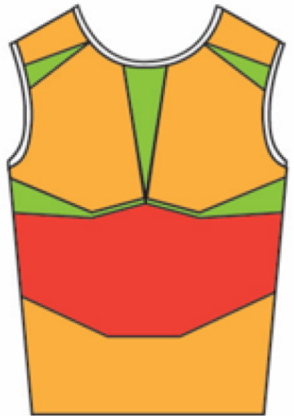
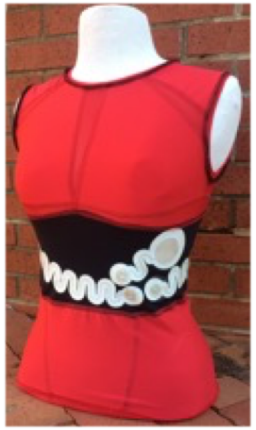
NEXT Wear: ECG Shirt

Retro-fit Garment

- Easy to incorporate into existing processes and product
- Lower cost structures
- ***Difficult to fit wide range of sizes***
- Less likely to maintain good electrode/skin contact

Cut & Sew Garment





- Requires new product development
- ***'intelligent/custom design'***
  - ***Compression***
  - ***Sensor location***
- With more fitting to population, will lead to AI designing

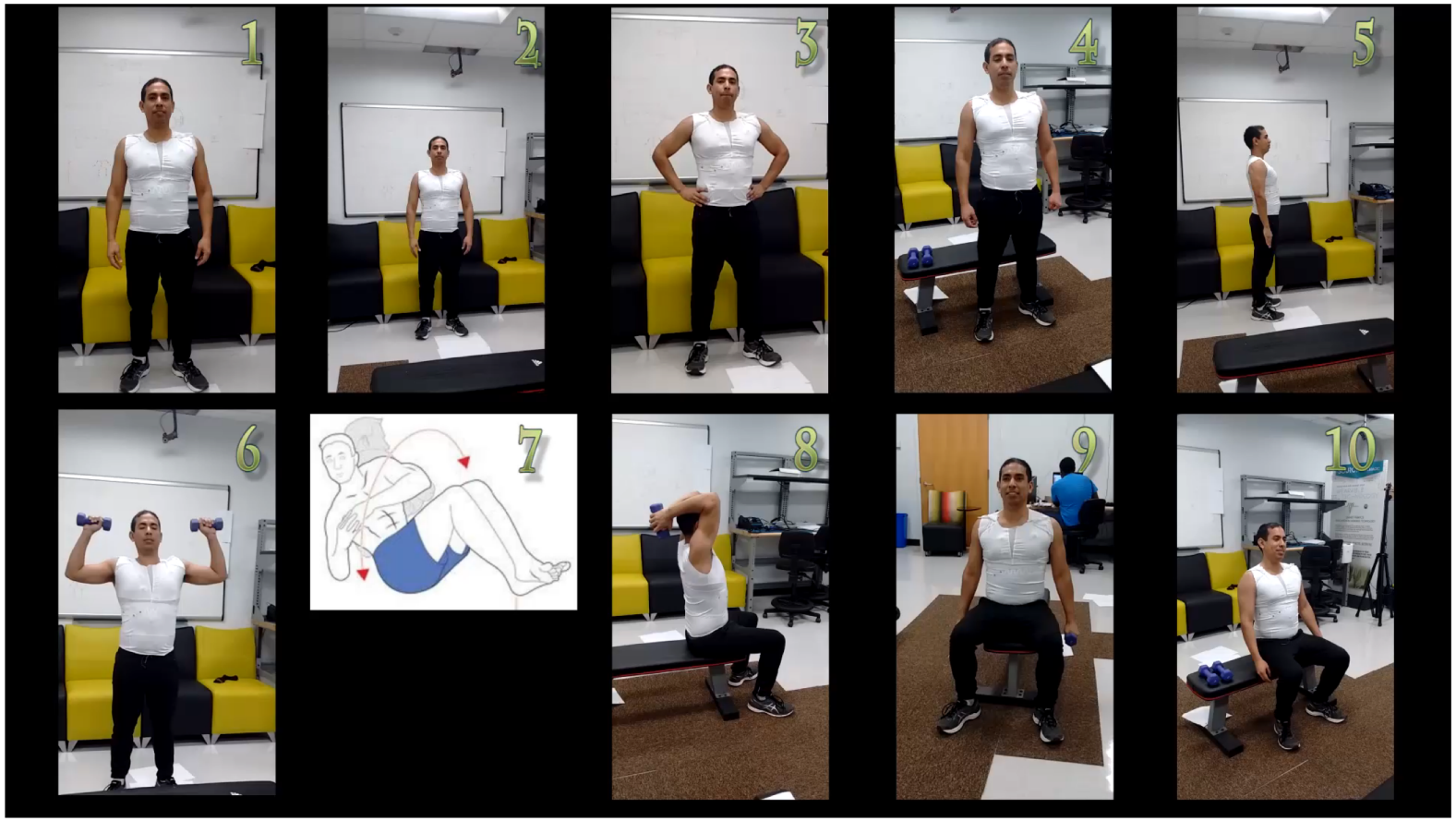
Whole Garment

- 3D Printing of garments
- ***Knit entire garment in one operation***
- Yarn (including conductive yarns) can be selectively added/designed
- ***Localized compression can be added based on knit structure***

