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# How to help save the World (by adjusting your video)

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# General scope: Green IT

- Reduction in the carbon footprint of Video
- Lot's of work on energy efficiency in ICT for:
  - server hardware
  - datacentres
  - physical level, e.g. radio systems, CPU's etc.
- What about client systems and applications?
  - Outnumber servers/datacentres by several orders of magnitude
  - Are increasing in number
  - Small individual savings can scale globally

# Our Focus: Video

- Video usage is on the increase
  - 66% of traffic today, 80% predicted by 2020<sup>[1]</sup>
- Video is a great enabler:
  - applications and services for developing regions:(e-\*, e.g. e-Education, e-Health, e-Agriculture ...)
  - high-levels of (functional) illiteracy
- Developing regions:
  - large numbers of users, low penetration rates
  - so, huge growth in numbers of users possible

[1] CISCO VNI 2014: <http://blogs.cisco.com/news/cisco-visual-networking-index-vni-global-ip-traffic-and-service-adoption-forecast-update-2013-2018/>

# Aims

- Examine energy usage of video decode (and encode) at a desktop client.
- **Assess worldwide impact (Fermi estimate).**
- **Examine how user choice could be enabled.**
- Focus on decode for now:
  - decode events outnumber encode events, e.g. YouTube, Netflix, Amazon PIV, etc.
  - however, encode events on the rise, e.g. user-generated content, video sharing, real-time video

# Experiment – testbed



# Experiment – Codecs investigated

- Flash Video (Sorenson Spark/ FLV1)
- MPEG-4 Part 2 (MPEG4)
- Microsoft MPEG-4 Part 2 version 3 (MSMPEG4)
- MPEG-4 Part 10 / H.264
- High Efficiency Video Codec(HEVC)/ H.265
- Google VP8
- Google VP9

Open Source Videos: Big buck bunny and Tears of Steel

# Energy usage metrics for video

- Simple, intuitive metrics:

- $P_v$ : Energy used per second of video {de,en} coded

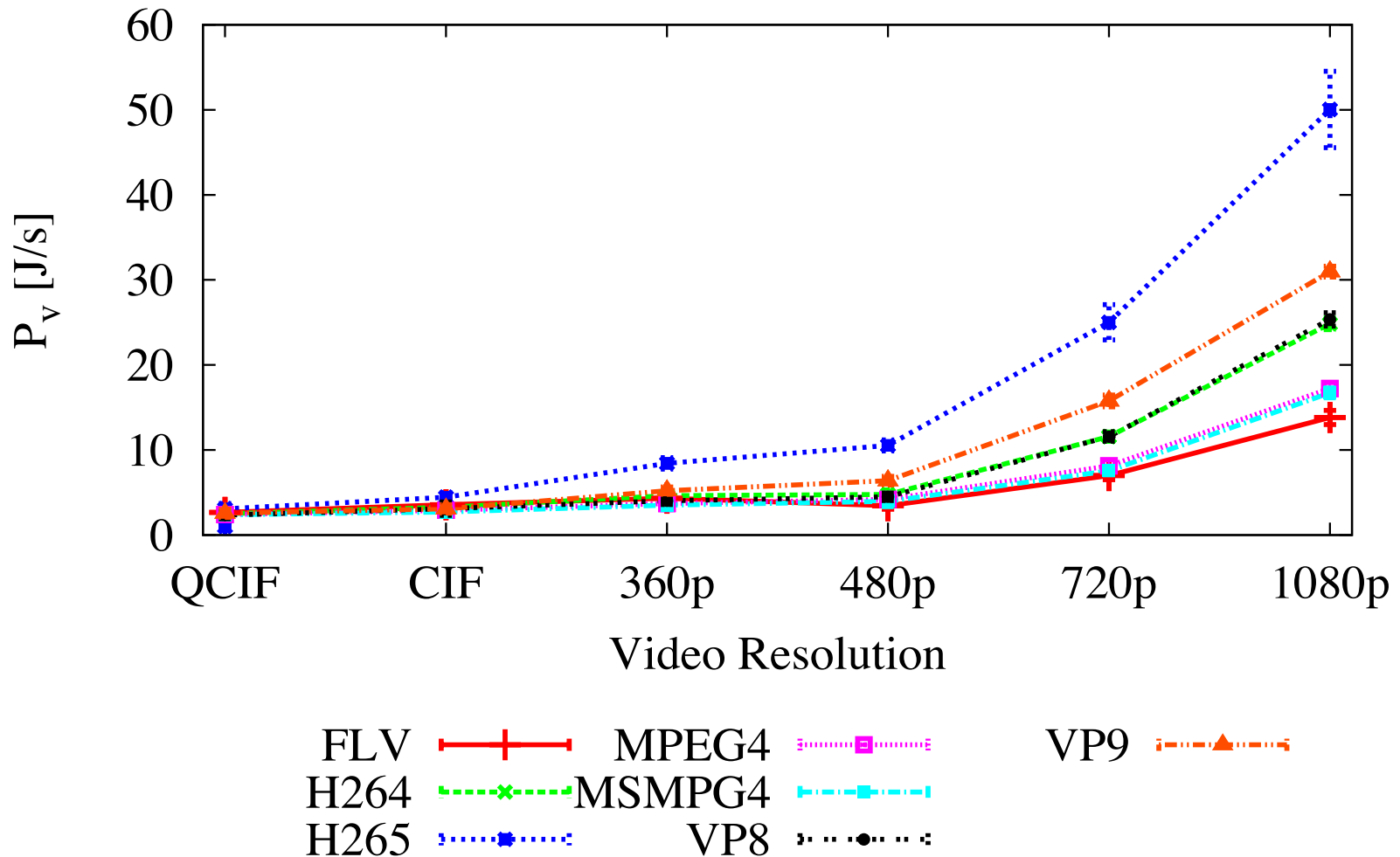
Joules per second of video,  $J/s_v$  .

