibration); Engineered for Managing Galloping (less slack, stiffer in torsion & bending, compact design)
- **Less:** 50% Reduction in Line Losses for Least Life Cycle Cost
- **Green:** Maximal integration of renewable, Minimal Compensatory Generation for GHG Reduction
- **Affordable:** Fewer/Shorter Structures for lowest CAPEX (least cost per MW)
- **Smart:** Digitalized Wires for Precise Sag, Fault Location, Temperature and Tension (hot & cold spots, wildfires, and ice and wind events) Real-time
- **De-risked:** No-regret Deployment through ESCO Financing (avoid upfront capital)

Compatibility with Standard Compression Tools/Methods
(no new tools, no new equipment, no new training)



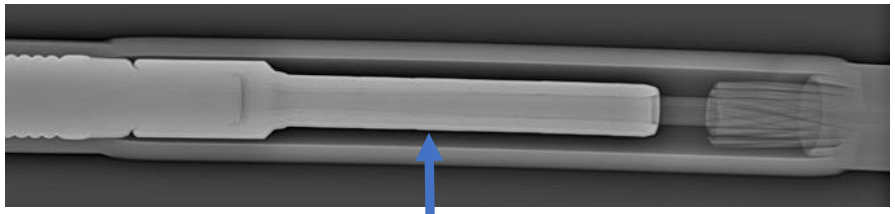


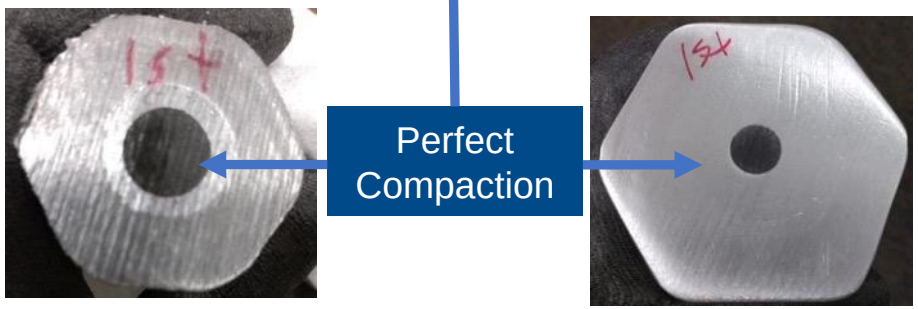
TEST SETUP

Four deadend samples were tested to failure on TS Drake BC150 9.5.

A picture of one sample in the general test setup is shown below.

Figure 1 – Tensile load test setup for complete conductor.





AFL

Installation Instructions
INS-ACA125

Installation Instructions

for AFL Compression Dead End Installed

on TS HTLS Conductor

Dr. Jason Huang

TS Conductor is co-founded and led by Jason Huang. Dr. Huang has been working in advanced conductors in the past 10 years, and over 20 years prior experience in composite material technologies (A350, A380, 787, 737, F35, V22, F18). He is a member of the CIGRE B2 Technical Advisory Group 6 (Conductor & Fitting) since 2010, and is regarded as one of the utility industry's leading experts in composite core wire and cable technology

Professional Experience

- Founder and CEO of TS Conductor Technologies (2018 – Present)
- CEO and CTO of CTC Global (2010 – 2017)
- VP of Engineering Technology at BAE Systems Composite Structures
- Senior Director, Product Development, Cytec Engineered Materials
- Senior Manager, Goodrich Corporation

Education

- PhD in Materials Science and Engineering from The Ohio State University, MBA from Fisher College of Business
- MS in Materials Science from University of California

TS Differentiators and TS Contact Information

TS Differentiators (via the Enabling Encapsulation Design)

- ✓ Safety, Reliability, Longevity, All Designed In the Conductor
- ✓ Compatibility with Industry Standard Work Methods
- ✓ Best Materials Science Offers
- ✓ Most Aluminum Content for Highest Ampacity and Best Efficiency

Jason Huang

CEO

818 430 5831(c); 714 842 3392 (o)

Jason@tsconductor.com; www.tsconductor.com

Kyle Wagner

Director, Sales & Marketing

(414) 460 9295 (c)

Kyle.wagner@tsconductor.com

Agents in the US

Moehn Electrical Sales Company, www.moehansales.com

Preferred Sales Agency, www.preferredsales.com

Stephens, McCarthy Lancaster LLC, www.stephens-mccarthy-lancaster.com

Best Ampacity (Drake Size Conductor Options)