Data Collection

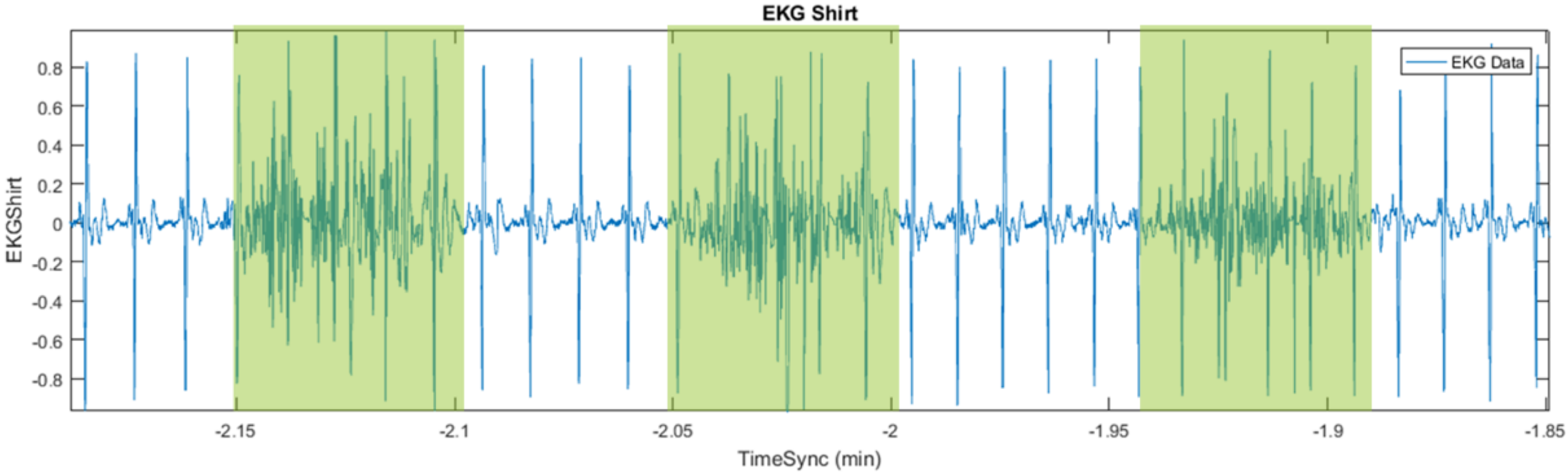
- **Devices:** Shimmer (EKG + IMU), **HET** (Chest + Wrist), **EKG-Shirt** (EKG), Chest strap (Respiration + IMU), Motion Capture, Video, Smartphone (IMU + Annotations)

- **Protocol 1 – Activities of Daily Life:** IRB Approved, 20 participants
- **Protocol 2 – Muscle Activation:** IRB Approved, 10 participants



w/ E. Lobaton (NC State)

Research: Data Analysis

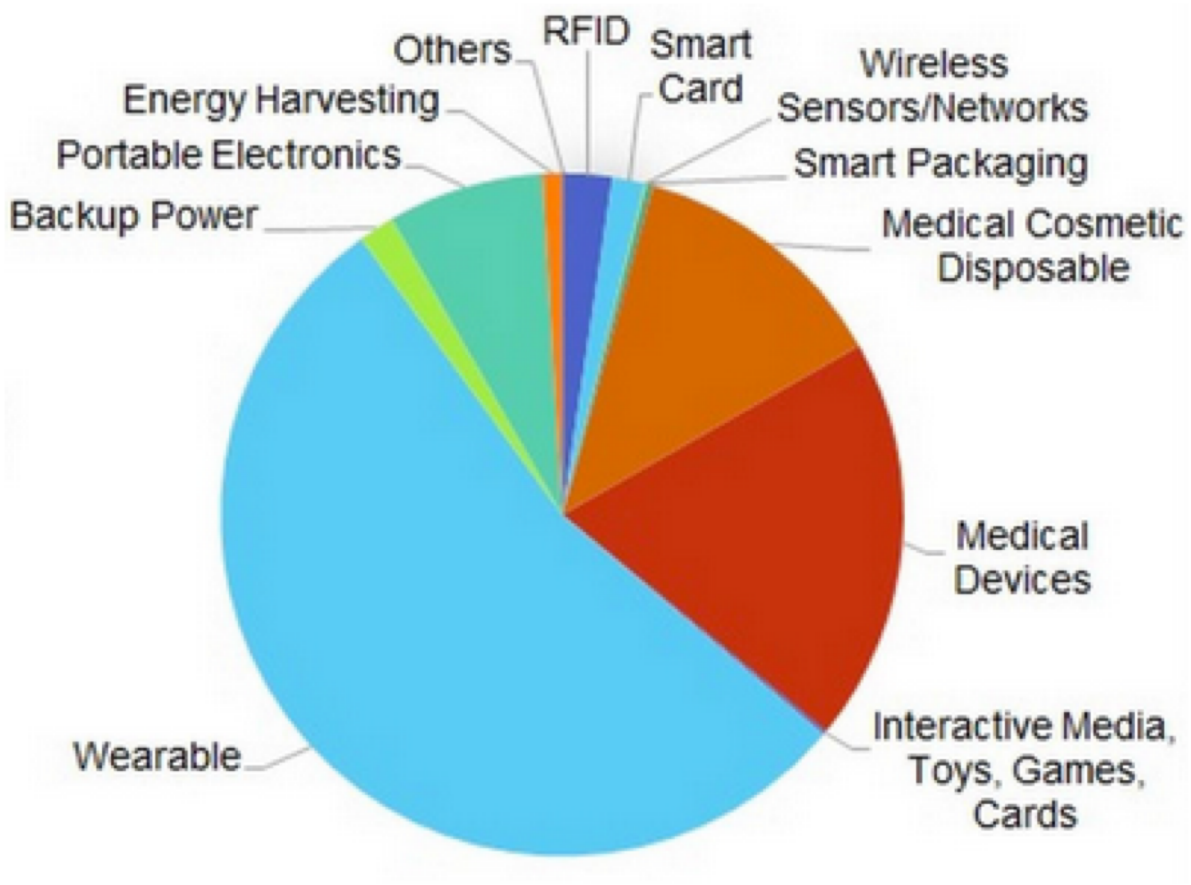


Waving Motion

w/ E. Lobaton (NC State)

What's next big challenge in wearables?