- $Q_v$ : Quality-Energy metric

Weighted mean of a (normalized) quality metric (e.g SSIM, PSNR, VQM, MOS etc.) and (normalized) energy used per second of video.

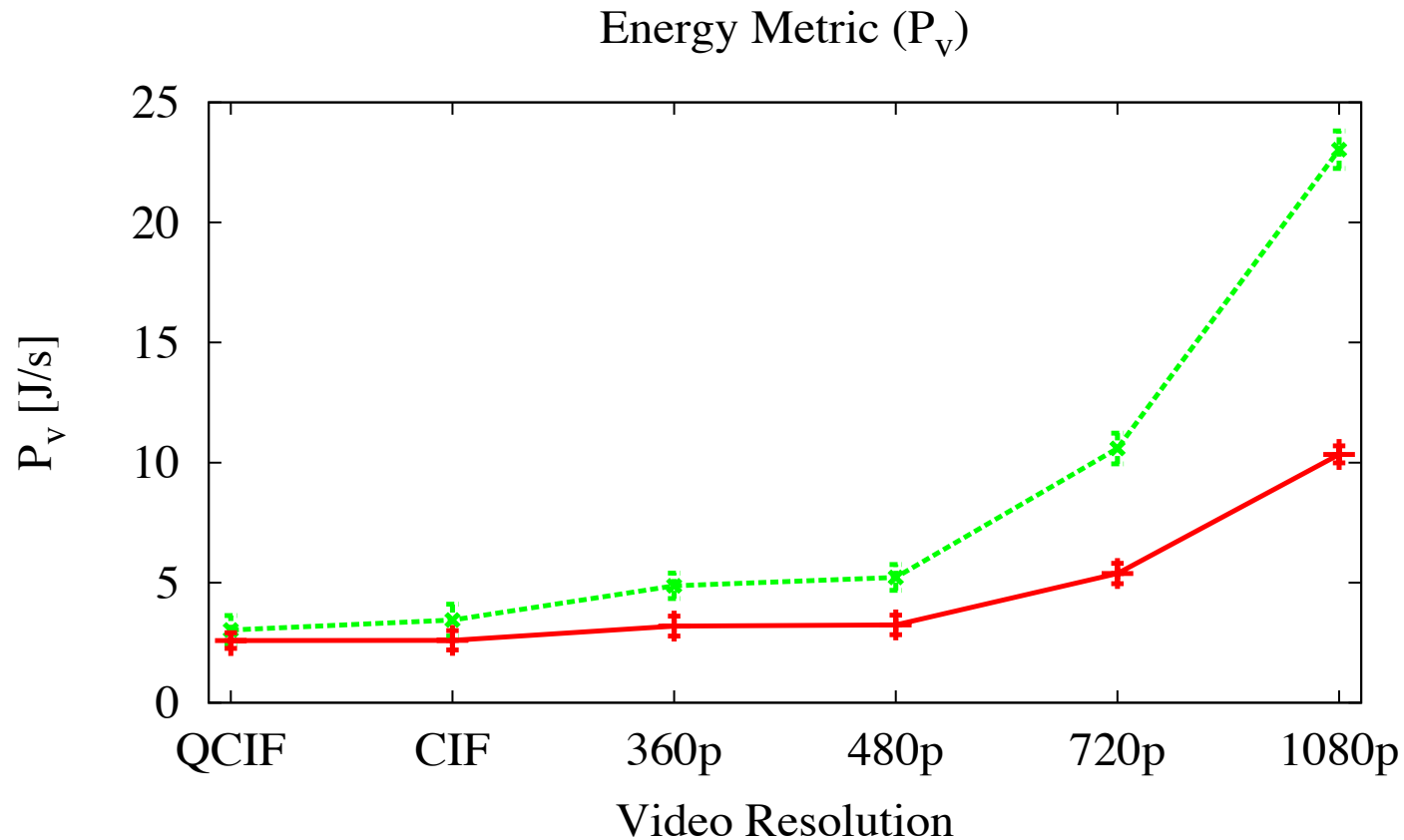
# Energy usage – decode (software)