Thin film & flexible battery market: 400 mil USD in 2025



IDTechEx

1 human = 10 W

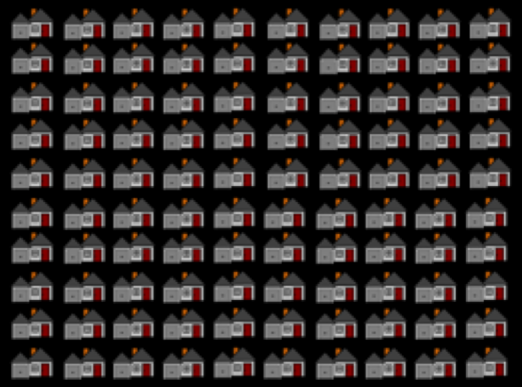
or

200 humans = 2.0 kW

or

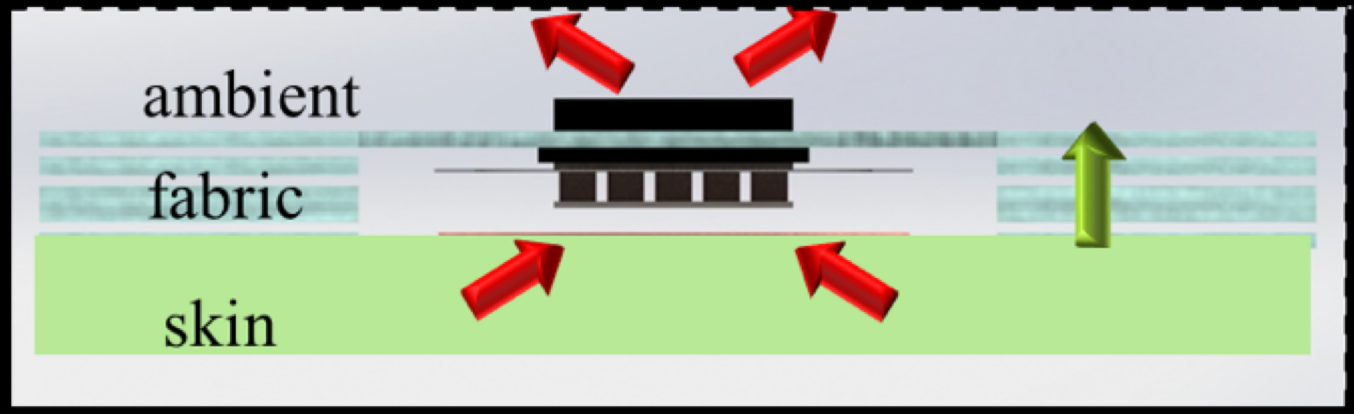
SN: E-3778Q-1

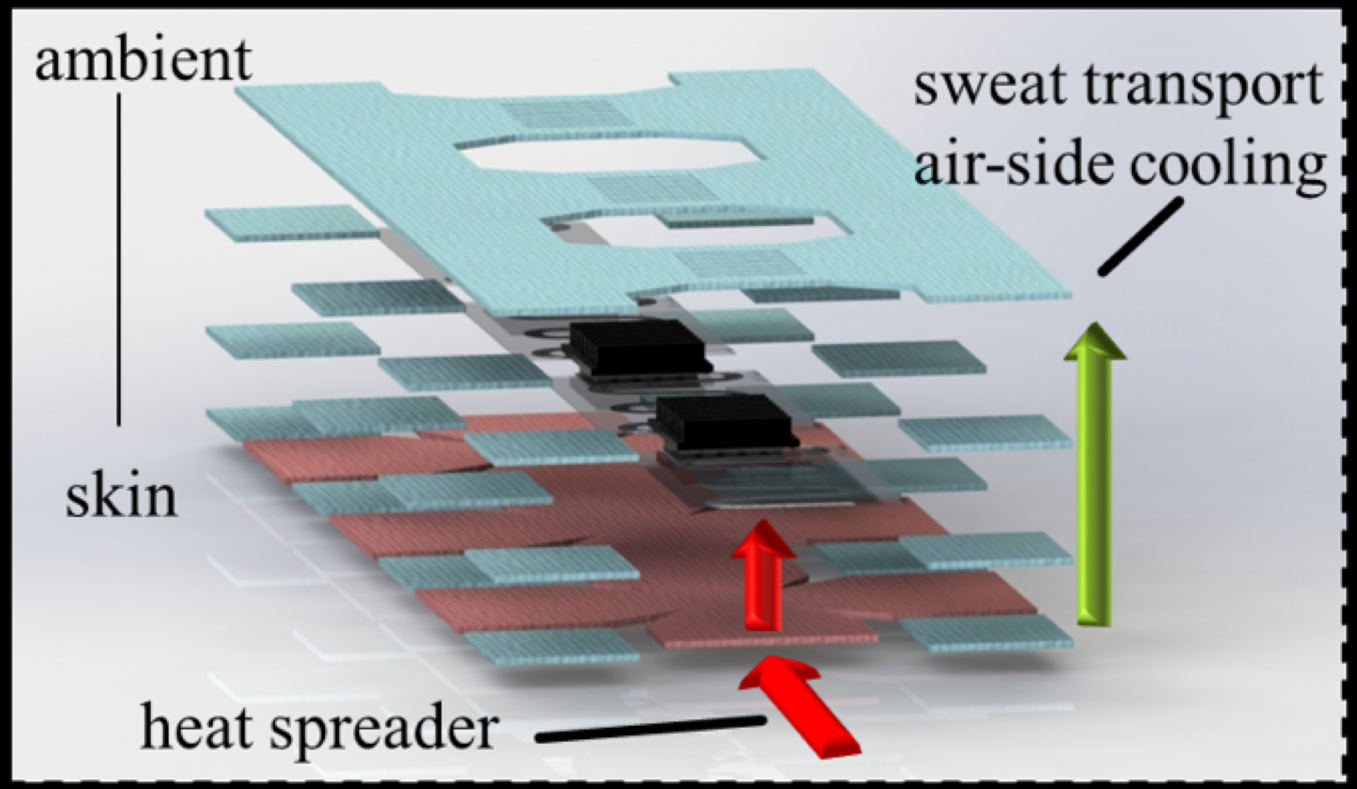
41,000 humans = 0.4 MW



or

‘Power Shirt’


ambient
fabric
skin


ambient
sweat transport
air-side cooling
skin
heat spreader

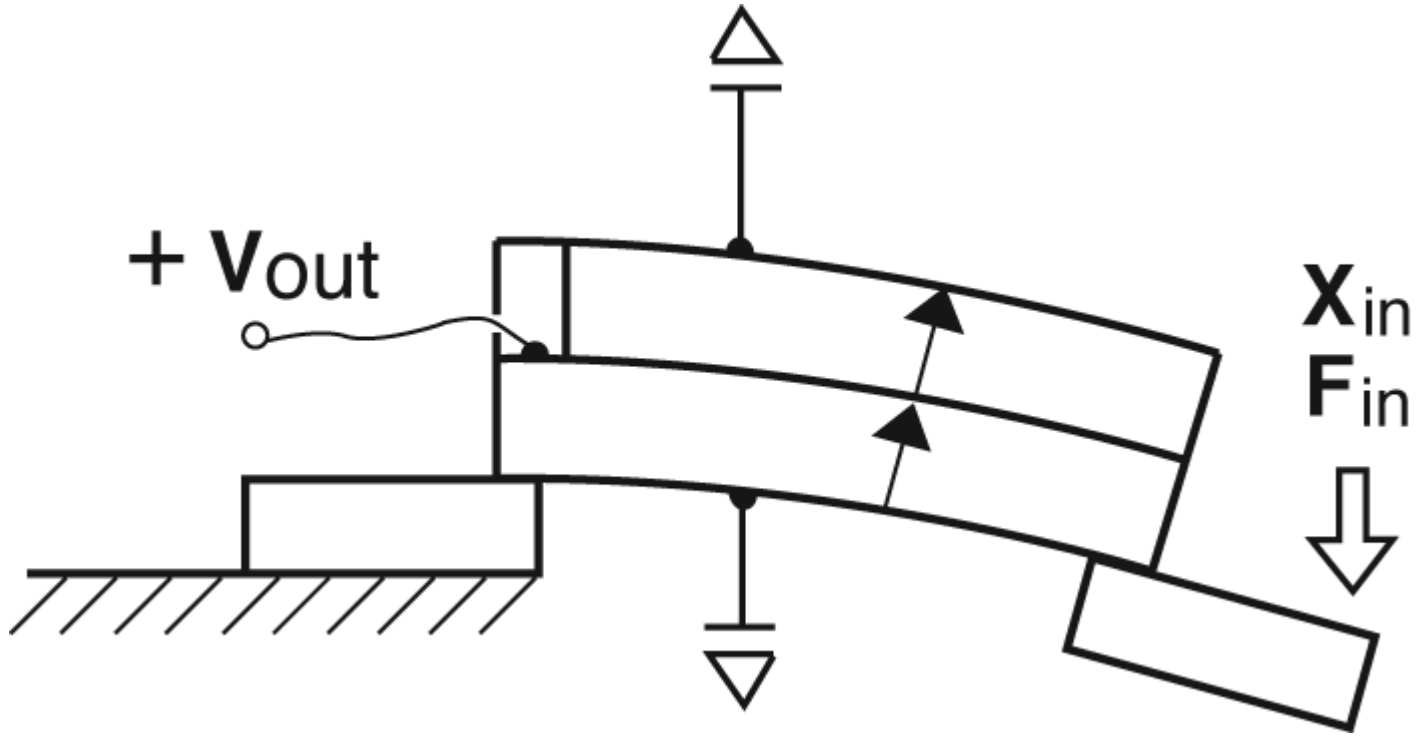
Piezoelectric (Kinetic) Harvesting

Constitutive Equations

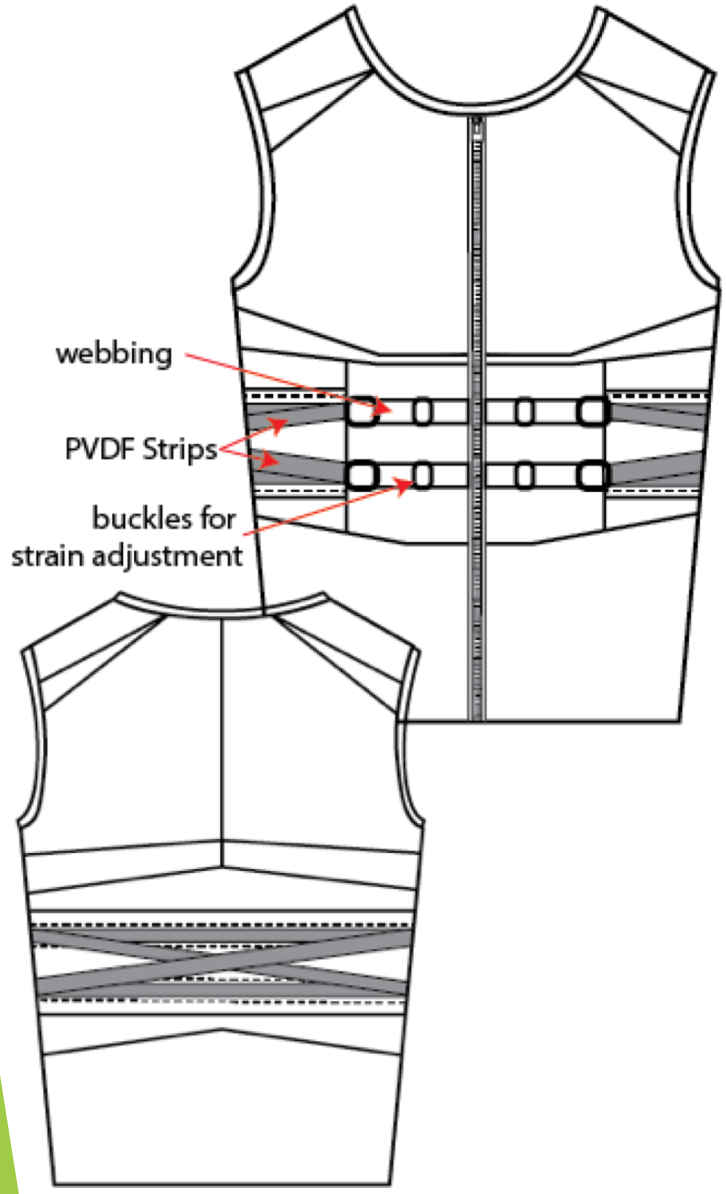
$$S = \frac{1}{C_p} T + dE$$

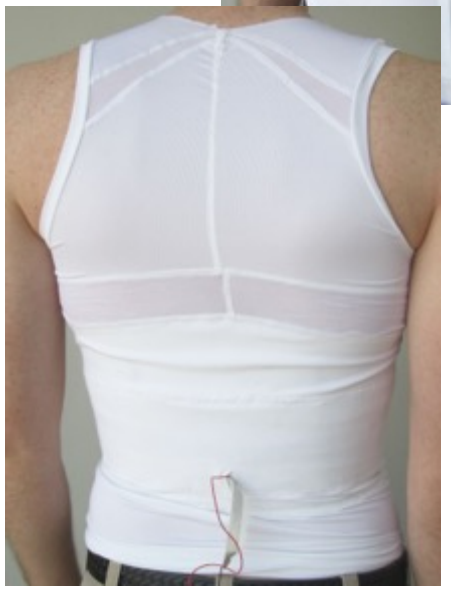
$$D = dT + \varepsilon E$$

S = strain (non-dimensional)
T = stress (Pa)
c_p= Young's modulus (Pa)
d = piezoelectric coefficient (m/V)
D = dielectric displacement (C/m^2)
ε = dielectric permittivity (F/m)
E = electric field (V/m)