Energy Metric ( $P_v$ )





# Energy usage – decode (hardware)[1]



H264 (SOFTWARE)  H264 (HW ASSIST) 

Using HW ASSIST is more efficient but consumes more idle power (~25 W)

# Impact – YouTube example

(In the spirit of a Fermi estimate)

- 72 billion hours of video streamed from YouTube annually<sup>[2]</sup>
- Smallest saving observed: 1 J/s<sub>v</sub>
- Largest saving observed: 40 J/s<sub>v</sub>

J/s <sub>v</sub>	KWh <sup>[3]</sup>	No. of Homes	Cost	Kg CO <sub>2</sub>
1	72M	18,947	£10.8 M (US\$17.8M)	12.2M
40	2880M	757,880	£432.0 M (US\$732.8M)	189.6M

- **Imagine if users could make sensible choices on codec and picture size towards greenness!**

[2] Youtube Statistics: <http://www.youtube.com/yt/press/statistics.html>

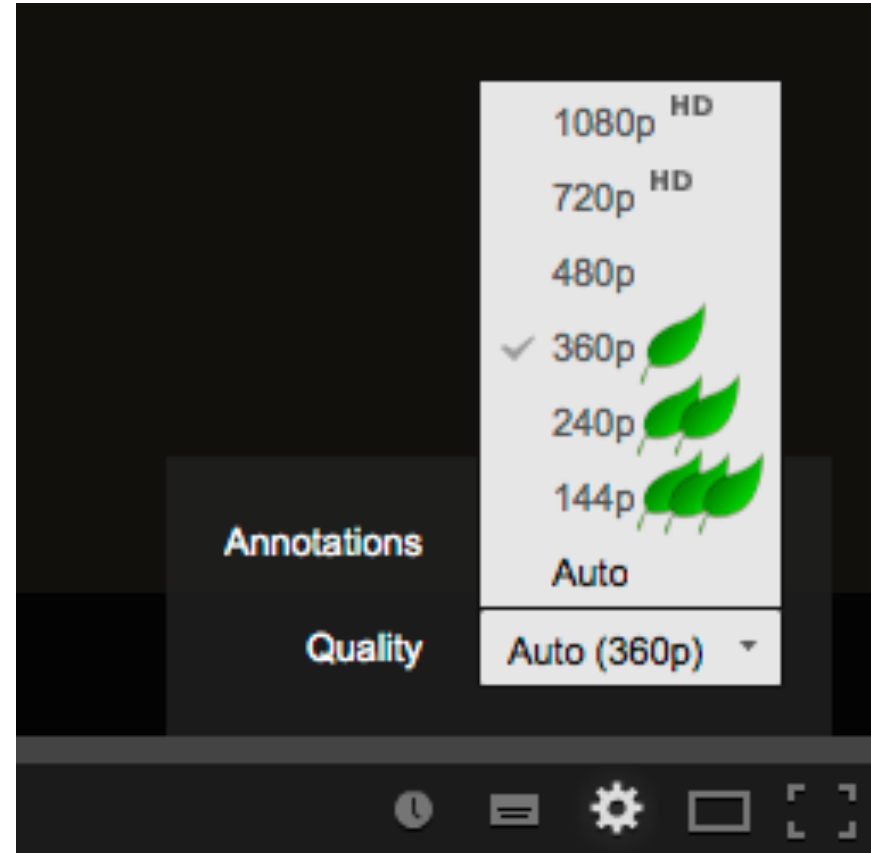
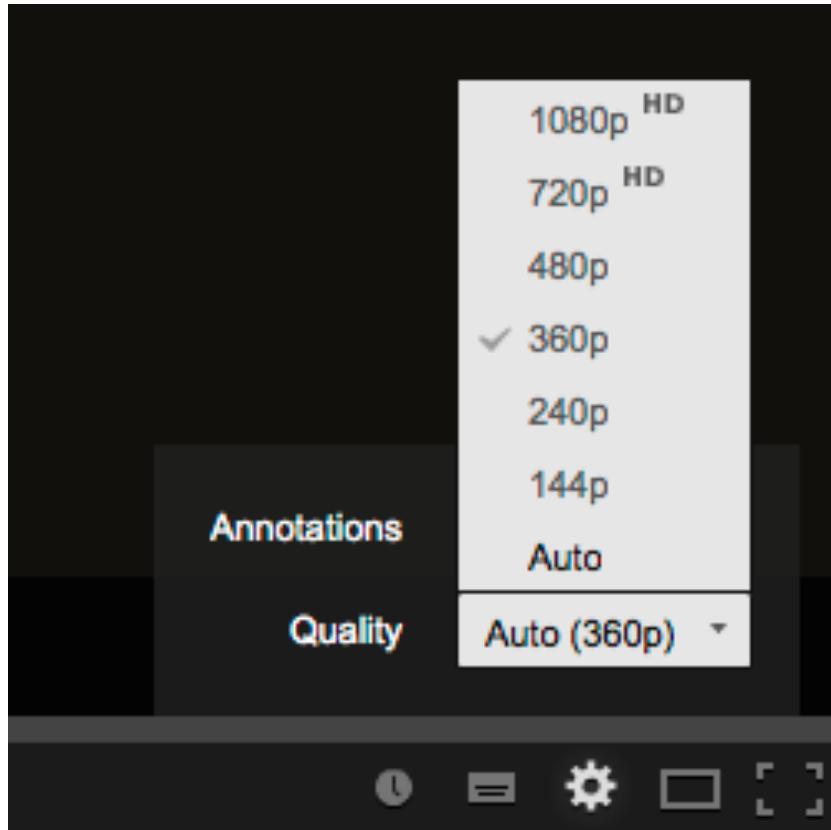
[3] UK Energy Statistics:

[www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/296183/pn\\_march\\_14.pdf](http://www.gov.uk/government/uploads/system/uploads/attachment_data/file/296183/pn_march_14.pdf)