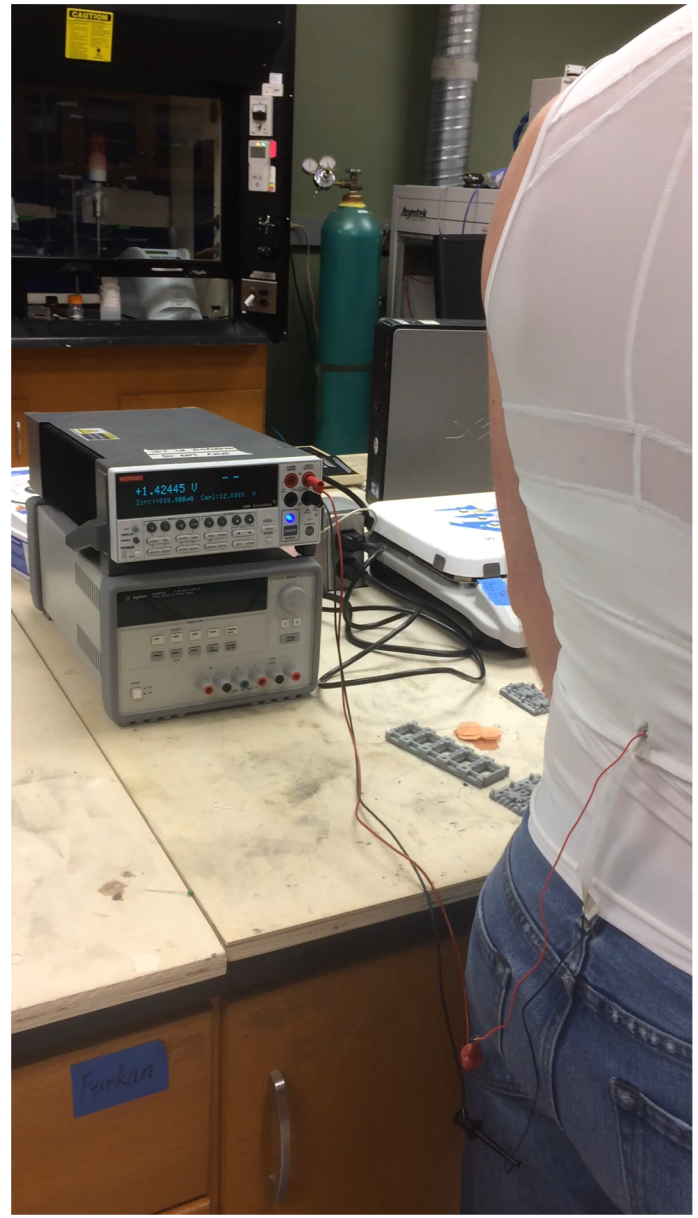


Piezoelectric Energy Harvesting





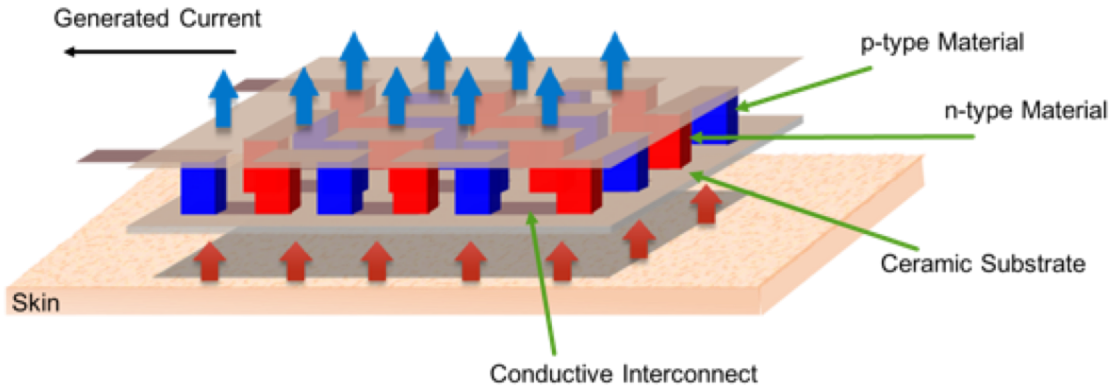
'piezo-shirt'

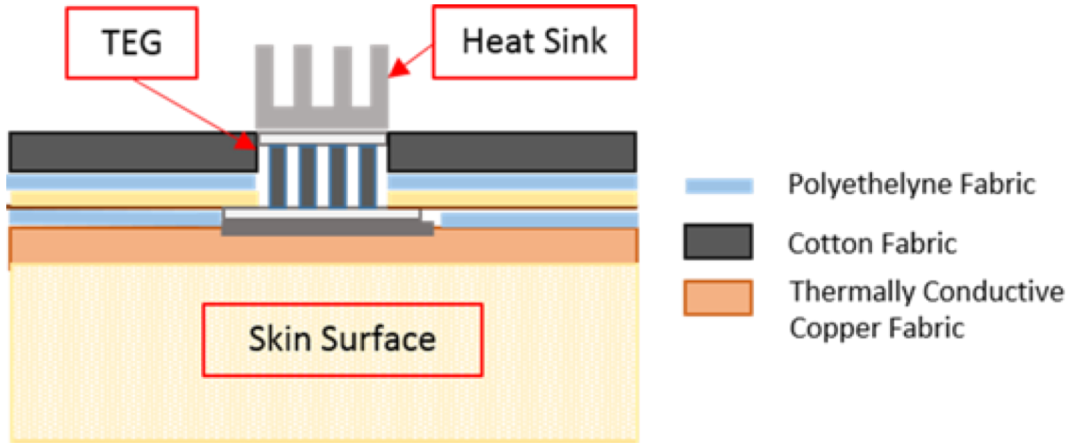


w/ C. Rhan (Penn State)

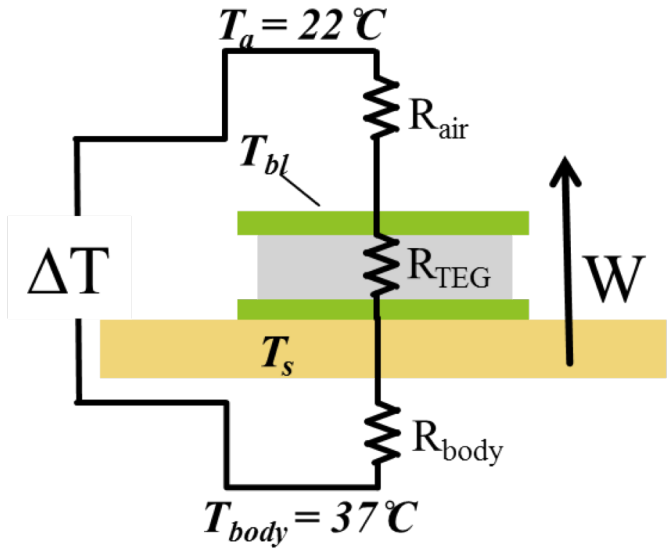
Thermal Energy Harvesting

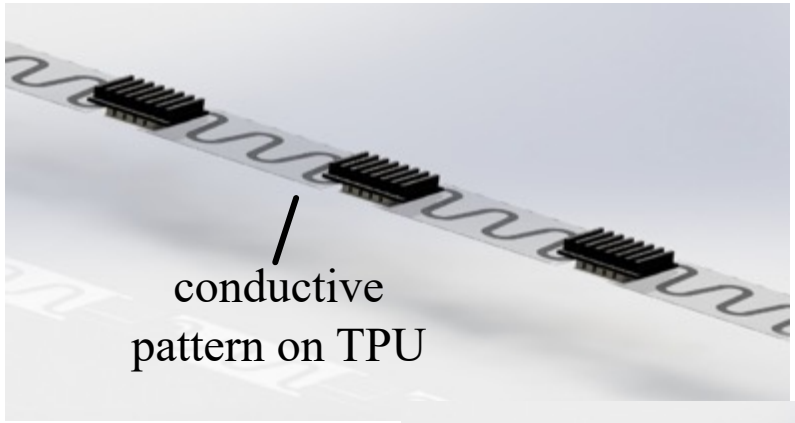
Thermoelectric energy generator (TEG)