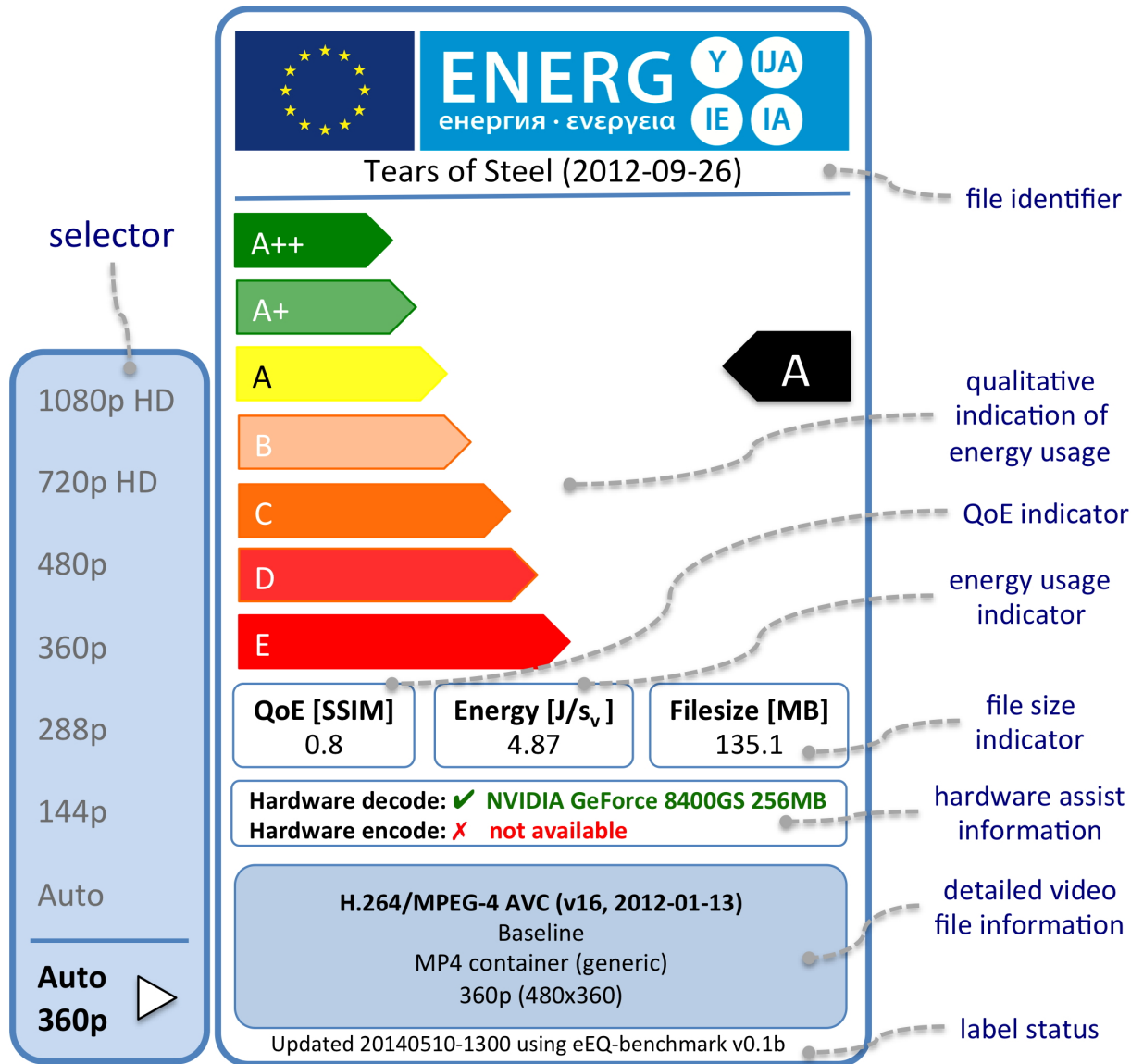
# How to enable user choice? [1]

- Future video energy/quality benchmark:
  - vEQ-benchmark
  - measurement-based, heterogeneous systems
  - e.g. SPEC Power:  
[http://www.spec.org/power\\_ssj2008/](http://www.spec.org/power_ssj2008/)
  - could use future ACPI API to access power info
- Need suite of “sample videos” to test:
  - would need to agree vEQ metric

# How to enable user choice? [2]



# How to enable user choice? [3]



# Summary

- Video is an increasingly popular use-case on the Internet today (80% by 2020)
- Energy consumption during video playback varies significantly by codec and picture size
- Using YouTube as an example, up to 2880 TWh can be saved annually (in theory), enough to power 758,000 homes in UK.
- Allowing users to choose picture settings towards greenness, can help save the planet!

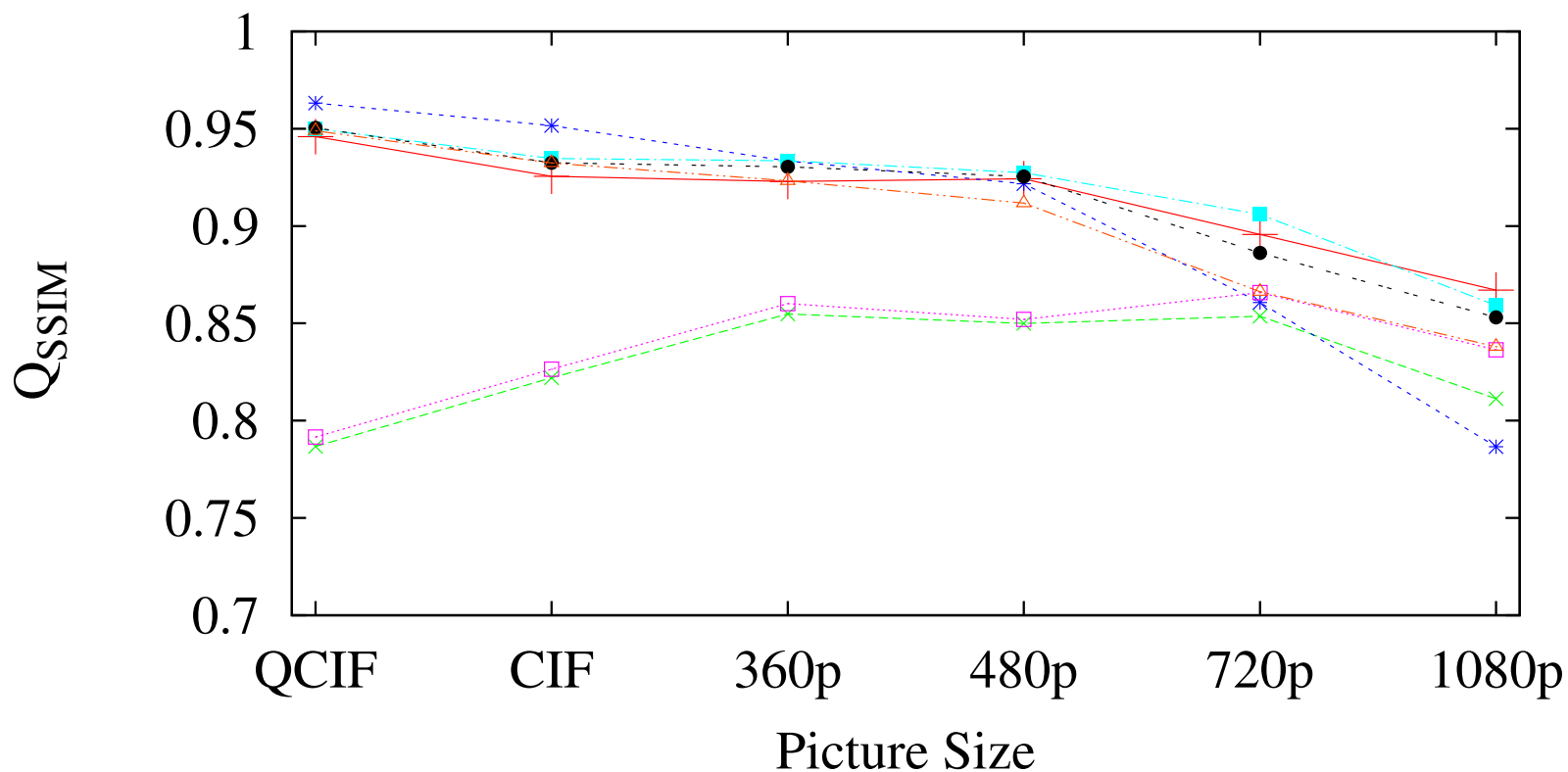
Thank You! Questions?

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# Energy-Quality metric

Normalized Energy-Quality (SSIM) Metric ( $Q_{SSIM}$ )



FLV —+— MPEG4 .....□..... VP9 -.-.-△-.-.-  
H264 -.-.-x-.-.- MSMPG4 -.-.-■-.-.-  
H265 .....\*..... VP8 -.-.-●-.-.-