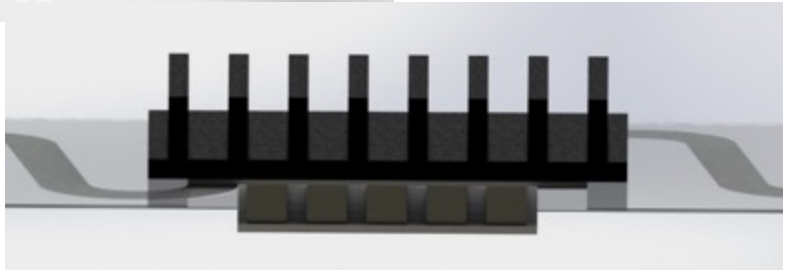


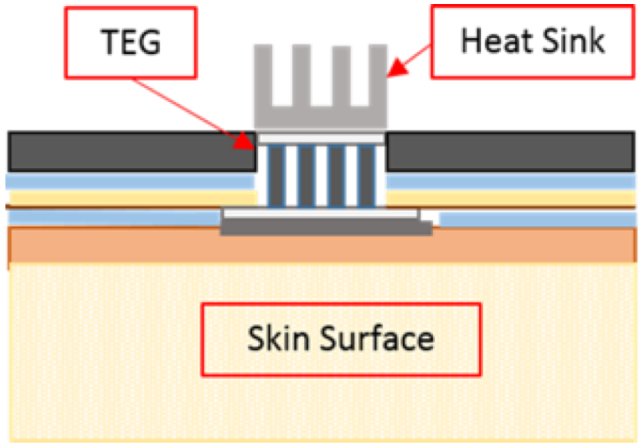
Heat flow (W)

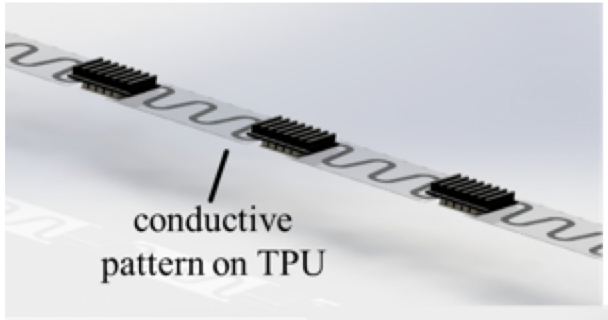




TEG & heat sink

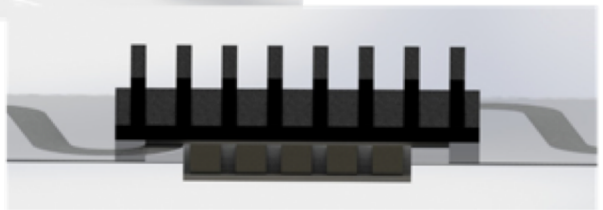






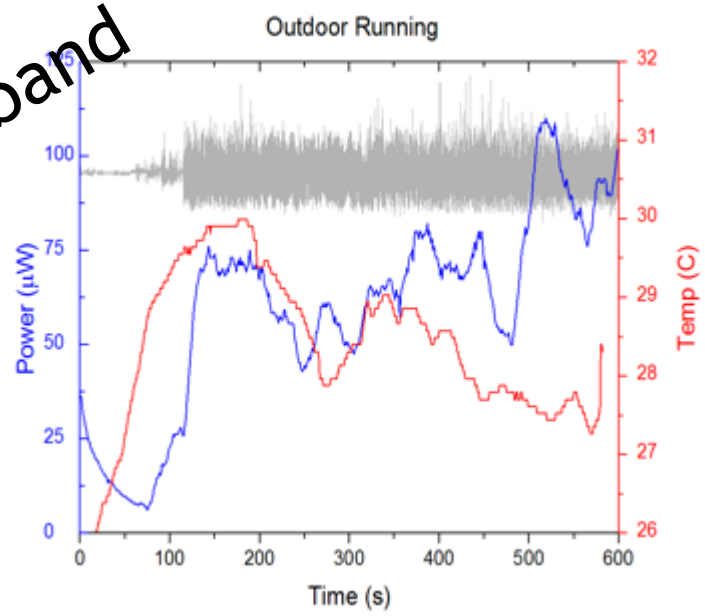
Polyethelyne Fabric
Cotton Fabric
Thermally Conductive
Copper Fabric

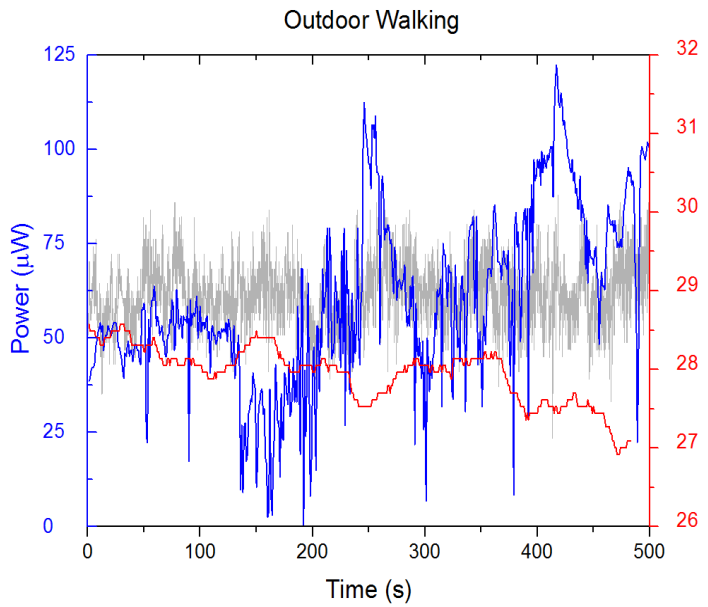
TEG & heat sink

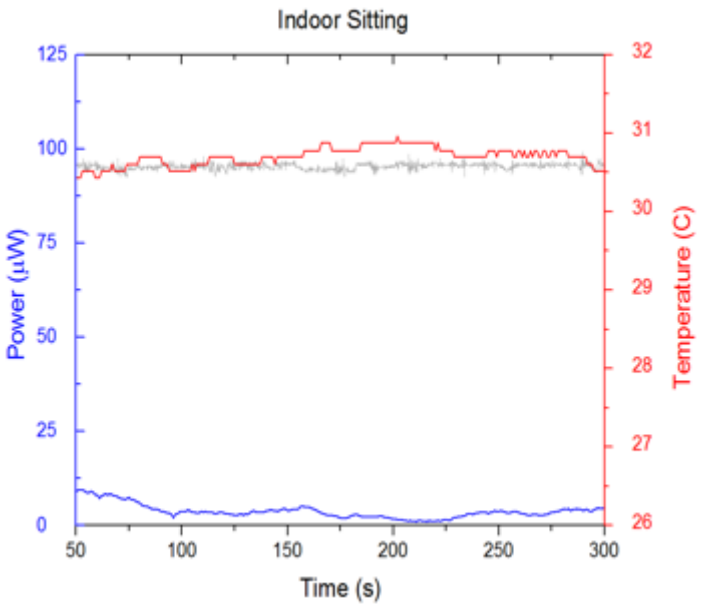


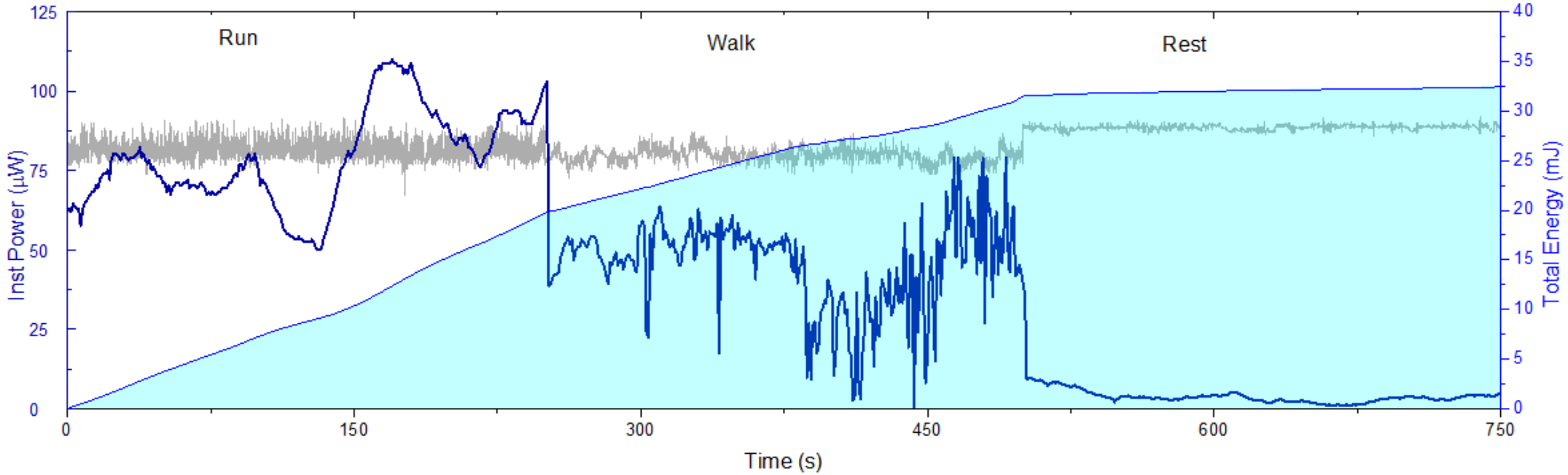
Human Energy Harvesting: IRB Study

Headband



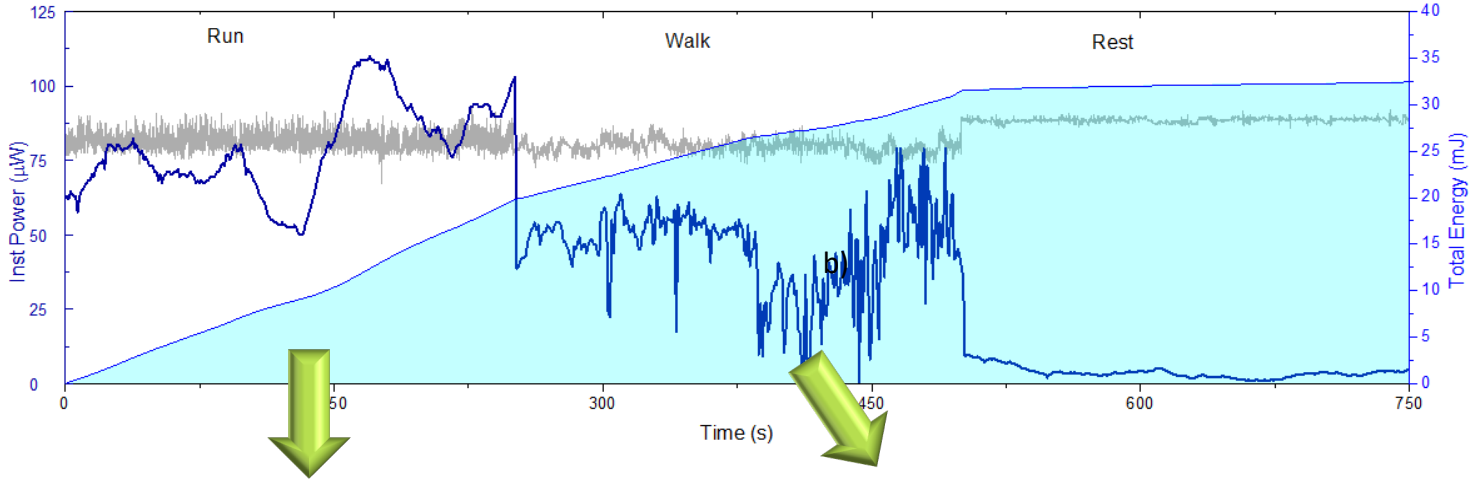


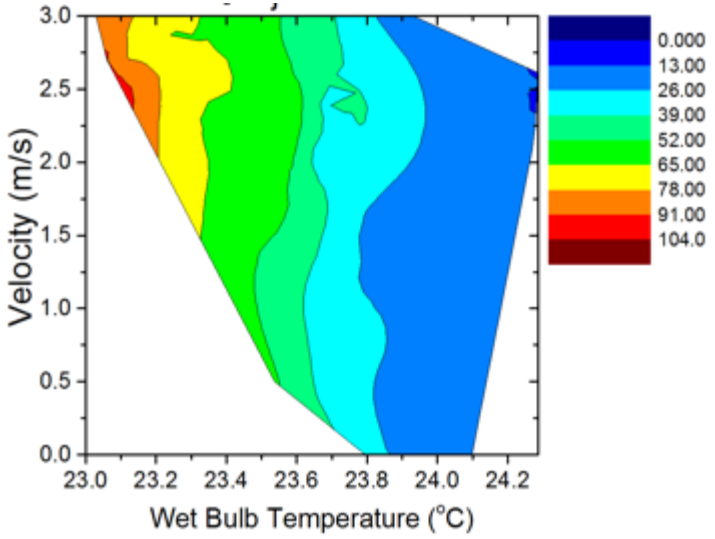


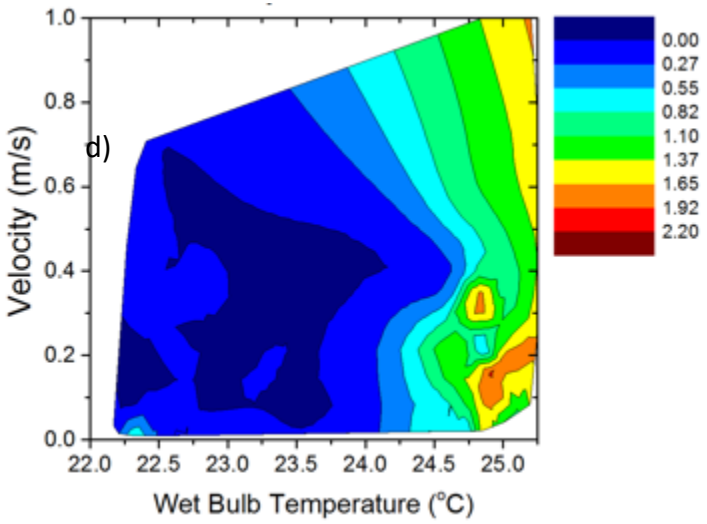


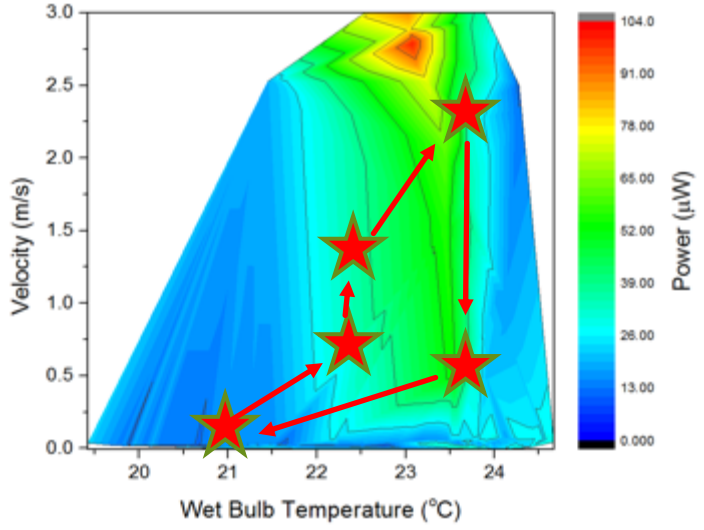
Thermal Energy Harvesting Assessment

Human Trial: Power Prediction





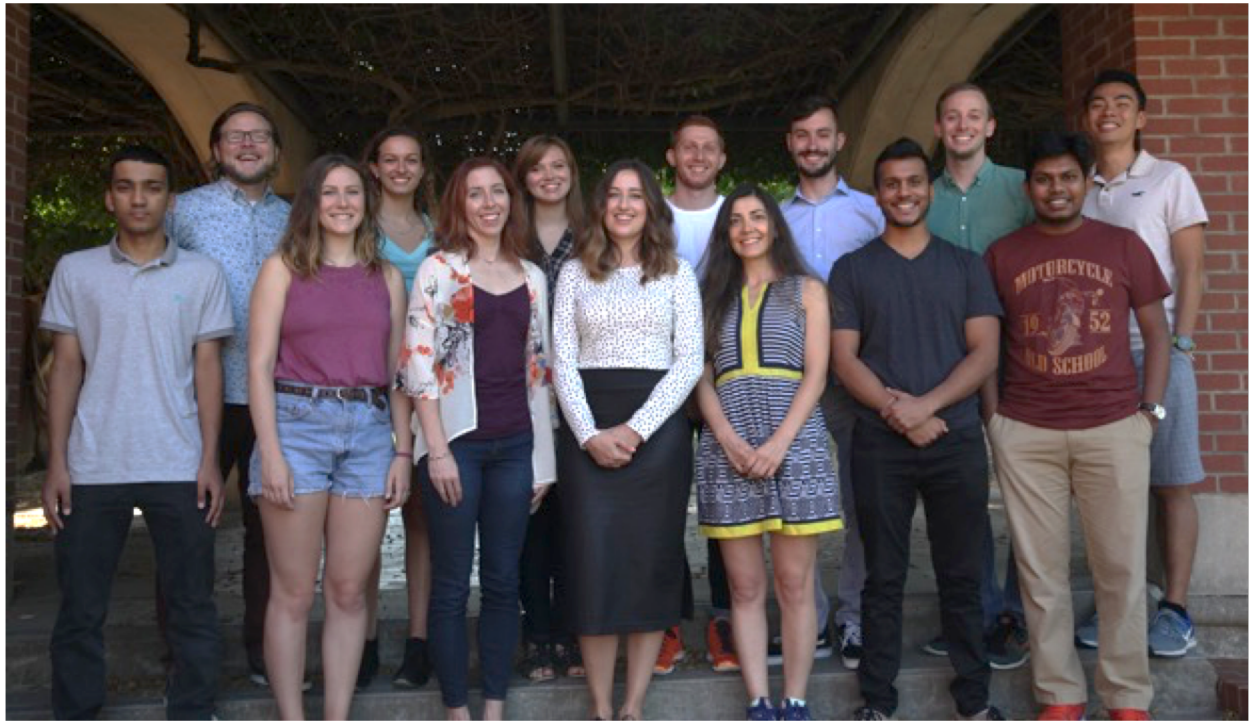




PI: Jur

Publication: A. Myers, R. Hodges and J.S. Jur *Energy Conv. & Man.* **143** 1 (2017)

Research Team of 'Fusion Designers'



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